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(54) **ANTI-VIBRATION MOUNT**

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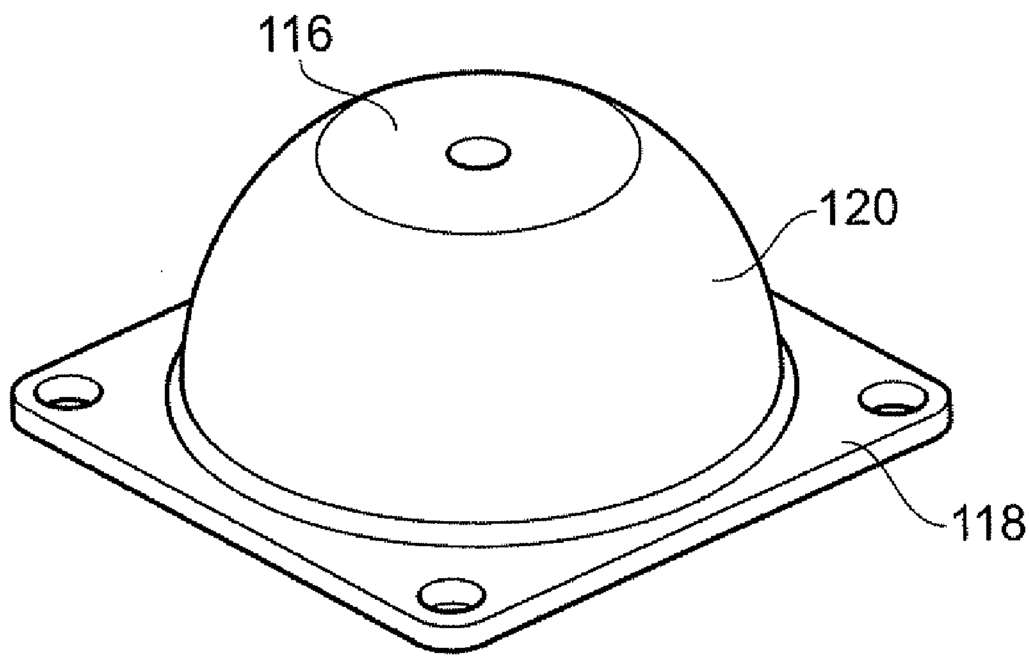
(57) **ABSTRACT**

An anti-vibration mount is provided for mounting a first component to a second component. The mount has an elastomeric body which provides a recess into which the first component is received. The mount further has pair of brackets which fit to opposing sides of the elastomeric body sandwiching the first component received in the recess therebetween. At least one of the brackets is arranged to connect the anti-vibration mount and second component together. The mount further has a clamping arrangement which applies clamping pressure across the brackets and thereby compresses the elastomeric body to secure the first component in the recess.



