United States Patent

[11] 3,579,942

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[54] **FASTENER ANCHORED IN HONEYCOMB PANEL**
10 Claims, 16 Drawing Figs.

[52] **U.S. Cl.** **52/615,** 52/300, 52/705, 85/81, 151/37, 151/41.75, 151/70
[51] **Int. Cl.** **E04b 2/28,** F16b 13/08
[50] **Field of Search** ..... 52/364, 365, 615, 617, 621, 705, 707; 151/41.72, 41.73, 41.7, 41.75; 85/80, 81; 287/189.36 (F), 189.36 (D)

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Assistant Examiner—Leslie A. Braun
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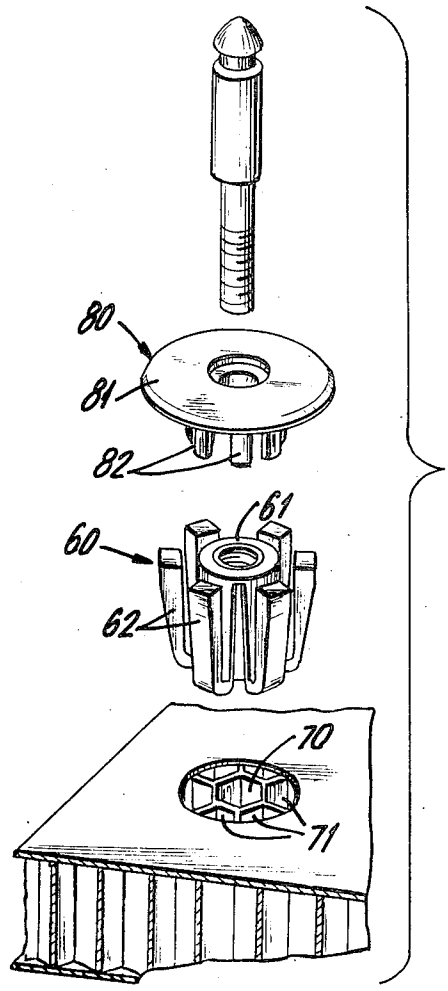
ABSTRACT: A honeycomb fastener retainer includes the combination of a fastener receiving body member designed to be inserted through an opening in one surface of the panel and into a hollowed out cavity area of the panel core where it is retained in place by means of body attached, elongated, flexible finger elements which collapse in a limited manner to permit the body member to pass through the outer panel opening which spread out to a normal position beneath the panel surface in the area of the outer panel opening to permit removal of the body member from the panel. A cap member covers the panel opening, and interlocks with the finger element of the body member and engages the panel surface by suitable means to prevent rotation of the fastener retainer assembly upon its receiving a threaded fastener.



