ELECTRICAL HOUSINGS FOR AIRCRAFT

Abstract Of The Invention

One aspect of the present invention provides a housing 100 for housing electrical equipment in an aircraft. The housing 100 comprises one or more panels 110 defining an enclosed space 150 for housing electrical equipment in an aircraft. The housing 100 also comprises at least one electrical busbar 130 for providing electric power to the electrical equipment. The at least one electrical busbar 130 is configured to provide structural support for the housing 100. By providing a housing 100 in which the busbar 130 itself provides structural support for the housing 100, various aspects and embodiments of the present invention enable a reduced weight electrical housing 100 to be provided in an aircraft. Such housings 100 may also be easier and quicker to manufacture than conventional housings since they can require less need for the use of bolts, rivets, etc. during their manufacturing and assembly process.

Figure 2

WE CLAIM :

1. A housing for housing electrical equipment in an aircraft, the housing comprising one or more panels defining an enclosed space for housing electrical equipment in an aircraft, the housing further comprising at least one electrical busbar for providing electric power to the electrical equipment, said at least one electrical busbar being further configured to provide structural support for the housing.

2. The housing of claim 1, wherein said one or more panels are made of composite material.

3. The housing of any preceding claim, wherein at least one electrical busbar comprises one or more of: copper and aluminium.

4. The housing of any preceding claim, wherein the busbar is a high power busbar.

5. The housing of any preceding claim, wherein the busbar is a three-phase busbar.

6. The housing of claim 5, wherein the three-phase busbar comprises three plate-shaped bars separated by insulating material.

7. The housing of any preceding claim, said enclosed space having a height dimension from about 50 cm to about 150 cm, a width dimension from about 40 cm to about 150 cm and a depth dimension from about 10 cm to about 50 cm.

8. The housing of any preceding claim, wherein at least one of said panels incorporates one or more conductive elements so as to provide electromagnetic (EMC) screening within said enclosed space.

9. The housing of any preceding claim, wherein at least one of said panels provides a monocoque or semi-monocoque structure.

10. The housing of any preceding claim, wherein at least one busbar is embedded wholly or partially in at least one of the panels.

11. A housing for housing electrical equipment in an aircraft substantially as hereinbefore described in connection with the accompanying drawings.

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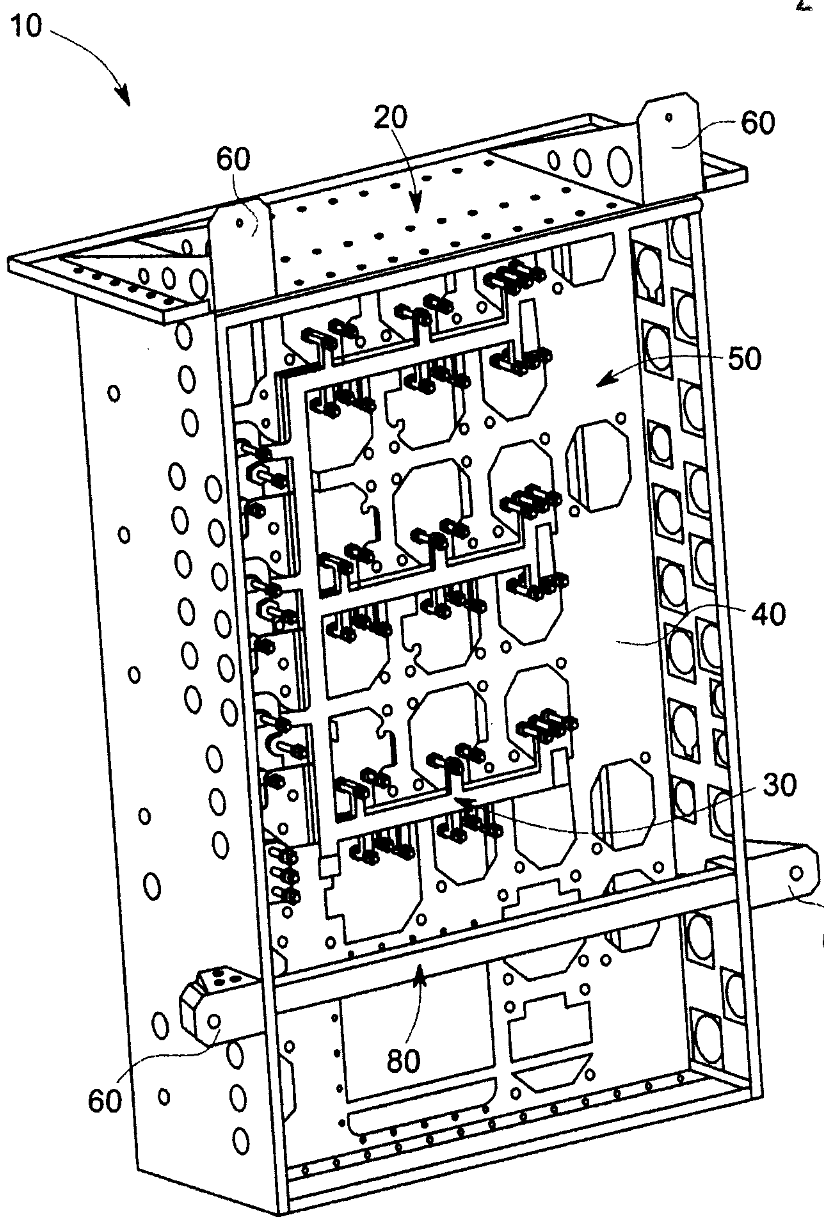