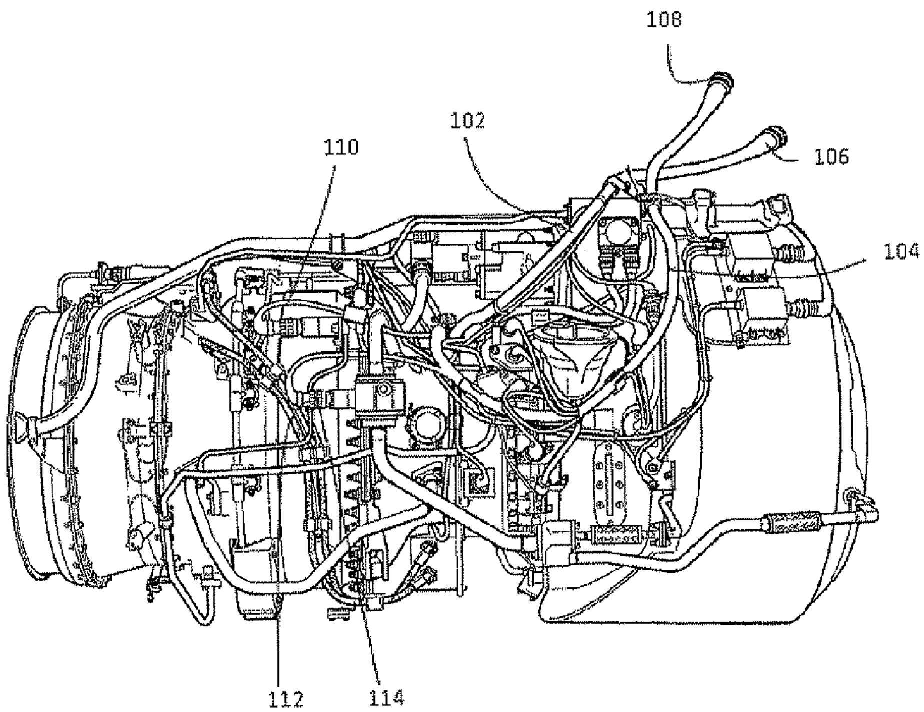


Fig. 1

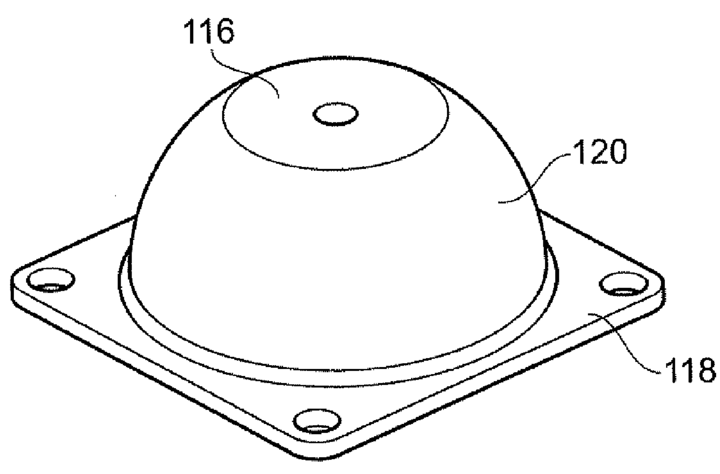


Fig. 2

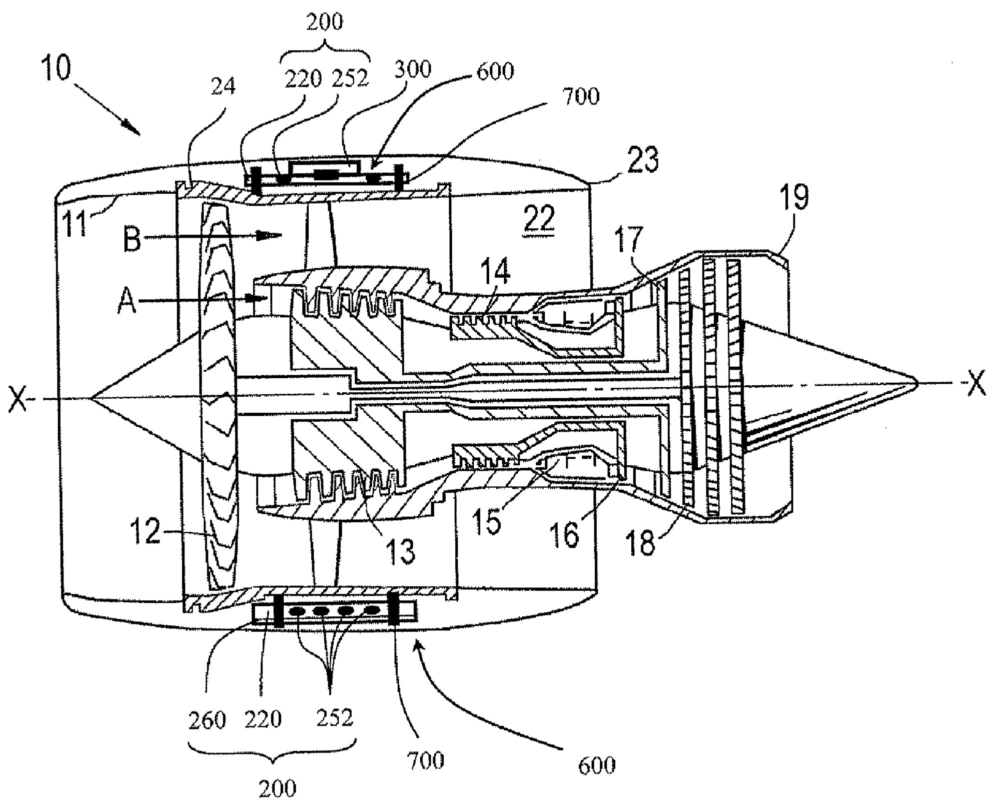

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Fig. 3

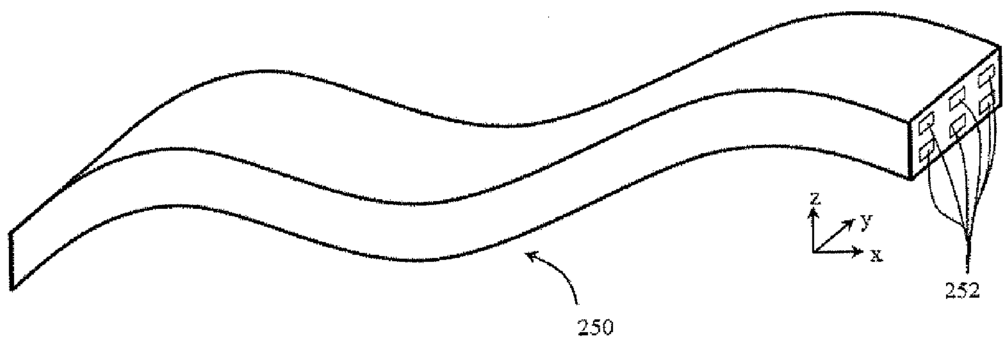

Fig. 4

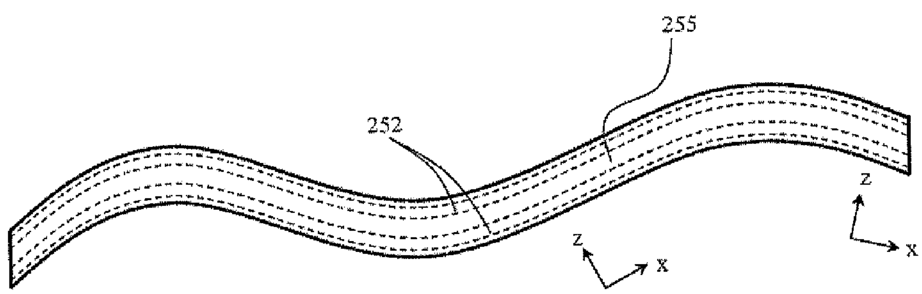

Fig. 5

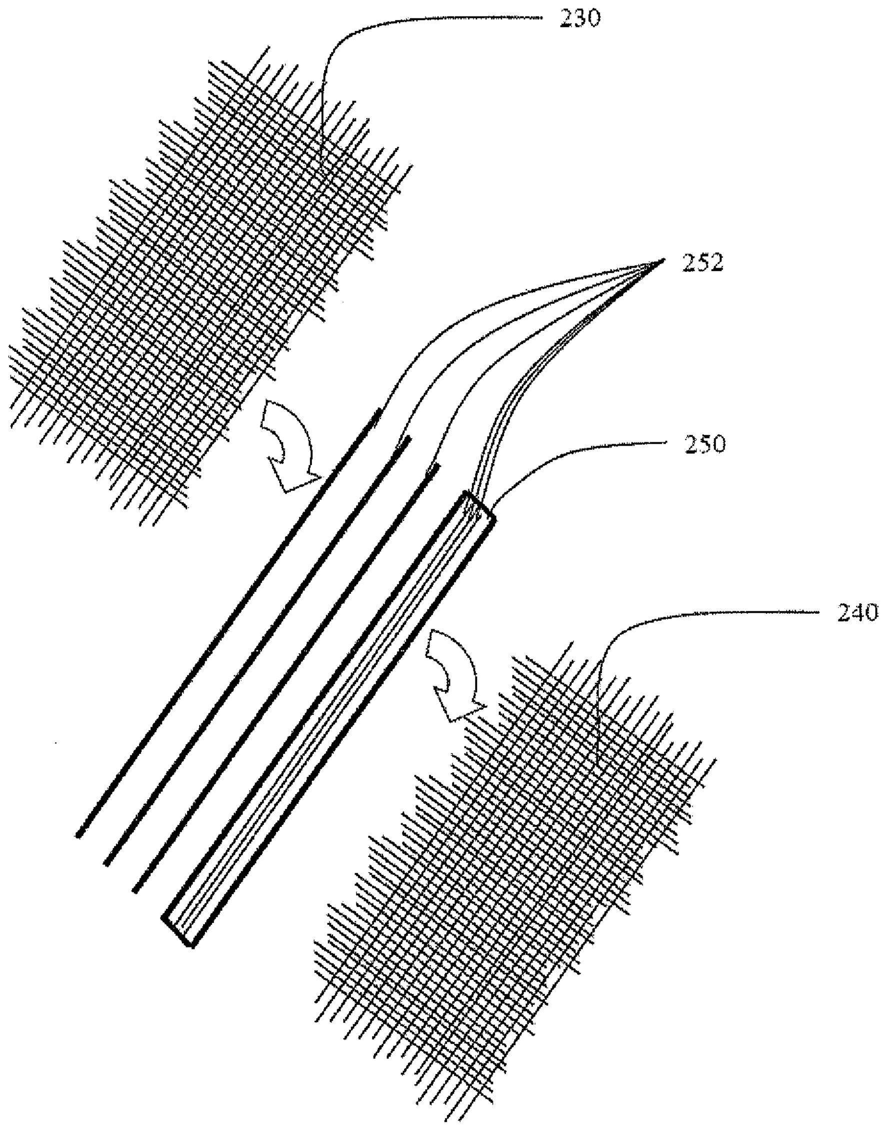

Fig. 6

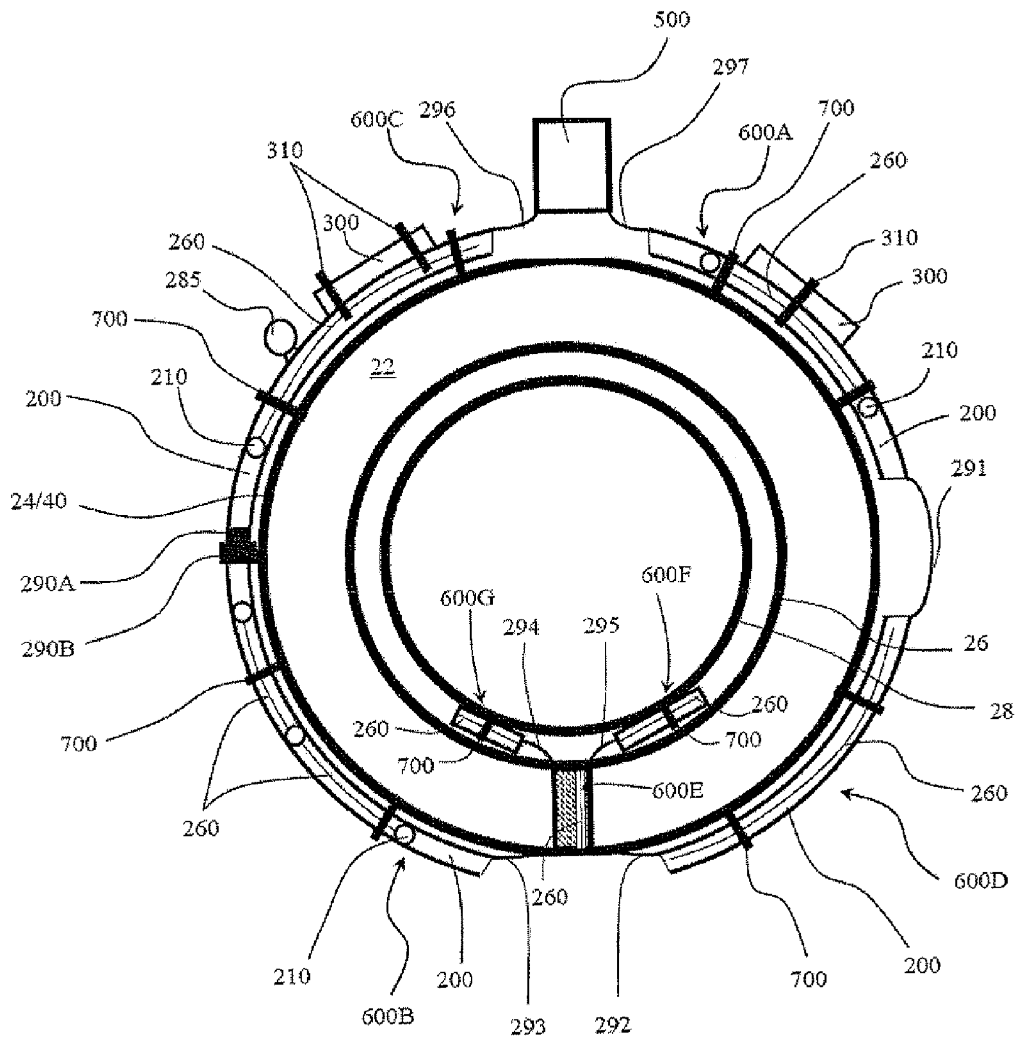
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Fig. 7