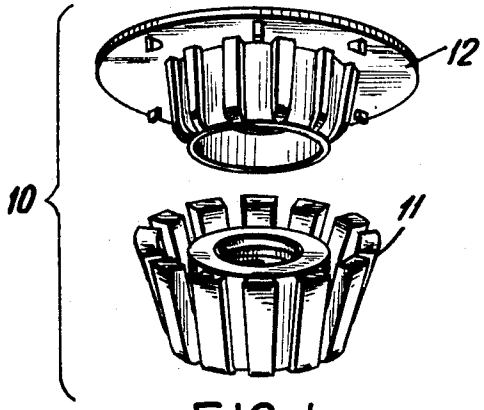


FIG. 1

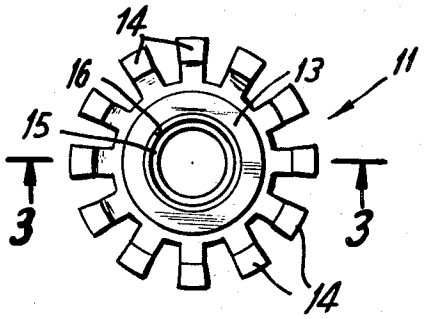


FIG. 2

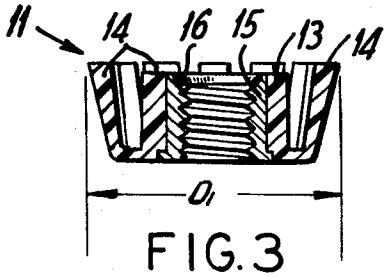


FIG. 3

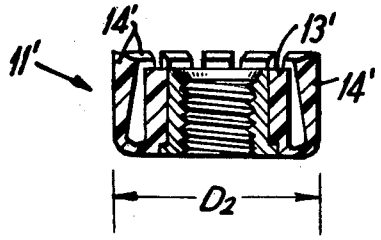


FIG. 4

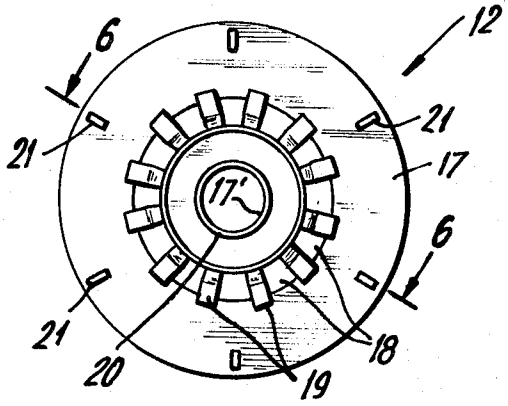


FIG. 5

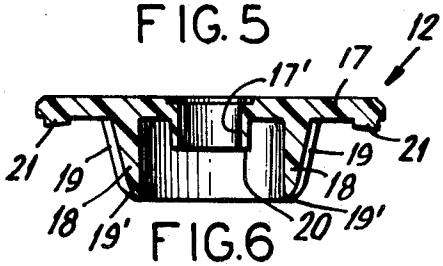


FIG. 6

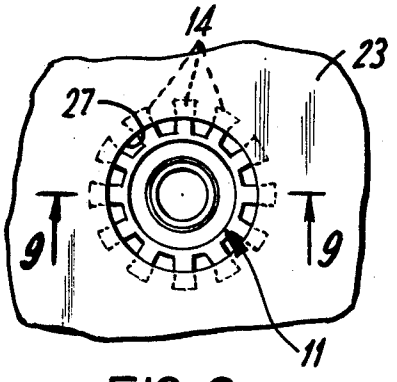


FIG. 8

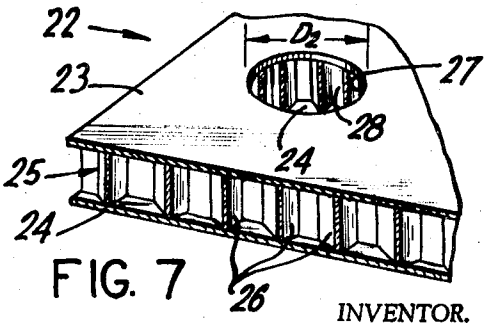


FIG. 7

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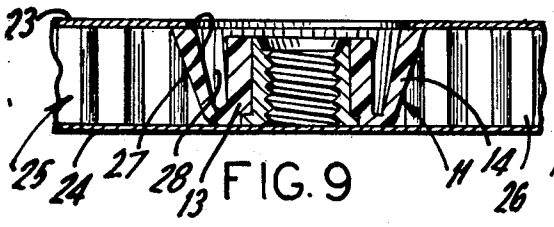

