

## A CONTAINER

## BACKGROUND OF THE INVENTION

The present invention relates to a container for aircraft (air cargo container), ships, freight trains, etc.

Among various means of transport, an airplane is large in gross factor, and since even slight reduction of weight is very effective, FRP (fiber reinforced plastics) has begun to be used in many portions of the airplane.

Containers for aircraft are absolutely necessary for carrying cargoes and passengers' baggage. One airplane, especially of an international line, is loaded with tens of containers, and a freight plane is loaded with more than 100 containers. So, the reduction in weight of containers is very economically effective. One presently used standard container of about 2 m in width, about 1.5 m in depth and about 1.6 m in height weighs about 90 kg. It is said that if the weight of the airplane of an international line can be reduced by 1 kg, the operation cost can be reduced by 10,000 yen per year. And yet, the reduction in weight of containers has been little achieved in these more than 20 years.

The presently used containers are made of aluminum alloy.

They are roughly handled when loaded into or unloaded from aircraft, and there are many problems such as that forks of forklifts often pierce containers, damages themselves and/or cargoes contained therein, and requires frequent repair. Furthermore, recently with the increase of products directly transported from places of production to consumers, the demand for heat insulated transport is increasing. However, since aluminum alloy is high in heat conductivity, a heat insulating material must be used in a large quantity to enhance heat insulation capability, and dew condensation occurs on the outer surface as another problem.

On the other hand, most of the presently used containers have a structure of a box assembled by riveting or welding aluminum alloy plates onto an aluminum alloy frame together with reinforcing materials such as gussets. The above mentioned standard container is made by assembling more than 50 parts, and

more than 500 rivets are used for assembling them. Such containers are heavy and require enormous time and cost for manufacture and assembling.

JP-A-07-257683 discloses a container of which side walls and roof are constituted of FRP. Although, this container is lighter and has higher strength than widely used container made of aluminium alloy, it does not mention anything about the improved thickness and fiber content of the FRP.

Furthermore, the presently used containers must use a frame large in section modulus, to secure the entire strength and rigidity, and this is also one of factors to prevent the reduction in weight of containers.

As a method for solving the problems of the containers for aircraft as mentioned above, for example, JP-A-94-48480 proposes a container for aircraft, comprising sandwiched plates with FRP as the outer skin and a foam as the core, being provided with joining flanges around them, so that the respectively adjacent sandwiched plates may be joined through the flanges to form a box structure. Since this container uses FRP, not requiring the large frame, it is lighter in weight than the conventional aluminum alloy containers, but because of no use of frame, the sandwiched plates used must be thick and the intended effects are decreased. Furthermore, because of the joining structure, the manufacture and assembling take much time and cost.

#### OBJECT OF THE INVENTION

The object of the present invention is to solve the above mentioned problems of the conventional containers, and to provide a container which is not only lighter in weight and higher in strength, but also excellent in heat insulation capability.

Another object of the present invention is to provide a container which, solving the above problems, is ideal especially for aircraft, being lighter in weight, sufficiently strong and rigid as a container, and can be manufactured and assembled at far less time and cost.

The container of the present invention can be used not only for aircraft, but also for ships, freight trains, etc.

## SUMMARY OF THE INVENTION

To achieve the above object, the present invention provides a container, comprising a frame, side walls, a roof and a base, wherein at least said side walls are made of FRP panel, the thickness,  $t(\text{mm})$ , and fiber content,  $V_f(\%)$ , of which are  $0.3 \leq t \leq 1.5$  and  $30 \leq V_f \leq 65$ , respectively. It is also possible that said side wall comprises at least two FRP panels used as one set for each side, with a gap formed therebetween, or that the gap is packed with a heat insulating material or contains a desiccant.

To achieve the above object, the container of the present invention preferably comprises at least adjacent two sides of the side walls, the roof and the base are constituted of an integrally formed continuous FRP panel.

The adjacent two sides can be side walls, or a side wall and the roof, or a side wall and the base. Furthermore, three or more adjacent plates can also be formed as an integrally formed continuous FRP panel, or two or more adjacent side walls and the roof or a base can be formed as an integrally formed continuous FRP panel. Moreover, one or more side walls and the the roof and the base can also be formed as an integrally formed continuous FRP panel.