FIG. 1

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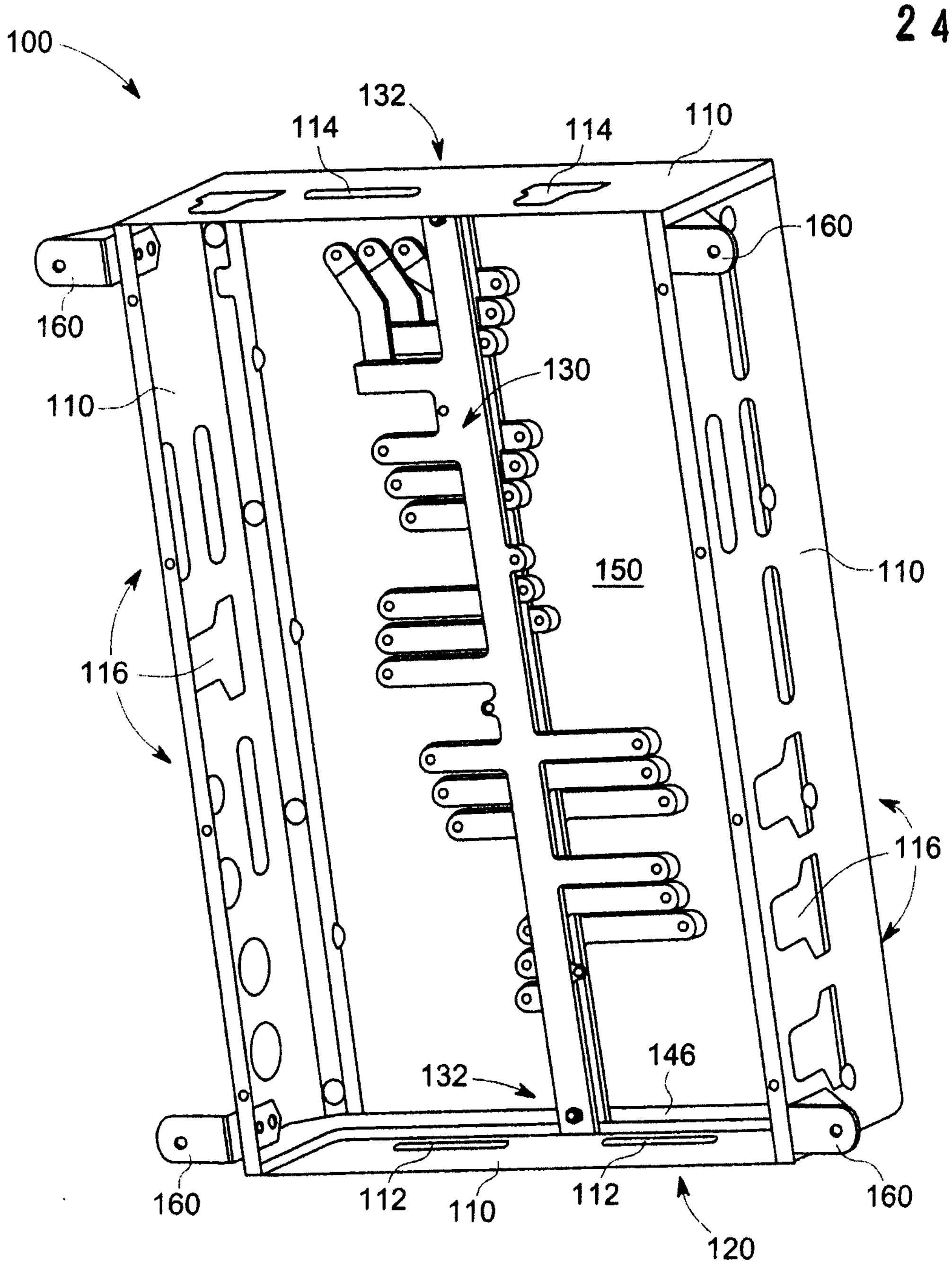