FIG. 9

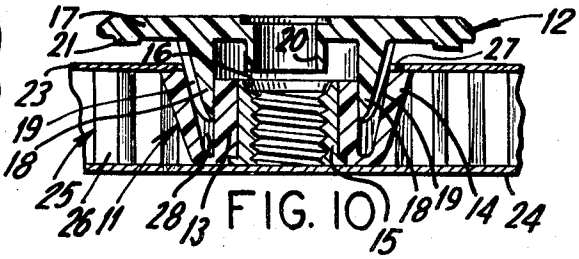

FIG. 10

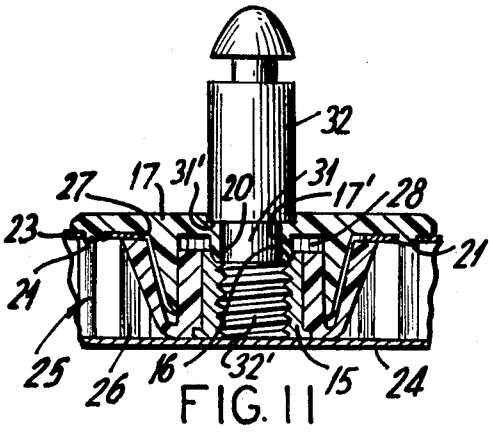

FIG. 11

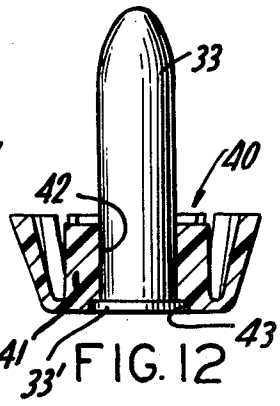

FIG. 12

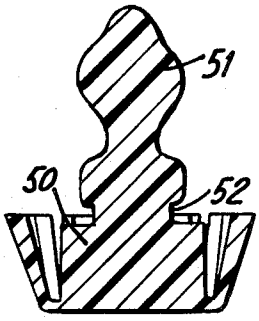

FIG. 13

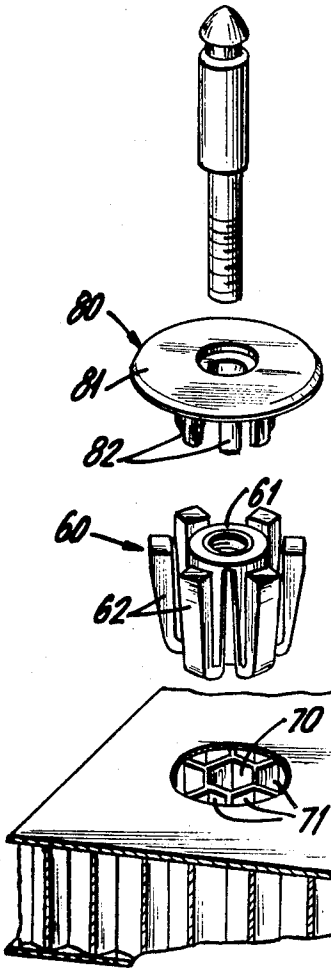

FIG. 14

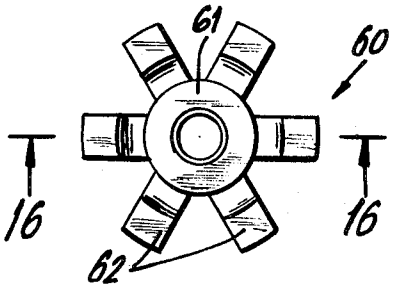

FIG. 15

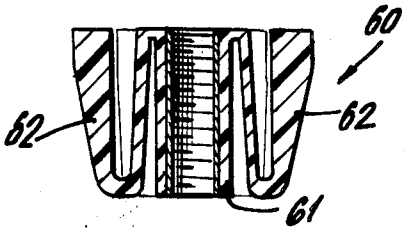

FIG. 16

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FASTENER ANCHORED IN HONEYCOMB PANEL

Honeycomb panels have found widespread uses where light weight is to be combined with strength, such as the interior panelling of aircraft. For example, in so-called convertible aircraft, those which can be used both for passenger service and cargo service, there is a requirement that the decorative panels, compartment dividers, and the like which are in place during passenger usage, can be removed so as to leave as much interior space as possible for cargo use. Thus, the panels must be quickly removed and just as quickly installed when the aircraft is reconverted for passenger service.