The kinds of the reinforcing fibers of the FRP constituting the side walls can be glass fibers or polyaramid fibers, but carbon fibers more excellent in specific strength and specific modulus or a woven carbon fiber fabric is preferable. Especially if a woven carbon fiber fabric of  $450 \text{ kgf/mm}^2$  or more in tensile strength  $\sigma_f$  and 1.7% or more in elongation  $\delta$  is used, the resistance against piercing impact of the FRP can be more than that of the aluminum alloy plates used in the conventional container.

The reinforcing fibers can be unidirectional, but are recommended to be a woven fabric as described above. The woven fabric is available as plain weave, satin weave or multiple weave, etc. as is well known, but plain weave is preferable, since it is strong in the constraining force of weft and warp threads and can enhance the resistance against piercing impact of the side walls.

4

The matrix resin of FRP<sup>4</sup> can be any of an ordinary thermosetting resin such as epoxy resin, unsaturated polyester resin, vinyl ester resin and phenol resin, or a thermoplastic resin such as nylon resin and ABS resin, but considering the possible occurrence of a fire, a flame proof phenol resin, flame proof epoxy resin or flame proof unsaturated polyester resin is preferable.

We found that it is impossible to achieve sufficient lightness and strength if the thickness or the fiber content of the FRP panel is not appropriate. It is preferable that the thickness is in the range of 0.3-1.5 mm. If the thickness is less than 0.3 mm, the strength of the FRP panel becomes lower than that of aluminium panel and is often broken with forks of forklifts. If the thickness is larger than 1.5 mm, its weight becomes equal to or larger than that of the side walls or roof made of aluminium alloy. On the other hand, fiber content of the FRP is preferably 25-65%. If  $V_f$  is lower than 25%, in order to achieve predetermined strength, the thickness must be large and, accordingly, the container cannot be light. As for FRP of high fiber content, although high strength can be expected, uniform impregnation with matrix resin is difficult or substantially impossible at the manufacture.

The side walls can be easily produced by any of ordinary FRP molding methods, such as autoclave molding of cross-laminated unidirectional prepregs or laminated woven prepreg fabrics, RTM molding or hand lay up with, such as, preform of reinforcing fibers.

The roof and the base can also be made like the side walls. However, the roof can also be a plate made of a synthetic resin such as polyamide resin, polypropylene resin, polyethylene resin, polyvinyl chloride resin, acrylic resin or polycarbonate resin, since it is less liable to be flawed than the side walls. The base is recommended to be preferably made of aluminum alloy since it contacts the carrier equipment such as roller conveyor.

The integrally formed continuous FRP panel forming the two or more adjacent plates can be obtained by autoclave molding of unidirectional prepregs or woven prepregs laminated in a mold, or molding a preform, etc. of reinforcing fibers by RTM or hand lay up method, or pultrusion method, or the method stated in U.S.

Patent No. 4902215, etc. or any other general FRP molding method.

Other parts of the container than FRP, such as plates, frame and door can be made of any conventional metallic material such as aluminum alloy or steel, or any other material. However, it is preferable to use a material excellent in specific strength and specific modulus such as aluminum alloy as a metallic material.

FRP such as side walls, a roof and a base, and the integrally formed continuous FRP panel can be joined with the other parts directly by using rivets or an adhesive, or using rivets, welding or an adhesive through any reinforcing material such as gusset or frame.

In cases rivets or bolts are used, when container wall is hit with, for example, fork of forklift, the wall can be broken around the holes for rivets or bolts not only the hit portion, since resistance against piercing impact of FRP is higher than that of aluminium plate. In such a case, the container cannot be repaired without replacing at least one wall and, thus, it is expensive. On the other hand, in case of a container made of aluminium alloy plate, the breaking mode is a type of forming a hole and the container can be repaired economically with a patch system.

To solve this problem of FRP container, it is effective to mount around the holes for rivets or bolts to make thicker than other portion. For example, it is preferable to additionally laminate prepregs around the holes and mold in autoclave. Alternatively, in case where resin transfer molding or hand lay up is applied, desired amount of reinforcing fibers should be laminated additionally around the portion where holes to be made.