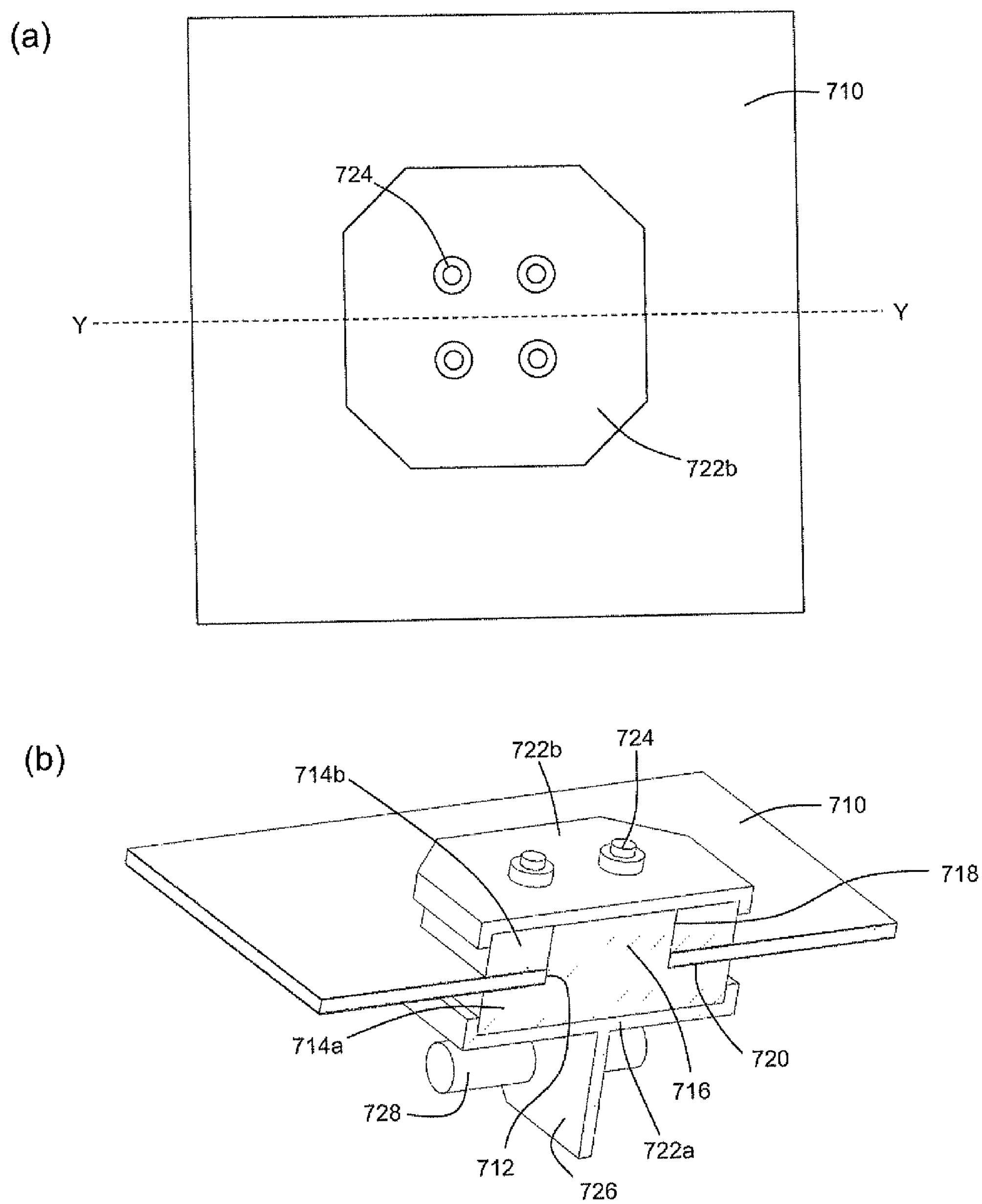
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Fig. 8

ANTI-VIBRATION MOUNT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from British Patent Application Number 1122140.5 filed 22 Dec. 2011, British Patent Application Number 1122143.9 filed 22 Dec. 2011, British Patent Application Number 1203991.3 filed 7 Mar. 2012 and British Patent Application Number 1217566.7 filed 7 Oct. 2012, the entire contents of which are incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an anti-vibration mount.

[0004] 2. Background of the Invention

[0005] A typical gas turbine engine has a substantial number of electrical components which serve, for example, to sense operating parameters of the engine and/or to control actuators which operate devices in the engine. Such devices may, for example, control fuel flow, variable vanes and air bleed valves. The actuators may themselves be electrically powered, although some may be pneumatically or hydraulically powered, but controlled by electrical signals.

[0006] Electrical power, and signals to and from the individual electrical components, is commonly transmitted along conductors. Conventionally, such conductors may be in the form of wires and/or cables which are assembled together in a harness. In such a conventional harness, each wire may be surrounded by an insulating sleeve, which may be braided or have a braided cover.

[0007] By way of example, FIG. **1** of the accompanying drawings shows a typical gas turbine engine including two conventional wiring harnesses **102**, **104**, each provided with a respective connector component **106**, **108** for connection to circuitry, which may be for example accommodated within the airframe of an aircraft in which the engine is installed.

[0008] The harnesses **102**, **104** are assembled from individual wires and cables which are held together over at least part of their lengths by suitable sleeving and/or braiding. Individual wires and cables, for example those indicated at **110**, emerge from the sleeving or braiding to terminate at plug or socket connector components **112** for cooperation with complementary socket or plug connector components **114** on, or connected to, the respective electrical components.

[0009] Each conventional harness **102**, **104** comprises a multitude of insulated wires and cables. This makes the conventional harness itself bulky, heavy and difficult to manipulate. The conventional harnesses occupy significant space within a gas turbine engine (for example within the nacelle of a gas turbine engine), and thus may compromise the design of the aircraft, for example the size and/or weight and/or shape of the nacelle.

[0010] Conventional harnesses comprise a large number of components, including various individual wires and/or bundles of wires, supporting components (such as brackets or cables) and electrical and/or mechanical connectors. This can make the assembly process complicated (and thus susceptible to errors) and/or time consuming. Disassembly of the conventional harnesses (for example removal of the conventional harnesses from a gas turbine engine during maintenance) may also be complicated and/or time consuming. Thus, in many maintenance (or repair or overhaul) procedures on a gas turbine engine, removal and subsequent refitting of the conventional electrical harness may account for a very significant portion of the operation time and/or account for a significant proportion of the potential assembly errors.

[0011] The electrical conductors in the conventional harnesses may be susceptible to mechanical damage. For example, mechanical damage may occur during installation (for example through accidental piercing of the protective sleeves/braiding) and/or during service (for example due to vibration). In order to reduce the likelihood of damage to the conductors in a conventional harness, the protective sleeves/braiding may need to be further reinforced, adding still further weight and reducing the ease with which they can be manipulated. Similarly, the exposed electrical connectors used to connect one conductor to another conductor or conductors to electrical units may be susceptible to damage and/or may add significant weight to the engine.

[0012] More generally, to reduce or avoid mechanical damage due to vibration, it is common to mount components to the engine using anti-vibration mounts. FIG. **2** shows schematically such a mount, which may be used, for example, to mount an engine control unit (ECU) such as an electronic engine control (EEC) or an engine health monitoring unit (EMU) to an engine. The mount has a first metal plate **116** and a second metal plate **118**. Spacing the two plates is a bowl-shaped elastomeric body **120**. The first metal plate is connected to the ECU via a bolt that passes through the centre of the first plate and through a fixing hole formed in the ECU casing, and the second metal plate is connected to the engine via further bolts at corners of the second plate. The elastomeric body allows relative movement of the plates and hence attenuates vibration between the engine and the ECU. An internal tube (not shown) may be present to prevent forces transmitted between the first and second plates from crushing the elastomeric body.