In order to maintain the decorative features of the panels, while simultaneously providing locating studs and retention elements on the panels, it is usually necessary to utilize so-called blind fasteners which are mounted through only one skin sheet of the panel.

Previous attempts to provide a blind fastening means by which honeycomb panelling may be attached to a frame or by which items can be attached to honeycomb panels, have involved removing a portion of one of the surface skins of the honeycomb panel, hollowing out a section of the honeycomb core, and inserting a spool-shaped metallic member having a central opening for receiving a stud, and two small holes in one end face thereof. While maintaining the metallic member in place using a temporary holding means, an adhesive potting material is squirted or forced through one hole to fill the vacated honeycomb core until the adhesive potting material starts to come out of the other hole in the end face of the metallic member. The adhesive is then allowed to set, after which the temporary holding means is removed. A metal bayonet stud or bolt is then attached to the central opening in the metallic member.

It is readily apparent that the installation of the prior art fastener is both expensive and time consuming. Furthermore, during the insertion of the adhesive potting, e.g., epoxy, there is a possibility that the metallic member may float or be displaced, thereby moving offcenter or becoming inclined with respect to the panel surface, or becoming tilted such that a portion of the metallic member extends above the skin surface of the panel. This tilting or offcenter movement of the fastener may result in misalignment of the fastener's stud and its mating element, thereby rendering the fastener of little value. Accordingly, the fastener will have to be removed and replaced, or the panel will have to be discarded. Another problem with the prior art fastener is the possibility of voids being formed in the adhesive material in the vacated core of the honeycomb panel, thereby resulting in a weak bond between the metallic member and the panel.

Besides the cost of installation of the prior art fastener, it is also apparent that the metallic member is more expensive to produce in that it is usually made of a machined metallic part, and must include carefully located and dimensioned holes for the passage of the adhesive potting. Furthermore, prior to installation, the metallic member must be free of grease, oil or oily films in order to enable the potting compound to adhere to the metallic member.

Another disadvantage of the prior art fastener is brought about during the curing of the adhesive material. Certain adhesives undergo an exothermic reaction which produces heat which could adversely affect the structural integrity of the panel and could possibly result in the formation of blisters or voids in a decorative material attached to the opposite side of the panel. One further disadvantage of the prior art fastener is that the total weight of the resulting fastener (less the stud) is greater than the weight of the core material removed to accommodate the fastener. This is particularly objectionable in applications such as aircraft where weight is a primary factor. Accordingly, it is an object of this invention to provide a blind honeycomb fastener retainer which is inexpensive, easy to install, and does not require the use of an adhesive or potting material.

It is a further object of this invention to provide a blind honeycomb fastener retainer which is mechanically connected to the honeycomb panel.

It is still another object of this invention to provide a blind honeycomb fastener retainer which is self-centering, and capable of limited flexibility for alignment purposes.

Another object of this invention is to provide a blind honeycomb fastener retainer which is light in weight, and does not affect the decorative characteristics of the honeycomb panel when installed.

It is still another object of this invention to provide a blind honeycomb fastener retainer which is simple in design, and inexpensive in cost.