To enhance the strength and rigidity of the entire container, the integrally formed continuous FRP panel can also be a FRP sandwiched plate with the FRP panels as the outer skin. In this case, the core of the FRP sandwiched plate can be a foam made of a thermoplastic resin such as polyethylene, polypropylene, polyvinyl chloride, polystyrene or ABS, or a foam made of a thermosetting resin such as phenol, epoxy, silicone or polyurethane, or a honeycomb made of aluminum or meta aramid resin.

To obtain a high strength high rigidity container lighter in weight, the side walls, a roof and/or a base constituted of the FRP can partially be reinforced with a sandwiched structural rib or hollow structural rib with said FRP as the outer skin.

Furthermore, the sandwiched structural rib or hollow structural rib can be provided at the inside corner between the side walls, or between a side wall and a roof, or between a side wall and the base constituted of the integrally formed continuous FRP panel. In this case, since the sandwiched structural rib or hollow structural rib shares the load applied to the entire container like the frame of the conventional container for aircraft, the side walls, a roof and/or a base constituted of the FRP can be thinner preferably to provide a high strength high rigidity container lighter in weight.

The sandwiched structural rib and hollow structural rib, can be assembled with the FRP panel as the outer skin, the core and the inner skin located on the side opposite to the FRP by applying an adhesive, etc. but if they are formed together at the molding of the FRP, the time for post-processing and assembling can be saved. In this case, the inner skin located on the side opposite to the FRP is molded beforehand.

The core of the sandwiched structural rib can be a foam made of a thermoplastic resin such as polyethylene, polypropylene, polyvinyl chloride, polystyrene or ABS, or a foam made of a thermosetting resin such as phenol, epoxy, silicone or polyurethane, or a honeycomb made of aluminum or meta aramid resin. For the inner skin, any material can be used, but considering adhesiveness and linear expansion coefficient, it is preferable to use a material similar to the integrally formed continuous FRP panel used as the outer skin.

The reinforcing fibers in the FRP can be of any style, but it is preferable that they are continuous at least through the one set of adjacent two sides. Since the use of continuous reinforcing fibers can secure the strength and rigidity of the entire container, the container can be made by using thinner plates, to be greatly reduced in weight.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is described below in reference to an illustrated example.

Fig. 1 is a schematic perspective view showing the container for aircraft of the present invention as an example.

The container shown in Fig. 1 has side walls 2 and a roof 6 respectively made of FRP and a base 7 made of aluminum alloy installed to a frame 1 made of aluminum alloy. As for the installation of the side walls 2, a roof 6 and a base 7 to the frame 1, as shown in Fig. 2 where the side walls are installed, a side wall 2 is fitted in the groove formed in the frame and fixed by an adhesive 3 applied to the faces to be inserted, and rivets 4. If plural, say, two FRP panels 2 are to be fitted in for each lateral, they can be installed as shown in Fig. 3. In the example shown in Fig. 3, a gap is formed between the two FRP panels 2 and 2 and contains a desiccant 5 arranged. The gap acts as a heat insulating layer, and may also be packed with a lightweight, preferably flame retardant heat insulating material such as glass wool or foamed synthetic resin.

Fig. 4 is another schematic perspective view showing the container for aircraft of the present invention as an example.

In Fig. 4, symbol 11 denotes an integrally formed continuous FRP panel forming a side wall portion 11a as one of four side walls, and a roof portion 11b; 12, a door installing frame member made of aluminum alloy; 13, a base made of aluminum alloy; 14, a bottom frame member made of aluminum alloy; and 15, a door. The door installing frame member 12 is riveted to the FRP 11 and is provided with functions required for opening, closing and locking the door. The door 15 has a door plate 15b made of FRP riveted to a door frame member 15a made of aluminum alloy, and is provided with functions necessary for opening, closing and locking the door. The FRP 11 and the base 13 are joined by riveting through the bottom frame member 14, and the door 15 is also riveted to the FRP 11 through the door frame member 15a and the door installing frame member 12.

Fig. 5 is a schematic vertical section showing a corner between the roof and a side wall of the container of the present invention. In Fig. 5, symbol 16 denotes a sandwiched structural rib with the FRP 11 as an outer skin at the inside corner; 16a, a core made of polyvinyl chloride foam contained in the rib 16; and

16b, an inner skin made of FRP. A hollow structural rib constituted of removing the core 16a from the sandwiched structural rib 16 can also be used.