[0013] To produce the mount, the metal plates **116**, **118** and tube (if fitted) are chemically bonded to the elastomeric body **120** to prevent the mount from falling apart before and during assembly. In some mounts, the chemical bond is required to prevent the elastomeric body from shifting in normal operation.

OBJECTS AND SUMMARY OF THE INVENTION

[0014] It would be desirable to provide a mount which is simpler to produce, and which can avoid possible sources of manufacturing error.

[0015] Accordingly, in a first aspect, the present invention provides an anti-vibration mount for mounting a first component to a second component, the mount having:

[0016] an elastomeric body which provides a recess into which the first component is received;

[0017] a pair of brackets which fit to opposing sides of the elastomeric body sandwiching the first component received in the recess therebetween, at least one of the brackets being arranged to connect the anti-vibration mount and second component together (for example, at least one of the brackets may be joinable to the second component); and

[0018] a clamping arrangement which applies clamping pressure across the brackets and thereby compresses the elastomeric body to secure the first component in the recess.

[0019] By providing a recess in the elastomeric body into which the first component is received and secured, chemical bonding of the brackets to the elastomeric body may be avoided, which can simplify production and avoid sources of manufacturing error. The mount can reduce (or substantially eliminate) the amount (for example the amplitude and/or the number/range of frequencies) of vibration being passed from the second component to the first component.

[0020] The mount may have any one or, to the extent that they are compatible, any combination of the following optional features.

[0021] The elastomeric body can be in two parts which are separable from each other when the clamping pressure is removed, the first part providing one of the opposing sides of the elastomeric body and one side of the recess and the second part providing the other opposing side of the elastomeric body and an opposing side of the recess. By using a two part body instead of a one piece body, mounting of the first component can be considerably simplified as the two parts can be brought together from opposite sides of the first component to form the recess in which the first component is received.

[0022] The first component may have a through-hole which locates in the recess. The first part of the elastomeric body may have a projection which extends through the through-hole and is received in a matching cavity formed in the second part. Such an arrangement allows the two parts of the elastomeric body to be engaged loosely together, with the first component in the recess, before the brackets are fitted, which facilitates the assembly of the complete mount. Preferably, therefore, the projection is a frictional fit in the cavity.

[0023] The first component may be planar. The recess may then be a slot.

[0024] The clamping arrangement which applies clamping pressure across the brackets may be one or more bolts, studs, rivets or other suitable fasteners. Conveniently, when the first component has a through-hole which locates in the recess, the fastener(s) can extend through the through-hole.

[0025] The bracket which is joinable to the second component can have any suitable formation for perfecting such a joint. For example, the bracket may have a joining flange or plate containing one or more holes through which bolts, studs, rivets or other suitable fasteners can be passed.

[0026] Protective interlayers may be provided in the recess at the interfaces between the first component and the elastomeric body. For example, particularly when the first component is formed from carbon fibre reinforced plastic (CFRP), to avoid rubbing damage between the elastomeric body (which is typically formed of rubber) and the CFRP, glass fibre reinforced plastic (GFRP) interlayers may be located at these interfaces, GFRP being less susceptible to rubbing damage than CFRP.

[0027] The first and the second components may be gas turbine engine components. Vibration isolation can be particularly beneficial for components attached to gas turbine engines.

[0028] The first component may be an engine control unit such as an electronic engine control or an engine health monitoring unit.

[0029] In another example, the first component may be a rigid raft assembly, such as an electrical raft or electrical raft assembly in which electrical conductors are embedded in a rigid material. Use of the anti-vibration mount may help to prolong the life of the rigid raft assembly. The electrical raft (or electrical raft assembly) may be at least a part of an electrical harness for an engine, for example a gas turbine engine, and thus may be referred to herein as an electrical harness raft (or electrical harness raft assembly). The environment of a gas turbine engine during operation may be particularly severe, with high levels of vibration. Using the anti-vibration mount to attach an electrical raft/assembly to a gas turbine engine may help to prolong the life of the electrical raft. Furthermore, any other components that may be attached to the electrical raft (as discussed below and elsewhere herein) may also benefit from being mounted to the gas turbine engine via the anti-vibration mounts, through being mounted on the electrical raft. For example, the reduced vibration may help to preserve the electrical contact between the electrical raft and any electrical unit connected thereto. As such, any components (such as an electrical unit mounted to the electrical raft) that would conventionally be mounted directly to the gas turbine engine and require at least a degree of vibration isolation may no longer require their own dedicated anti-vibration mount. Thus, the total number of anti-vibration mounts that are required to assemble an engine may be reduced. This may reduce the number of parts required and/or the time taken to assemble an engine or engine installation and/or reduce the total assembled weight and/or reduce the likelihood of errors occurring during assembly.

[0030] Any other components that may be attached to the rigid raft assembly may also benefit from being mounted to a gas turbine engine via the anti-vibration mount, through being mounted on the rigid raft assembly. This may mean that any components that would conventionally be mounted directly to a gas turbine engine and require at least a degree of vibration isolation may no longer require their own dedicated anti-vibration mount. These components may include, for example, ECUs such as EECs and EMUs. Thus, the total number of anti-vibration mounts that are required to assemble an engine may be reduced. This may reduce the number of parts required and/or the time taken to assemble an engine or engine installation and/or reduce the total assembled weight and/or reduce the likelihood of errors occurring during assembly.

[0031] Furthermore, components that are conventionally mounted to an engine without anti-vibration mounts (for example because of the weight and/or cost penalty), but which are now mounted to a rigid raft assembly, may benefit from vibration isolation without any weight/cost/assembly time penalty. This may reduce the possibility of damage occurring to such components and/or increase their service life. Such components may include, for example, ignitor boxes (used to provide high voltage power to engine ignitors), and pressure sensors/switches, for example for fluid systems such as oil, air, fuel, pneumatics and/or hydraulics.

[0032] More generally, the use of one or more electrical raft assemblies may significantly reduce build time of an engine. For example, use of electrical raft assemblies may significantly reduce the part count involved in engine assembly compared with a conventional harness arrangement. The number and/or complexity of the operations required to assemble an engine (for example to assemble/install the electrical system (or network) and/or other peripheral components, which may be referred to in general as engine dressing) may be reduced. For example, rather than having to install/assemble a great number of wires and/or wiring looms together on the engine installation, it may only be necessary to attach a relatively small number of electrical rafts/electrical raft assemblies, which themselves may be straightforward to handle, position, secure and connect. Thus, use of electrical raft assemblies in a gas turbine installation may reduce assembly time and/or reduce the possibility of errors occurring during assembly.

[0033] Use of electrical raft assemblies may provide significant advantages during maintenance, such as repair and overhaul. As discussed above, the electrical rafts may be particularly quick and straightforward to assemble. The same advantages discussed above in relation to assembly apply to disassembly/removal from the gas turbine engine. Thus, any repair/overhaul that requires removal of at least a part of the electrical harness may be simplified and/or speeded up through use of electrical rafts as at least a part of the electrical harness, for example compared with conventional harnesses. Use of electrical rafts (for example as part of one or more electrical raft assemblies) may allow maintenance procedures to be advantageously adapted. For example, some maintenance procedures may only require access to a certain portion of the gas turbine engine that only requires a part of the harness to be removed. It may be difficult and/or time consuming, or not even possible, to only remove the required part of a conventional harness from a gas turbine engine. However, it may be relatively straightforward to only remove the relevant electrical raft, for example by simply disconnecting it from the engine and any other electrical rafts/components to which it is connected. Decreasing maintenance times has the advantage of, for example, reducing out-of service times (for example off-wing times for engines that are used on aircraft).

[0034] The build/assembly times may be additionally or alternatively reduced by pre-assembling and/or pre-testing individual and/or combinations of electrical rafts and/or electrical raft assemblies prior to engine assembly. This may allow the electrical and/or mechanical operation of the electrical rafts to be proven before installation, thereby reducing/eliminating the testing required during engine installation.