FIG. 2

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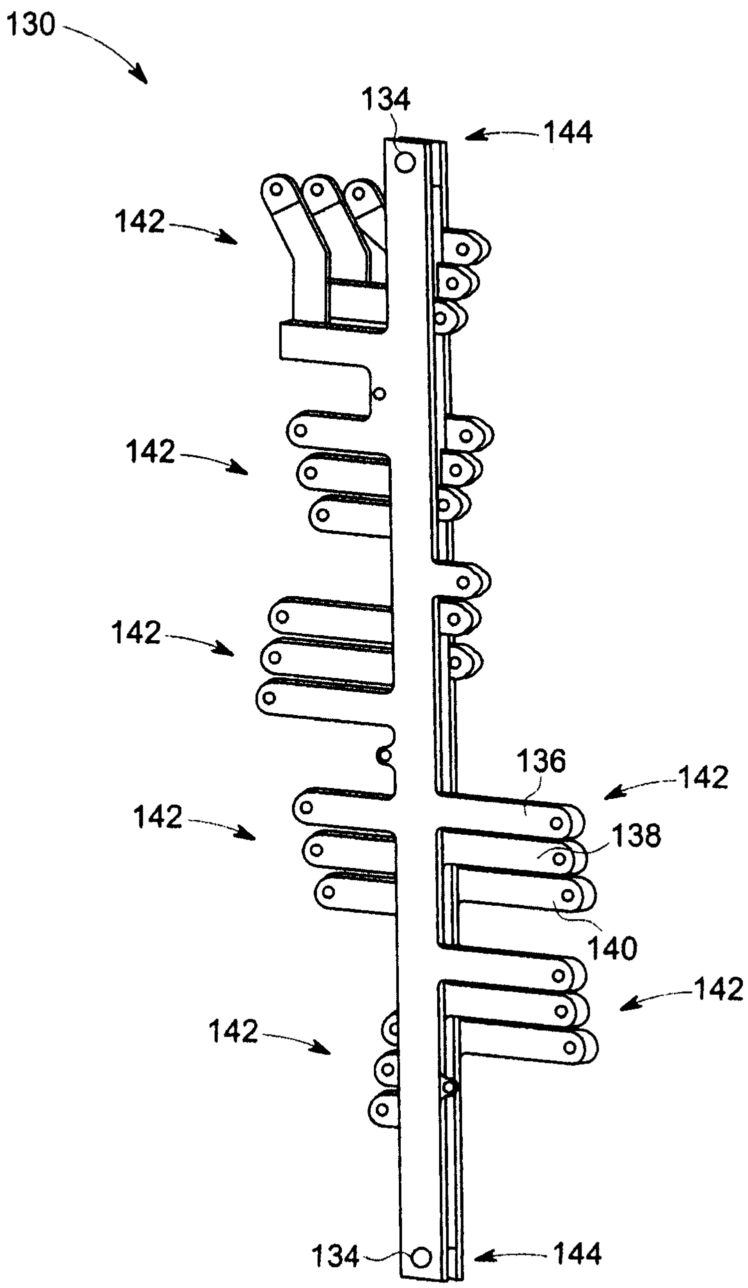

FIG. 3

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Field

The present invention relates generally to electrical housings for aircraft. More particularly, the present invention relates to a housing for housing electrical equipment in an aircraft in which an electrical busbar is used to provide power to the electrical equipment.

Background

Electrical housings for protecting power distribution systems from environmental contamination and for protecting persons from electrocution are known generally [1, 2, 3]. Some such systems may use composite materials, e.g. made from fibre-composite material and reinforcing glass fibres, to provide insulating parts [4]. Moreover, it is also known to use composite materials to provide whole housings for various power distribution equipment [5].