Fig. 6 shows a sandwiched structural rib which consists of a side wall (top or a base) 1a constituted of the integrally formed FRP, a core 17a partially provided under the side wall 11a, and an inner skin 17b provided on the side opposite to the lateral FRP plate 11a. The core 17a and the inner skin 17b can be bonded to the lateral FRP plate 11a later using an adhesive, etc., or can also be molded simultaneously when the FRP is molded.

#### EFFECTS OF THE INVENTION

The container of the present invention has a frame, side walls, a roof and a base, wherein at least the side walls, preferably the side walls and the roof are made of FRP. Therefore, compared with the conventional container made of aluminum alloy, the container of the present invention is higher in strength and lighter in weight to allow more economical operation in service, and is also very excellent in heat insulation capability. The weight reduction effect reaches about 20%, for example, if the side walls and a roof are made of a carbon fiber reinforced plastic (CFRP) material, and if the frame is also made of CFRP, the effect reaches about 30%. Furthermore, if the side walls and a roof are made of CFRP, the heat insulation capability is further enhanced since the heat conductivity of CFRP is 0.7 to 4.2 kcal/m·hr·°C, very low compared to about 200 kcal/m·hr·°C of aluminum alloy. The resistance against piercing impact and heat insulation capability can be further enhanced by using a set of at least two FRP panels for each side wall or roof, with a gap formed between the two panels, and the heat insulation capability can be still further enhanced if the gap is packed with a heat insulating material or contains a desiccant.

If the container of the present invention has at least a set of adjacent two sides constituted of an integrally formed continuous FRP panel, it is higher in strength and lighter in weight, compared to the conventional containers, to allow more

economical operation, and can be manufactured and assembled spending far less time and cost.

For example, if four side walls, the roof and the door are formed as an integrally formed continuous carbon fiber reinforced plastic (CFRP) part, and the base, bottom frame member and door frame member are made of aluminum alloy, and these are joined using aluminum alloy rivets, then the number of parts constituting a similar container can be 25 which is about one half of that of the conventional container, and the number of rivets is also about 200 which is less than one half. The time taken for manufacture and assembling can be considerably decreased to two thirds of the conventional time.

Furthermore, if a sandwiched structural rib or hollow structural rib made of FRP which is a portion of the side walls or the roof or the base is provided at the inside corner between the side walls, or between a side wall and the roof, or between a side wall and the base of an integrally formed continuous FRP panel, the strength and rigidity of the entire container can be secured, to allow the elimination of the frame and the use of thinner plates, for further raising the weight reduction rate.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1: A schematic perspective view showing the container for aircraft of the present invention as an embodiment.

Fig. 2: A cross sectional view showing an important portion of the container for aircraft of the present invention.

Fig. 3: A cross sectional view showing another important portion of the container for aircraft of the present invention.

Fig. 4: A schematic perspective view showing the container for aircraft of the present invention as an example.

Fig. 5: An X-X arrow sectional view of Fig. 1.

Fig. 6: A sectional view showing the sandwiched structural rib of the present invention as an example.

#### Symbols

- 1: frame
- 2: side wall
- 3: adhesive

- 4: rivet
- 5: desiccant
- 6: a roof
- 7: a base
- 11: integrally formed continuous FRP panel to form a side wall portion and a roof portion
- 11a: side wall portion
- 11b: a roof portion
- 12: door installing frame member
- 13: a base made of aluminum alloy
- 14: bottom frame member made of aluminum alloy
- 15: door
- 15a: door frame member
- 15b: door plate made of FRP
- 16: sandwiched structural rib
- 16a, 17a: core
- 16b, 17b: inner skin