[0035] Accordingly, there is provided (and aspects of the invention may be used with/as a part of) a method of servicing a gas turbine engine, the method comprising: removing a first rigid raft assembly from the gas turbine engine, the rigid raft assembly incorporating at least a part of at least one component or system of the gas turbine engine; and installing a second, pre-prepared, rigid raft assembly onto the gas turbine engine in place of the first raft assembly. The first and second rigid raft assemblies may comprise electrical rafts having electrical conductors embedded in a rigid material. The electrical conductors may be at least a part of an electrical system arranged to transfer electrical signals around the engine, and the first and second rigid raft assemblies may be electrical harness raft assemblies.

[0036] The electrical rafts/electrical raft assemblies may be a particularly lightweight solution for transferring electrical signals around an engine. For example, an electrical raft may be lighter, for example significantly lighter, than a conventional harness required to transmit a given number of electrical signals. A plurality of conductors may be embedded in a single electrical raft, whereas in a conventional arrangement a large number of heavy, bulky wires, usually with insulating sleeves, would be required. The reduced weight may be particularly advantageous, for example, when used on gas turbine engines on aircraft.

[0037] Electrical rafts may be more easily packaged and/or more compact, for example than conventional harnesses. Indeed, as mentioned above, the electrical rafts can be made into a very wide range of shapes as desired. This may be achieved, for example, by manufacturing the electrical rafts using a mould conforming to the desired shape. As such, each electrical raft may be shaped, for example, to turn through a tighter corner (or smaller bend radius) than a conventional harness. The electrical rafts may thus provide a particularly compact solution for transferring electrical signals around a gas turbine engine. The electrical rafts may be readily shaped to conform to neighbouring components/regions of a gas turbine engine, for example components/regions to which the particular electrical raft assembly is attached, such as a fan casing or a core casing.

[0038] The electrical raft(s) may provide improved protection to the electrical conductors during manufacture/assembly of the raft/gas turbine installation, and/or during service/operation/maintenance of the gas turbine engine. This may result in lower maintenance costs, for example due to fewer damaged components requiring replacement/repair and/or due to the possibility of extending time intervals (or service intervals) between inspecting the electrical system, for example compared with a system using only conventional harnesses.

[0039] Any suitable material may be used for the rigid material of the raft. For example, the rigid material may be a rigid composite material, for example an organic matrix composite. Such a rigid composite material may be particularly stiff and/or lightweight. Thus, a rigid composite raft may be used that has suitable mechanical properties, whilst being thin and lightweight, for example compared with some other materials. The rigid composite material may comprise any suitable combination of resin and fibre as desired for a particular application. For example, any of the resins and/or fibres described herein may be used to produce a rigid composite material for the electrical raft. Any suitable fibres may be used, for example carbon fibres, glass fibres, aramid fibres, and/or para-aramid fibres. The fibres may be of any type, such as woven and/or chopped. Any suitable resin may be used, for example epoxy, BMI (bismaleimide), PEEK (polyetheretherketone), PTFE (polytetraflouroethylene), PAEK (polyaryletherketone), polyurethane, and/or polyamides (such as nylon).

[0040] In any example of electrical raft or electrical raft assembly, at least one of the electrical conductors embedded in the electrical raft may be an electrically conductive wire. The or each electrically conductive wire may be surrounded by an electrically insulating sleeve.

[0041] At least some (for example a plurality) of the electrical conductors may be provided in a flexible printed circuit (FPC). Thus, at least some of the electrical conductors may be provided as electrically conductive tracks in a flexible substrate. The flexible printed circuit may be flexible before being embedded in the rigid material.

[0042] Providing the electrical conductors as tracks in a flexible printed circuit may allow the size of the resulting electrical raft to be reduced further and/or substantially minimized. For example, many different electrical conductors may be laid into a flexible printed circuit in close proximity, thereby providing a compact structure. The flexible substrate of a single flexible printed circuit may provide electrical and/or mechanical protection/isolation to a large number of electrical conductors.

[0043] Any given electrical raft may be provided with one or more electrical wires embedded therein (which may be sheathed) and/or one or more flexible printed circuits embedded therein. As such, a given electrical raft may have wires and flexible printed circuits laid therein.

[0044] It will be appreciated that the embedded electrical conductors (whether they are provided as embedded electrical wires or as conductive tracks in a flexible printed circuit embedded in the rigid material) may be described as being fixed in position by the rigid material, for example relative to the rest of the electrical harness raft. It will also be appreciated that the embedded electrical conductors may be said to be surrounded by the rigid material and/or buried in the rigid material and/or integral with (or integrated into) the rigid material.

[0045] An electrical raft (or electrical raft assembly) may comprise a fluid passage. Such a fluid passage may be embedded therein and/or otherwise provided thereto. The fluid passage may be part of a fluid system, such as a gas (for example pneumatic or cooling gas/air) and/or liquid (for example a fuel, hydraulic and/or lubricant liquid).

[0046] Accordingly, there is provided (and aspects of the invention may be used with/as a part of) a rigid raft assembly for a gas turbine engine, the rigid raft assembly comprising a rigid material that carries at least a part of a first gas turbine engine system and at least a part of a second gas turbine engine system, wherein: the first gas turbine engine system is a fluid system that comprises at least one fluid passage that is at least partially embedded in the rigid raft assembly. The second gas turbine engine system may be an electrical system that comprises electrical conductors at least partially embedded in the rigid material.

[0047] The electrical raft may comprise one or more electrical connectors or sockets, which may be electrically connected to at least one of the embedded electrical conductors. The electrical connector or socket may allow electrical connection of the electrical raft to other electrical components, for example to other electrical rafts (either directly or indirectly, via an electrical cable or lead) or to electrical units (again, either directly or indirectly, via an electrical cable or lead). Such an electrical connector or socket may take any suitable form, and may be at least partially embedded in the rigid electrical raft.

[0048] The electrical raft (or electrical raft assembly) assembly may be a first engine installation component, and the gas turbine engine may further comprise a second engine installation component having electrical conductors. The first and second engine installation components may be part of an electrical system arranged to transfer electrical signals around the engine installation. The gas turbine engine may further comprise at least one flexible cable connected between the electrical raft assembly and the second engine installation component (which itself may be or comprise an electrical raft) so as to electrically connect electrical conductors of the electrical raft assembly with electrical conductors of the second engine installation component.

[0049] The second engine installation component may be, for example, an ECU, such as an EMU or EEC. Additionally or alternatively, the second engine installation component may be a further electrical raft or electrical raft assembly.

[0050] The environment of a gas turbine engine during operation may be particularly severe, with, for example, high levels of vibration and/or differential expansion between components as the temperature changes through operation and as the components move relative to each other. Providing at least one flexible cable to connect an electrical raft assembly to another component may allow the electrical rafts and/or components to accommodate vibration and/or relative movement, for example of the component(s)/assemblies to which they are attached/mounted during use. For example, the flexible cable(s) (where present) used to electrically connect electrical raft assemblies to other component(s) may have sufficient length to accommodate such vibration and/or movement during use.

[0051] For example, providing separate (for example more than one) electrical raft assemblies and connecting at least some (for example at least two) of them together using at least one flexible cable may allow the electrical rafts to accommodate vibration and/or relative movement of the component(s)/assemblies to which they are attached/mounted during use.

[0052] The electrical signals transferred by the conductors in the electrical raft, and around the engine using the electrical rafts/raft assemblies may take any form. For example, the electrical signals may include, by way of non-limitative example, electrical power and/or electrical control/communication signals and/or any other type of transmission through an electrical conductor. Transmission of signals around the engine may mean transmission of signals between (to and/or from) any number of components/systems in the engine and/or components/system of a structure (such as an airframe) to which the gas turbine engine is (or is configured to be) connected/installed in. In other words, an electrical raft may be used to transfer/communicate any possible combination of electrical signals in any part of a gas turbine engine installation or a related (for example electrically and/or mechanically connected) structure/component/system.

[0053] An electrical raft or raft assembly may be provided in any suitable location/position of the gas turbine engine, for example to a mounting structure at any suitable location. For example, the gas turbine engine may comprise a bypass flow duct formed between an engine core and an engine fan casing (the gas turbine engine may be a turbofan engine, for example); and the electrical raft assembly may form at least a part of a radially extending splitter (which may be referred to as a bifurcation) that extends across the bypass flow duct. In this way, an electrical raft (which may be referred to as a splitter electrical raft) may provide an electrical connection between a fan casing and an engine core. By way of further example, the electrical raft assembly may be attached to the engine core case or engine fan case, for example to a mounting structure on such cases.