However whilst numerous housings for housing domestic electrical equipment are known, the provision of housings for use in aircraft imposes strict technical requirements for such housings, particularly when they are used to house primary power distribution equipment (for example, of the type that provides a three-phase 415 volt supply). Such technical requirements may be imposed by various aviation authorities and/or be desirable from a manufacturing point-of-view [6, 7].

For example, conventional housings that meet various aviation authority insulation, screening, vibration, impact, fire-safety, cooling regulatory requirements, etc. may be heavy because of extra structural support that is needed to produce such a housing.

Clearly, a reduction of weight for a housing for housing electrical equipment in an aircraft would thus be desirable.

Summary

The present invention has therefore been devised whilst bearing the above-mentioned drawbacks associated with housings for electrical equipment when used for aircraft in mind.

According to an aspect of the present invention, there is thus provided a housing for housing electrical equipment in an aircraft. The housing comprises one or more panels defining an enclosed space for housing electrical equipment. The housing also comprises at least one electrical busbar for providing electric power to the electrical equipment. At least one electrical busbar is configured to provide structural support for the housing.

By providing a housing in which the busbar itself provides structural support for the housing, various aspects and embodiments of the present invention enable a reduced weight electrical housing to be provided in an aircraft. Moreover, such housings can also be more easily and quickly manufactured than conventional housings as they may require less need for the use of bolts, rivets, etc. during the manufacturing and assembly process.

Brief description of the drawings

Various aspects and embodiments of the present invention will now be described in connection with the accompanying drawings, in which:

Figure 1 shows a rear-view of a conventional aircraft electrical housing;

Figure 2 shows a rear-view of a housing for housing electrical equipment in an aircraft according to an embodiment of the present invention; and

Figure 3 shows a three-phase busbar for use in the housing of Figure 2.

Detailed description

Figure 1 shows a rear-view of a conventional aircraft electrical housing 10. The electrical housing 10 comprises an aluminium enclosure 20 defining an enclosed space 50. An aluminium backing plate 40 is affixed to the enclosure 20 and supports copper, substantially E-shaped, busbars 30. The busbars 30 are electrically connected to an external power supply unit (not shown) and are used to provide electrical power to electrical components (not shown) that are housed within the enclosed space 50.

The electrical components may also be mounted to the backing plate 40, which additionally provides mechanical support for the aircraft electrical housing 10. Further mechanical support for the aircraft electrical housing 10 is provided by a transversely-orientated reinforcing bar 80. The aircraft electrical housing 10 additionally comprises four mounting brackets 60 for fixing the assembled aircraft electrical housing 10 to an aircraft fuselage (not shown).

Figure 2 shows a rear-view of a housing 100 for housing electrical equipment in an aircraft according to an embodiment of the present invention. The housing 100 includes four panels 110, provided as respective opposing parallel pairs of panels 110, that together define an enclosed space 150 having a substantially rectangular cross-sectional shape. An additional front panel (not shown) may also be provided so as to prevent access to the enclosed space 150 once the housing 100 is installed in an aircraft.

Various electrical equipment, such as, for example, high-power electro-mechanical switches (not shown) may be housed within the enclosed space 150. Such electrical equipment may, for example, be mounted onto an optionally provided backing plate (not shown).

An aluminium busbar 130 is also provided within the enclosed space 150. The busbar 130 is a three-phase busbar (see Figure 3, below, for example) connected between a pair of opposing panels 110 at respective panel-busbar interfaces 132. Such a configuration provides enhanced mechanical strength and rigidity to the housing 100 without the need to provide additional structural support components. This enables a relatively light-weight housing 100 to be provided, particularly when used with an aluminium (or other light-weight conducting material) busbar 130 and one or more panels 110 made using composite materials. For example, one or more panels 110 may be constructed using carbon fibre, glass fibre, resins, etc. Such composite materials may also be provided with one or more conductive elements (e.g. wire grids, metallic particles, etc.) so as to provide electromagnetic (EMC) screening within the enclosed space 150.

In various embodiments, the housing 100 is used for distributing primary power in an aircraft. The panels 110 can be designed so as to provide a naturally convection-cooled, light weight, compact design that physically and electrically protects component parts from mechanical loading and electrostatic discharge in order to meet a set of environmental conditions, such as, for example, those designated within DO160E [6]. For example, respective of the panels may include various lower vents 112, upper vents 114 and/or side vents 116 to provide a predetermined airflow pattern effective to provide cooling within the housing 100. Wiring and external connections can also be provided through certain of the vents 112, 114, 116. Various or all of such vents 112, 114, 116 may additionally be screened to help prevent the ingress of foreign objects into the housing 100.