## WHAT IS CLAIMED:

1. A container comprising; a frame, side walls, a roof and a base, wherein at least said side walls are made of FRP panel, the thickness,  $t(\text{mm})$ , and fiber content,  $V_f(\%)$ , of which are  $0.3 \leq t \leq 1.5$  and  $25 \leq V_f \leq 65$ , respectively.
2. A container of Claim 1, wherein the fiber content,  $V_f(\%)$ , is  $30 \leq V_f \leq 65$ .
3. A container of claim 1, wherein said roof are made of FRP.
4. A container of claim 3, wherein said frame and said base are made of aluminum alloy.
5. A container of claim 1, wherein said side wall comprises at least two FRP panels as the outer skin with a gap formed therebetween.
6. A container of claim 5, wherein the gap is packed with a heat insulating material.
7. A container of claim 5, wherein a desiccant is contained in the gap.
8. A container of claim 1, wherein at least adjacent two sides of said side walls, said roof and said base are constituted of an integrally formed continuous FRP panel.
9. A container of claim 8, wherein said at least adjacent two sides are side walls.
10. A container of claim 8, wherein said at least adjacent two sides are one side wall and said roof.
11. A container of claim 8, wherein said at least adjacent two sides are one side wall and said base.
12. A container of claim 8, wherein at least one side wall, the roof and said base are constituted of an integrally formed continuous FRP panel.
13. A container of claim 8, wherein said at least two sides comprises partially or wholly with integrally formed continuous FRP panels as the outer skin with a gap formed therebetween.





THIS SHEET HAS BEEN  
REPLACED

14. A container of claim 8, wherein said integrally formed continuous FRP panel is reinforced with a sandwiched structural rib or hollow structural rib having FRP as the outer skin.

15. A container of claim 14, wherein the container is reinforced with said sandwiched structural rib or hollow structural rib at the inside corner.

16. A container of claim 8, wherein the reinforcing fibers in the FRP are continuous through the at least one set of adjacent two sides.

17. A container of claim 1 or 8, wherein said container has holes for revets or bolts and the thickness of the portion of said FRP panel around the holes is thicker than other portion.

18. A container of claim 1 or 8, wherein the reinforcing fibers in the FRP contain carbon fibers of 450 kgf/mm<sup>2</sup> or more in tensile strength and 1.7% or more in elongation.