[0054] An electrical raft may be provided with at least one mount on which other components (for example auxiliary/ancillary components/systems) of the gas turbine engine are (or may be) mounted. The mount may be a bracket, for example a bespoke bracket for the component/system mounted thereon or a conventional/standard bracket. The electrical raft may provide a stable, regular and convenient platform on which to mount the various systems/components. The combination of the installed electrical raft assembly with components/systems mounted thereon may be much more compact and/or straightforward to assemble and/or have a greatly reduced number of component parts, for example compared with the corresponding conventional electrical harness and separately mounted components/systems.

[0055] The mounts may be used to attach any component/system to an electrical raft (and thus to the engine) as required. For example, fluid pipes for transferring fluid around the engine may be mounted to the electrical rafts (for example mechanically mounted using a bracket), and thus to the engine. More than one set of fluid pipes, for example for carrying different or the same fluids, may be mounted on the same electrical raft.

[0056] In a second aspect, the present invention provides a gas turbine engine or gas turbine engine installation (for example for an airframe) having a first component mounted to a second component by an anti-vibration mount according to the first aspect.

[0057] The gas turbine engine or gas turbine engine installation may have any one or, to the extent that they are compatible, any combination of the following optional features.

[0058] The first component may comprise an electrical raft having electrical conductors embedded in a rigid material. The rigid material may be a rigid composite material.

[0059] Such an electrical raft may be part of an electrical raft assembly that has a further engine component mounted thereon, as described elsewhere herein by way of example.

[0060] Such an electrical raft may be part of an electrical system of the gas turbine engine or installation. The electrical system may comprise at least one other component, for example at least one other electrical raft or electrical raft assembly. The electrical system further may further comprise a flexible cable electrically connected between the electrical raft and another component of the electrical system.

[0061] In a third aspect, the present invention provides the use of an anti-vibration mount according to the first aspect for mounting the first component to the second component.

[0062] Further optional features of the invention are set out below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0063] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

[0064] FIG. **1** shows a gas turbine engine with a conventional harness;

[0065] FIG. **2** shows a conventional anti-vibration mount;

[0066] FIG. **3** shows a cross-section through a gas turbine engine having anti-vibration mounts in accordance with the present invention;

[0067] FIG. **4** shows a perspective view of a flexible printed circuit;

[0068] FIG. **5** shows a side view of the flexible printed circuit of FIG. **4**;

[0069] FIG. **6** shows a schematic of an electrical raft prior to assembly;

[0070] FIG. **7** shows a cross-section normal to the axial direction through a gas turbine engine having anti-vibration mounts in accordance with the present invention; and

[0071] FIG. **8** shows (a) a plan view of an anti-vibration mount in accordance with the present invention, and (b) a cross-section along line Y-Y through the mount.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0072] With reference to FIG. **3**, a ducted fan gas turbine engine generally indicated at **10** has a principal and rotational axis X-X. The engine **10** comprises, in axial flow series, an air intake **11**, a propulsive fan **12**, an intermediate pressure compressor **13**, a high-pressure compressor **14**, combustion equipment **15**, a high-pressure turbine **16**, and intermediate pressure turbine **17**, a low-pressure turbine **18** and a core engine exhaust nozzle **19**. The engine also has a bypass duct **22** and a bypass exhaust nozzle **23**.

[0073] The gas turbine engine **10** works in a conventional manner so that air entering the intake **11** is accelerated by the fan **12** to produce two air flows: a first air flow A into the intermediate pressure compressor **13** and a second air flow B which passes through the bypass duct **22** to provide propulsive thrust. The intermediate pressure compressor **13** compresses the air flow A directed into it before delivering that air to the high pressure compressor **14** where further compression takes place.

[0074] The compressed air exhausted from the high-pressure compressor **14** is directed into the combustion equipment **15** where it is mixed with fuel and the mixture combusted. The resultant hot combustion products then expand through, and thereby drive the high, intermediate and low-pressure turbines **16**, **17**, **18** before being exhausted through the nozzle **19** to provide additional propulsive thrust. The high, intermediate and low-pressure turbines **16**, **17**, **18** respectively drive the high and intermediate pressure compressors **14**, **13** and the fan **12** by suitable interconnecting shafts.

[0075] The gas turbine engine **10** shown in FIG. **3** shows two electrical raft assemblies **600** mounted to the engine with anti-vibration mounts (discussed below with reference to FIG. **8**). As such, the gas turbine engine **10** is in accordance with the present invention. Each electrical raft assembly **600** comprises an electrical raft **200**. The electrical rafts **200** may be used to transmit/transfer electrical signals (or electricity, including electrical power and/or electrical control signals) around the engine and/or to/from the engine **10** from other components, such as components of an airframe. The function and/or construction of each electrical raft **200** and electrical raft assembly **600** may be as described above and elsewhere herein.

[0076] In FIG. **3**, each electrical raft **200** (which may be referred to herein simply as a raft **200** or an electrical harness raft **200**) comprises at least one electrical conductor **252** embedded in a rigid material **220**, which may be a rigid composite material.

[0077] The electrical conductors **252** in the electrical raft **200** may be provided in a harness **250**, which may be a flexible printed circuit board (or FPC) **250**.

[0078] An example of an FPC **250** in which the electrical conductors **252** may be provided is shown in greater detail in FIGS. **4** and **5**. FIG. **4** shows a perspective view of the FPC **250**, and FIG. **5** shows a side view.

[0079] Such an FPC **250** may comprise a flexible (for example elastically deformable) substrate **255** with conductive tracks **252** laid/formed therein. The FPC **250** may thus be deformable. The FPC **250** may be described as a thin, elongate member and/or as a sheet-like member. Such a thin, elongate member may have a major surface defined by a length and a width, and a thickness normal to the major surface. In the example shown in FIGS. **4** and **5**, the FPC **250** may extend along a length in the x-direction, a width in the y-direction, and a thickness (or depth or height) in the z-direction. The x-direction may be defined as the axial direction of the FPC. Thus, the x-direction (and thus the z-direction) may change along the length of the FPC **250** as the FPC is deformed. This is illustrated in FIG. **5**. The x-y surface(s) (i.e. the surfaces formed by the x and y directions) may be said to be the major surface(s) of the FPC **250**. In the example shown in FIGS. **4** and **5**, the FPC **250** is deformable at least in the z direction, i.e. in a direction perpendicular to the major surface. FPCs may be additionally of alternatively deformable about any other direction, and/or may be twisted about any one or more of the x, y, or z directions.

[0080] The flexible substrate **255** may be a dielectric. The substrate material may be, by way of example only, polyamide. As will be readily apparent, other suitable substrate material could alternatively be used.

[0081] The conductive tracks **252**, which may be surrounded by the substrate **255**, may be formed using any suitable conductive material, such as, by way of example only, copper, copper alloy, tin-plated copper (or tin-plated copper alloy), silver-plated copper (or silver-plated copper alloy), nickel-plated copper (or nickel-plated copper alloy) although other materials could alternatively be used. The conductive tracks **252** may be used to conduct/transfer electrical signals (including electrical power and electrical control signals) through the rigid raft assembly (or assemblies) **200**, for example around a gas turbine engine **10** and/or to/from components of a gas turbine engine and/or an airframe attached to a gas turbine engine.

[0082] The size (for example the cross-sectional area) and/or the shape of the conductive tracks **252** may depend on the signal(s) to be transmitted through the particular conductive track **252**. Thus, the shape and/or size of the individual conductive tracks **252** may or may not be uniform in a FPC **250**.

[0083] The example shown in FIGS. **4** and **5** has six conductive tracks **252** running through the substrate **255**. However, the number of conductive tracks **252** running through a substrate **255** could be fewer than six, or greater than six, for example tens or hundreds of tracks, as required. As such, many electrical signals and/or power transmission lines may be incorporated into a single FPC **250**.

[0084] A single FPC **250** may comprise one layer of tracks, or more than one layer of tracks, for example, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more than 10 layers of tracks. An FPC may comprise significantly more than 10 layers of tracks, for example at least an order of magnitude more layers of tracks. In this regard, a layer of tracks may be defined as being a series of tracks that extend in the same x-y surface. Thus, the example shown in FIGS. **4** and **5** comprises 2 layers of tracks, with each layer comprising 3 tracks **252**.