In one embodiment constructed and tested by the Applicant, the potential for the use of composite panels for primary power distribution was investigated. The volume packaging requirements for use in aircraft were found to lend themselves to the use of pre-impregnated materials (prepregs) and a manual lay-up process. The use of carbon composite materials in the panel design achieved a lightweight "monocoque" structure which was investigated to test the feasibility of replacing conversional fabricated, machined and riveted together aluminium components.

The panels 110 were assembled using pre-impregnated carbon fibre composite materials from the MTM® range supplied by the Advanced Composite Group Limited [8]. A fibre reinforced composite material is a structural system comprising a matrix of one type of material, reinforced with a fibrous form of another material, in this instance the two constituents being epoxy resin and carbon fibre.

The MTM® 46 composite material selected had a mid-range performance level and was cured at a relatively low temperature (80°C), without the requirement to use an autoclave. The MTM® 46 material was developed specifically for the production of high quality laminates using a low-pressure process. However whilst this specific embodiment used this particular material, in general the prepreg composition can be optimised for tailored mechanical and thermal performance, with high fibre content being achievable within the matrix if desired.

To produce the composite panels 110, prepreg material was laid up by hand into a female mould surface, vacuum bagged and then heated to 120°C. This allowed the resin to initially reflow and eventually to cure. The resin was near-solid at ambient temperatures, and the prepreg had a light sticky/tacky feel to it, which aided in the lay-up of the layers into the mould.

The lay-up consisted of seven layers of prepreg, with each layer being orientated at 45° with respect to the adjacent layer. For high-strength applications, fibre orientation may be designed to provide high strength aligned to the load conditions. The density of the panels 110, with a typical fibre volume of 50%, was around 1.51 grams/cubic centimetre (with the fibre density being 1.77 grams/cubic centimetre and the resin density 1.25 grams/cubic centimetre).

The panels 110 were used to provide a housing 100 with an enclosed space 150 having a height dimension (substantially equivalent to the longest dimension of the busbar 130) of 30 inches (about 75 cm), a width dimension of 20 inches (about 50 cm), and a depth dimension (defined along an axis perpendicular to the plane containing the busbar 130) of 10 inches (about 25 cm).

Figure 3 shows a three-phase busbar 130 for use in the housing 100 shown in Figure 2. The busbar 130 actually made is a high power busbar designed to be used to distribute primary high-tension (HT) power in an aircraft.

The busbar 130 is formed using a first conductor 136, a second conductor 138 and a third conductor 140 provided in a stacked arrangement. Respective conductors 136, 138, 140 are provided to distribute respective power phases of a three-phase delta power supply (not shown). The busbar 130 additionally provides mechanical reinforcement when installed in the housing 100.

The first conductor 136, second conductor 138 and third conductor 140 are made by powder coating respective aluminium cut-outs and firing them to form insulating coatings thereon. The powder coated conductors 136, 138, 140 are then interspersed with adhesively attached shaped thermosetting fibre-glass DELMAR sheets (not shown) and sandwiched together (see [9], for example). Retaining bolts (not shown) may optionally or alternatively be used to secure the busbar 130 such that the conductors 136, 138, 140 remain spatially fixed with respect to each other. By powder coating the conductors 136, 138, 140 and separating them using mica, fibre-glass or other electrically-insulating sheeting, for example, a double-insulated busbar arrangement is provided.

The first conductor 136 and third conductor 140 are provided with mounting through-holes 134 at each end thereof. The second conductor 138 is dimensioned such that no part of it lies between the through-holes 134 of the first conductor 136 and third conductor 140 when they are aligned in the final assembled busbar 130. This arrangement thus provides a respective recess 144 at each end of the busbar 130 into which can be slotted a respective lip 146 formed on respective opposing panels 110. Such lips 146 can themselves be provided with though-holes that align with the respective through-holes 134 of the first conductor 136 and third conductor 140 to form a channel through which respective bolts (not shown) may be passed. The channels may be provided with respective insulating grommets (not shown) therein, and the bolts can be fixed in place using respective nuts (not shown) to provide the panel-busbar interfaces 132 for the housing 100. In this configuration the ends of the second conductor 138, nearest to the through-holes 134, preferably abut respective lips 146 so as to provide additional mechanical support.