19. A container of claim 1 or 8, wherein said FRP panel is reinforced with a woven fabric of carbon fibers.

20. A container of claim 1 or 8, wherein the FRP panel is reinforced with a plain fabric of carbon fibers.

21. A container of claim 1 or 8, wherein the matrix resin in the FRP contains a flame proof agent.

22. A container of claim 1 or 8, which is for aircraft.

This Sheet Has Been Replaced



Fig. 1

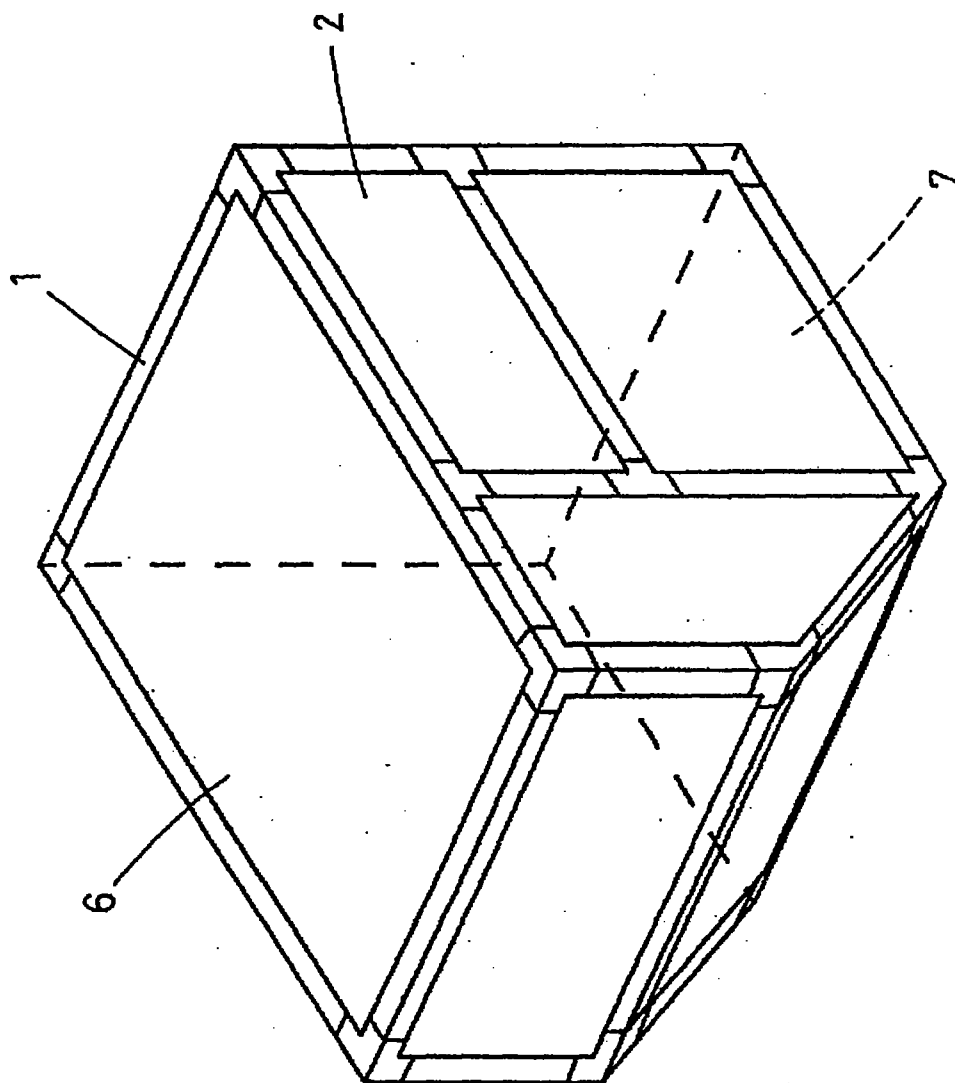


Fig. 2

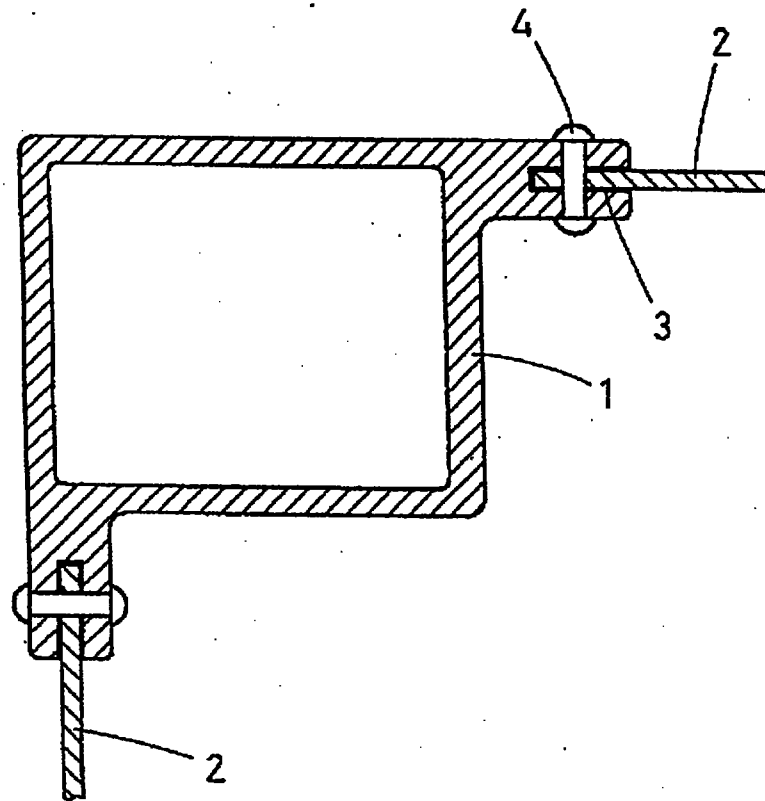


Fig. 3

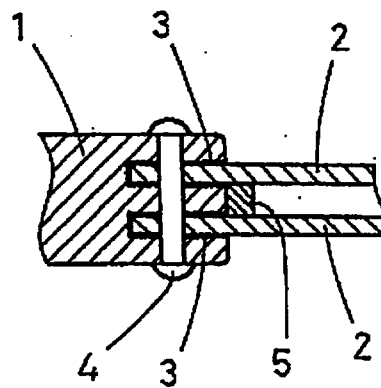
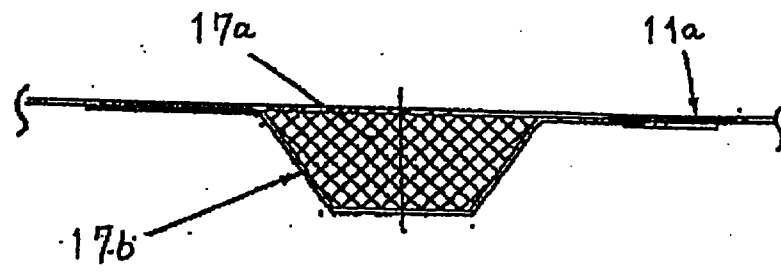




Fig. 6



## ABSTRACT

## A CONTAINER

To present a container especially ideal for aircraft which has sufficient strength and rigidity as a container lighter in weight and can be manufactured and assembled spending far less time and cost.

A container with side walls, a roof and a base, wherein at least at least side walls are made of FRP and wherein adjacent two sides of the above plates, are constituted of an integrally formed continuous FRP panel.

FIGURE 1



|                                                   |
|---------------------------------------------------|
| REPLACEMENT SHEET<br>- 3 AUG 1998<br>Date : ..... |
|---------------------------------------------------|

**WHAT IS CLAIMED:**

1. A container comprising:  
a frame;  
side walls made of CFRP (carbon fiber reinforced plastic) panel;  
a roof; and  
a base,  
wherein the thickness of said CFRP panel, except around holes for rivets or bolts, is between 0.3 mm and 1.5 mm,  
wherein the thickness of said CFRP panel around holes for rivets or bolts is thicker than other portions of said CFRP panel, and  
wherein the tensile strength and elongation of reinforcing fibers in said CFRP panel are at least 450 kgf/mm<sup>2</sup> and at least 1.7%, respectively.
2. A container of claim 1, wherein said side walls and said roof are made of an CFRP.
3. A container of claim 2, wherein said frame and said base are made of aluminum alloy.
4. A container of claim 1, wherein said side wall comprises at least two CFRP panels as outer skin with a gap formed therebetween.