[0085] An electrical raft **200** may be manufactured using any suitable method. For example, the rigid material **220** may initially be provided as layers of flexible material, such as (by way of example only) layers of fibre and resin compound. This flexible material may be placed into a mould, for example having a desired shape. Other components (such as fluid pipes **210** and/or the electrical conductors **252**, which may be embedded in a FPC **250**) may also be placed into the mould, for example between layers of the flexible material from which the rigid material **220** is ultimately formed. Parts of the mould may have any suitable form and/or construction, for example that could be readily removed when the electrical raft **200** is formed into the desired shape.

[0086] FIG. **6** shows components of an example of an electrical raft **200** prior to one method of construction. The electrical conductors **252** are provided between two layers of material **230**, **240** that, after construction, form the rigid material **220**. Some of the electrical conductors **252** are provided in an FPC **250**. The material **230**, **240** may be a fibre and resin compound, as described elsewhere herein. Such a fibre and resin compound may, after suitable treatment (for example heat treatment), produce the rigid composite material **220**. In the example of FIG. **6**, the fibre and resin compound is formed of a sheet of interwoven fibres, or strands. The strands in FIG. **6** extend in perpendicular directions, although the strands may extend in any one or more directions as required. The strands/fibres may be pre-impregnated (or "pre-pregged") with the resin.

[0087] Prior to any treatment, both the first and second layers **230**, **240** and the electrical conductors **252** may be flexible, for example supple, pliable or malleable. As such, when the layers **230**, **240** and the electrical conductors **252** are placed together, they may be moulded, or formed, into any desired shape. For example, the layers **230**, **240** and the electrical conductors **252** may be placed into a mould (which may be of any suitable form, such as a glass or an aluminium mould) having the desired shape. The desired shape may be, for example, a shape that corresponds to (for example is offset from) a part of a gas turbine engine, such as, by way of example only, at least a part of a casing, such as an engine fan casing or engine core casing. This may enable the final raft to adopt shapes that are curved in two-dimensions or three-dimensions.

[0088] Any suitable method could be used to produce the electrical raft **200**. For example, the strands/fibres need not be pre-impregnated with the resin. Instead, the fibres/strands could be put into position (for example relative to electrical conductors **252**/FPC **250**) in a dry state, and then the resin could be fed (or pumped) into the mould. Such a process may be referred to as a resin transfer method. In some constructions no fibre may be used at all in the rigid material **220**.

[0089] FIG. **7** is a schematic showing a cross-section perpendicular to the direction X-X of a gas turbine engine comprising electrical raft assemblies **600**A-**600**G. Any one of the electrical raft assmblies **600**A-**600**G may comprise any or all of the features of an electrical raft assembly **600** as described above, for example. Thus, for example, any one of the electrical raft assemblies may comprise an electrical raft **200** (not labelled for raft assemblies **600**E-**600**G for simplicity only) having electrical conductors **252** (not labelled in FIG. **7** for simplicity only) embedded therein. Some or all of the electrical raft assemblies **600**A-**600**G (which may collectively be referred to as electrical raft assemblies **600**) comprise a mounting fixture for attaching the respective assembly **600** to a mounting structure via an anti-vibration mount (discussed below with reference to FIG. **8**) in accordance with the present invention.

[0090] The mounting structure is part of a fan case **24** for electrical raft assemblies **600**A-**600**D, part of a bifurcation splitter that radially crosses a bypass duct **22** for electrical raft assemblies **600**E and part of an engine core case **28** for electrical raft assemblies **600**F and **600**G. However, it will be appreciated that an electrical raft assembly **600** could be mounted in any suitable and/or desired location on a gas turbine engine.

[0091] In FIG. **7**, two electrical raft assemblies **600**A, **600**C are shown as having an electrical unit **300** mounted on the respective electrical raft **200**. However, any (or none) of the electrical raft assemblies **600**A-**600**G may have an electrical unit **300** mounted to the respective electrical raft **200**.

[0092] As mentioned herein, each of the electrical rafts **200** associated with the electrical raft assemblies **600**A-**600**G shown in FIG. **7** comprises one or more electrical conductors **252** embedded therein. However, any one or more of the electrical rafts **200** may be replaced with a raft that does not comprise electrical conductors **252**. Such a raft would not be an electrical raft **200**, but may otherwise be as described elsewhere herein, for example it may be a rigid raft that may have components/systems (such as, by way of example only, fluid systems, such as pipes) mounted thereon and/or embedded therein. Thus, for example, a gas turbine engine in accordance with the present invention may have a combination of electrical rafts **200** and non-electrical rafts.

[0093] The arrangement of electrical raft assemblies **600**A-**600**G shown in FIG. **7** is by way of example only. Alternative arrangements, for example in terms of number, size, shape and/or positioning, of electrical raft assemblies **600**A-**600**G may be used. For example, there need not be seven electrical raft assemblies, the assemblies may or may not be connected together, and the rafts could be provided to (for example mounted on) any one or more components of the gas turbine engine. Purely by way of example only, connection between electrical raft assemblies **600**A-**600**D mounted on the fan casing **24** to the electrical raft assemblies **600**F, **600**G mounted on the core casing **28** may be provided at least in part by means other than an additional electrical raft assembly **600**E, for example using wire conductors with insulating sleeves. By way of further example, one or more electrical raft assemblies **600** may additionally or alternatively be provided to the nose cone, structural frames or elements within the engine (such as "A-frames"), the nacelle, the fan cowl doors, and/or any connector or mount between the gas turbine engine **10** and a connected structure (which may be at least a part of a structure in which the gas turbine engine **10** is installed), such as the pylon **500** between the gas turbine engine **10** and an airframe (not shown).

[0094] Any one or more of the electrical rafts of the electrical raft assemblies **600**A-**600**G may have a fluid passage **210** embedded therein and/or provided thereto. The fluid passage **210** may be part of a fluid system, such as a gas (for example pneumatic or cooling gas/air) and/or liquid (for example a fuel, hydraulic and/or lubricant liquid). In the FIG. **7** example, three of the electrical rafts (of electrical raft assemblies **600**A, **600**B, **6000**) comprise a fluid passage **210** at least partially embedded therein. The electrical raft of assembly **6000** also has a fluid passage **285** (which may be for any fluid, such as those listed above in relation to embedded passage **210**) mounted thereon. Such a mounted fluid passage **285** may be provided to any electrical raft, such as those of electrical raft assemblies **600**A-**600**G shown in FIG. **7**. The fluid passages **210**, **285** shown in FIG. **7** may be oriented in an axial direction of the engine **10**. However, fluid passages may be oriented in any direction, for example axial, radial, circumferential or a combination thereof.

[0095] Any of the electrical raft assemblies **600**A-**600**G (or the respective electrical rafts **200** thereof) may have any combination of mechanical, electrical and/or fluid connections to one or more (for example 2, 3, 4, 5 or more than 5) other components/systems of the gas turbine engine **10** and/or the rest of the gas turbine engine **10**. Examples of such connections are shown in FIG. **7**, and described below, but other connectors may be used. For example, electrical raft assemblies **600** (and/or non-electrical rafts) may be connected together (or to other components) using any combination of electrical, fluid and/or mechanical connectors. Thus, any of the connections **290**A/**290**B, **291**-**297** shown in FIG. **7** may be any combination of electrical, fluid and/or mechanical connection. Alternatively, electrical raft assemblies **600** (and/or non-electrical rafts) may be standalone, and thus may have no connection to other rafts or components.

[0096] A connection **291** is shown between the electrical rafts of the assemblies **600**A and **600**D. The connection **291** may comprise an electrical connection. Such an electrical connection may be flexible and may, for example, take the form of a flexible printed circuit such as the flexible printed circuit **250** shown in FIGS. **4** and **5**. Such a flexible electrical connection may be used to electrically connect any electrical raft assembly **600** to any other component, such as another electrical raft assembly **600**. A connection **297** (which may be or comprise an electrical connection) is provided between the electrical raft of the assembly **600**A and a part of an airframe, or airframe installation **500**, which may, for example, be a pylon. Similarly, a fluid and/or mechanical connection **296** may additionally or alternatively be provided between the airframe **500** and another electrical raft of the assembly **600**C. As shown in FIG. **7**, other electrical and/or fluid connections **292**, **293**, **294**, **295** may be provided between electrical rafts **200** (or assemblies **600**) and other components, such as other electrical rafts **200** (or assemblies **600**).