Various transverse arms 142 are also provided on each respective conductor 136, 138, 140. These are preferably vertically staggered between each conductor 136, 138, 140, such that various electrical components may be connected to the various electrical phases without the need for complex wiring and whilst maintaining maximal physical separation between the wiring needed for each electrical phase. This thus helps minimise the chance that any wiring failures lead to a short circuit between the electrical power phases.

Busbars 130 may be made using a variety of conducting materials, such as copper for example. However, in a preferred embodiment aluminium is used because although a greater volume of material is required (compared to copper, for example) the Applicant has found that an overall weight reduction is obtained when providing the same power rating. Nevertheless, copper as a conductor may still be preferred for use in smaller housings where space requirements are an overriding factor.

Comparison of Applicant's embodiment with conventional housing

A housing using composite materials [8, 9] and an aluminium busbar was manufactured, as described above. This was compared to a conventional housing having the same dimensions and using a copper busbar, see Figure 1 for example. Both designs met the requirements of DO160E, DO254 and ANSI C37.20 [6, 7].

The conventional housing weighed 11kg compared to the embodiment which only weighed 3.6kg. Since, typically, three such housings may be used in any one aircraft, using embodiments of the present invention can potentially save 22.2kg or more per aircraft. Clearly this is advantageous from both fuel efficiency and emissions reduction points-of-view, particularly when considered over a long aircraft operating lifetime.

Additionally, various embodiments of the present invention have a simplified construction when compared to conventional electrical housings for aircraft. Furthermore, manufacture of the housings can be speeded up as the need to drill various components, provide rivets, bolt parts together, etc. is reduced. The simplified construction of certain housing embodiments of the present invention is thus faster to produce as well as being lighter than conventional housings.

Those skilled in the art will also realise that numerous embodiments of the present invention may be provided. For example, panels could be provided as a single integrated structure rather than as a plurality of individual panels connected together. In certain embodiments, the housing may provide a monocoque or semi-monocoque structure. Various busbar-housing mechanical reinforcing arrangements may be provided.

The busbar may also be formed using a plurality of electrically separated electrically conductive elements or could include one single-phase conductive element. Such busbars may, if desired, be embedded wholly or partially in at least one of the panels in order to provide additional mechanical support for the housing. Additionally, whilst embodiments of a busbar have been described with reference to a three-phase busbar comprising three stacked plate-shaped generally flat/planar bars generally extending in a plane, and separated by insulating material, various alternative arrangements are possible. For example, single phase busbars having a variety of shapes may be used (e.g. rod-shaped, planar, etc). Such busbars may be selected or designed according to the power requirements for the housing, which may be high. High voltage, high tension and/or high current busbars may be provided, e.g. delivering AC and/or DC power at $\geq$ 100 volts, > 30 amps, > 3kW, > 5kW, > 10kW, etc. For example, various three-phase star or delta configurations, three-phase AC 415 volts / 400 Amps per phase, three-phase 270 volts, single phase 270 or 450 volts AC, 270 volts DC, etc. supplies may be used.

Additionally, although embodiments of the invention have been described in relation to composite materials, those skilled in the art would realise that traditional manufacturing methods for production of, for example, standard primary power distribution enclosures consisting of a sheet metal aluminium enclosure reinforced with machined brackets may also be used. Such enclosures may be provided to exploit the advantages inherent in the manufacturing material properties such as, for example, mechanical strength, thermal conduction properties, EMC protection, etc. Moreover various materials having reduced alloy density (e.g. sintered materials) and/or novel structural concepts could also be used to provide embodiments in accordance with the present invention.

References:

1. US 2,766,405 (Edmunds)

2. US 3,761,780 (Plummer)

3. US 5,811,734 (Ponsioen)

4. US 2008/0100993 (Muller)

5. US 2007/0053142 (Allen)

6. DO160E standard requirements relating to panel vibration and thermal aspects and DO254 standard relating to design assurance guidance for airborne electronic hardware both available from http://www.rtca.org/downloads/DEC%202004%20-%2005-01-06.htm

7. ANSI C37.20 standard relating to busbar thermal aspects available from http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI/IEEE%20C37.20.1-2002

8. Advanced Composites Group Limited, Composites House, Sinclair Close, Heanor, Derbyshire DE75 7SP, United Kingdom, http://www.advanced-composites.co.uk

9. Grade UTR laminate available from Röchling Glastic® Composites, 4321 Glenridge Road, Cleveland, Ohio, OH 44121, USA, www.glastic.com

Where permitted, the content of the above-mentioned references are hereby also incorporated into this application by reference in their entirety.