5. A container of claim 4, wherein the gap is packed with a heat insulating material.
6. A container of claim 4, wherein a desiccant is contained in the gap.
7. A container of claim 1, wherein at least adjacent two sides of said side walls, said roof and said base are comprised of an integrally formed continuous CFRP panel.
8. A container of claim 7, wherein said at least adjacent two sides are side walls.
9. A container of claim 7, wherein said at least two adjacent sides are one side walls and said roof.
10. A container of claim 7, wherein said at least two adjacent sides are one of said side walls and said base.



11. A container of claim 7, wherein at least one of said side walls, the roof and said base are made of an integrally formed continuous CFRP panel.
12. A container of claim 7, wherein said at least portions of said at least two sides are comprised of integrally formed continuous CFRP panels as the outer skin with a gap formed therebetween.
13. A container of claim 7, wherein said integrally formed continuous CFRP panel is reinforced with one of a sandwiched structural rib and hollow structural rib having CFRP as the outer skin.
14. A container of claim 13, wherein the container is reinforced with one of said sandwiched structural rib and hollow structural rib at the inside corner thereof.
15. A container of claim 7, wherein the reinforcing fibers in the CFRP are continuous through at least one set of two adjacent sides.
16. A container of claim 1 or 7, wherein said CFRP panel is reinforced with a woven fabric of carbon fibers.
17. A container of claim 1 of 7, wherein the CFRP panel is reinforced with a plain fabric of carbon fibers.
18. A container of claim 1 or 7, wherein a matrix resin in said CFRP contains a flame proofing agent.
19. A container of claim 1 or 7, which is for aircraft.
20. A container of claim 1, wherein the fiber content of said CFRP is  $25 \leq V_f \leq 65$ .
21. A container of claim 1, wherein the fiber content of said CFRP is  $30 \leq V_f \leq 65$ .
22. A container of claim 1, wherein the thicker portions are made by additionally laminating prepregs or reinforcing fibers.
23. A container of claim 1, wherein the CFRP panel is a single panel.