[0097] A direct connection **290**A, **290**B may be provided, as shown for example between the electrical rafts of the assemblies **600**B and **600**C in the FIG. **7** arrangement. Such a direct connection **290**A, **290**B may comprise a connector **290**A provided on (for example embedded in) one electrical raft **200** connected to a complimentary connector **290**B provided on (for example embedded in) another electrical raft **200**. Such a direct connection **290**A, **290**B may, for example, provide fluid and/or electrical connection between the two electrical rafts assemblies **600**B, **600**C.

[0098] Where reference is made herein to a gas turbine engine, it will be appreciated that this term may include a gas turbine engine/gas turbine engine installation and optionally any peripheral components to which the gas turbine engine may be connected to or interact with and/or any connections/interfaces with surrounding components, which may include, for example, an airframe and/or components thereof. Such connections with an airframe, which are encompassed by the term "gas turbine engine" as used herein, include, but are not limited to, pylons and mountings and their respective connections. The gas turbine engine itself may be any type of gas turbine engine, including, but not limited to, a turbofan (bypass) gas turbine engine, turbojet, turboprop, ramjet, scramjet or open rotor gas turbine engine, and for any application, for example aircraft, industrial, and marine application. Electrical raft assemblies **600** such as any of those described and/or claimed herein may be used as part of any apparatus, such as any vehicle, including land, sea, air and space vehicles, such as motor vehicles (including cars and busses), trains, boats, submarines, aircraft (including aeroplanes and helicopters) and spacecraft (including satellites and launch vehicles).

[0099] It will be appreciated that many alternative configurations and/or arrangements of electrical raft assemblies **600** and gas turbine engines **10** comprising electrical raft assemblies **600** other than those described herein may fall within the scope of the invention. For example, alternative arrangements of electrical raft assemblies **600** (for example in terms of the arrangement, including number/shape/positioning/constructions, of mounting fixtures, the arrangement/shape/positioning/construction of the electrical rafts **200**, the type and/or positioning of components (if any) mounted to/embedded in the electrical rafts **200**, the rigid material **220** and the electrical conductors **252**) may fall within the scope of the invention and may be readily apparent to the skilled person from the disclosure provided herein. Alternative arrangements of connections (for example mechanical, electrical and/or fluid) between the electrical (or non-electrical) rafts and/or raft assemblies and between the electrical (or non-electrical) rafts or raft assemblies and other components may fall within the scope of the invention and may be readily apparent to the skilled person from the disclosure provided herein. Furthermore, any feature described and/or claimed herein may be combined with any other compatible feature described in relation to the same or another embodiment.

[0100] FIG. **8** shows (a) a plan view of an anti-vibration mount in accordance with the present invention, and (b) a cross-section along line Y-Y through the mount. The mount attaches a mounting fixture portion **710** of one of the electrical raft assemblies **600**A-**600**G to a respective mounting structure **700** (shown schematically in FIG. **7**) of the engine. The mounting fixture portion can be a planar region of the raft assembly containing a though-hole **712**. The mounting structure **700** can be a part of the engine, for example a flange extending from the respective part of the engine, e.g. the fan casing **24** or core casing **28**.

[0101] The anti-vibration mount has an elastomeric (e.g. rubber) body which is formed in two parts. The first part **714***a* is positioned on one side of the planar region **710**, with a projection **716** in the centre of the part extending through the through-hole **712**. The second part **714***b* is positioned on the other side of the planar region **710** with the projection **716** fitting into a matching cavity **718** formed at the centre of the second part. The first and second parts thus form a slot-shaped recess **720** in which the planar region **710** is received.

[0102] The anti-vibration mount also has a pair of, typically metal, brackets **722***a,* b which fit to respectively the outer surface of the first part **714***a* of the elastomeric body and the outer surface of the second part **714***b* of the body to sandwich the part of the planar region **710** received in the slot **720** therebetween. A number of bolts **724** (for example four are shown in FIG. **8**(*a*)), or other suitable fasteners, extend between the brackets through the through-hole **712** and within matching passages formed in the first part **714***a* of the elastomeric body.

[0103] The bolts are tightened to apply a clamping pressure across the brackets and thereby compress the elastomeric body to secure the planar region **710** in the slot **720**.

[0104] One of the brackets **722***a* has a joining plate **726** extending therefrom which is attachable via a bolt **728** to the engine mounting structure **700**.

[0105] The mount is thus rigidly and strongly attached to the engine while the raft or raft assembly is in turn attached to the mount in a manner which allows the elastomeric body to reduce (or substantially eliminate) the amount of vibration being passed from the engine to the raft assembly.

[0106] To prevent rubbing damage to the raft assembly at the interfaces between the planar region **710** and the parts **714***a, b* of the elastomeric body, interlayers (not shown in FIG. **8**(*b*)) may be located in the recess **720** at the interfaces of the planar region and the elastomeric body. For example, these interlayers may be formed of GFRP.

[0107] Advantageously, the anti-vibration mount does not require the parts **714***a, b* of the elastomeric body to be chemically bonded to the brackets **722***a, b*. The mount can be straightforwardly assembled by joining the lower bracket **722***a* to the engine mounting structure **700**, placing the first part **714***a* on the lower bracket, positioning the raft assembly so that the through-hole **712** sits over the projection **716**, fitting the second part **714***b* onto the projection, locating the upper bracket **722***b,* and then fitting and tightening the bolts **724**.

[0108] Optionally, one of the brackets **722***a, b* may be integral with the mounting structure **710**. Alternatively, both the lower bracket **722***a* and the upper bracket **722***b* may be separate from the mounting structure **710**, with at least one of the brackets **722***a, b* being connectable to the mounting structure **710**.

[0109] While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. For example, although described above in relation to the mounting of electrical raft assemblies to a gas turbine engine, the anti-vibration mount can be used to mount other components, such as electrical control units, to the engine, or indeed to mount any two components together where vibration isolation is desirable. Possible fields of application are thus aerospace, marine or automotive vehicles and machine tools. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

1. An anti-vibration mount for mounting a first component to a second component, the mount having:

- an elastomeric body which provides a recess into which the first component is received;
- a pair of brackets which fit to opposing sides of the elastomeric body sandwiching the first component received in the recess therebetween, at least one of the brackets being arranged to connect the anti-vibration mount and second component together; and
- a clamping arrangement which applies clamping pressure across the brackets and thereby compresses the elastomeric body to secure the first component in the recess.

2. An anti-vibration mount according to claim **1**, wherein the elastomeric body is in two parts which are separable from each other when the clamping pressure is removed, the first part providing one of the opposing sides of the elastomeric body and one side of the recess and the second part providing the other opposing side of the elastomeric body and an opposing side of the recess.

3. An anti-vibration mount according to claim **2**, wherein the first component has a through-hole and the first part has a projection which extends through the through-hole and is received in a matching cavity formed in the second part.

4. An anti-vibration mount according to claim **1**, wherein the first component is planar and the recess is a slot.

5. An anti-vibration mount according to claim **1**, wherein the first and the second components are gas turbine engine components.

6. An anti-vibration mount according to claim **1**, wherein the first component is a rigid raft assembly.

7. An anti-vibration mount according to claim **5**, wherein the first component is an engine control unit.

8. A gas turbine engine or gas turbine engine installation having a first component mounted to a second component by an anti-vibration mount according to claim **1**, the first and second components being gas turbine engine components.

9. A gas turbine engine or gas turbine engine installation having a first component mounted to a second component by an anti-vibration mount according to claim **2**, the first and second components being gas turbine engine components.

10. A gas turbine engine or gas turbine engine installation according to claim **8**, wherein the first component comprises an electrical raft having electrical conductors embedded in a rigid material.

11. A gas turbine engine or gas turbine engine installation according to claim **10**, wherein the rigid material is a rigid composite material.

12. A gas turbine engine or gas turbine engine installation according to claim **10**, wherein the electrical raft is part of an electrical raft assembly that has a further engine component mounted thereon.

13. A gas turbine engine or gas turbine engine installation according to claim **10**, wherein:

the electrical raft is part of an electrical system of the gas turbine engine; and

the electrical system further comprises a flexible cable electrically connected between the electrical raft and another component of the electrical system.

14. A method for mounting the first component to the second component, wherein the first component is mounted to the second component by the anti-vibration mount according to claim **1**.

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