Briefly, the honeycomb fastener retainer of the invention comprises essentially two elements, the first being a body member having a central portion for receiving a threaded stud, and having formed therewith a generally radially and axially extending array of flexible fingers. The second element comprises a cooperating cap suitably configured to project between the central portion and the flexible fingers thereby maintaining the latter in their radially outward positions relative to the central portion. To assemble the fastener retainer of the invention, a cavity is formed in the panel by removing an area of one skin surface of the panel and hollowing out the section of the exposed honeycomb core. Alternatively, the core opening could also be formed by crushing the core material in the vicinity of the skin opening. The body member of the fastener retainer is then inserted through the skin opening with the fingers thereof extending axially towards the opening. The fingers are sufficiently flexible radially to permit them to collapse radially inwardly sufficient to permit the body member to enter the skin opening and core cavity. After insertion, the fingers then will normally spread radially outwardly slightly beneath the rim of the opening in the skin by their natural resilience. Next, the suitably configured cap member is snapped into the skin opening and between the central portion of the body member and the fingers to hold the fingers in a radially spread position, and to interlock with the fingers to prevent rotation of the body member when the cap itself is locked against rotation. The cap also covers the skin opening except for the threaded socket area. Thus, a fastener threaded into the socket of the body member is retained relative to the honeycomb panel.

These and other objects and advantages of the invention will become more apparent from the foregoing detailed description and appended claims taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective exploded view of the fastener retainer of the invention;

FIG. 2 is a plan view of the body member of the fastener retainer of the invention;

FIG. 3 is a sectional view along lines 3–3 of FIG. 2;

FIG. 4 is a cross-sectional view similar to FIG. 3 of a modified form of the body member of the invention;

FIG. 5 is a bottom view of the cap locking means of the fastener retainer of the invention;

FIG. 6 is a sectional view of the cap locking means taken along lines 6–6 of FIG. 5;

FIG. 7 is a perspective view of a honeycomb panel having a cavity formed therein;

FIG. 8 is a plan view of the honeycomb panel illustrated in FIG. 7 with the body member of the invention inserted therein;

FIG. 9 is a sectional view taken along lines 9–9 of FIG. 8;

FIG. 10 is a sectional view similar to FIG. 9 but showing the partial installation of the cap locking means of the invention;

FIG. 11 is similar to FIG. 10 and illustrates the assembly of the cap locking means and the threaded stud in the body member;

FIG. 12 is a sectional view of a second form of modified body member of the invention;

FIG. 13 is a sectional view of a third form of modified body member of the invention;

FIG. 14 is a perspective exploded view of a second embodiment of the honeycomb fastener retainer of the invention;

FIG. 15 is a plan view of the body member of the embodiment illustrated in FIG. 14; and

FIG. 16 is a sectional view taken along lines 16–16 of FIG. 15.

Turning to FIG. 1, the blind honeycomb fastener retainer of this invention is designated by numeral 10 and comprises a body member 11 and a cooperating cap locking means 12. The honeycomb fastener retainer may be made by molding plastic or reinforced plastic material, or by machining or forming a metallic material having spring tempered properties. Additionally, the fastener may be made of sintered powdered metal particles, such as copper, aluminum, alloys, or any other suitable material or alloy material.

Referring to FIGS. 2 and 3, the body member 11 comprises an axial, cylindrical central portion 13 having an array of spaced, generally radially and axially extending resilient finger elements 14 which may be integral with the portion 13. The central portion 13 is formed with an axial fastener receiving opening, with a threaded metallic insert 15 therein having a bevelled opening 16 at its upper end. In lieu of the insert, of course, the body member may be formed with integral internal threads in the central portion 13, or may be smooth to receive a self threading fastener.

Each resilient finger element 14 is generally rectangular in cross section, and is preferably cantilevered at its lower end from the central portion 13. The finger elements are made of a flexible material for movement at least in a radial direction relative to the central portion 13, but which would stand collapsing forces along their length. In the embodiment illustrated in FIGS. 1 through 3, the fingers are formed with a slight tilt relative to the central portion so as to define, in plan view, a circular body member having a maximum diameter D_1.

A modified form of the body member is illustrated in FIG. 4 and designated by numeral 11'. The longitudinal axes of the fingers 14' of body member 11' are generally parallel to the longitudinal axis of the central portion 13' so as to define a body member having a maximum diameter equal to D_2 which is less than D_1. The importance of this dimension will become apparent hereinafter.

Turning to FIGS. 5 and 6, the cooperating cap locking means 12 generally comprises a fastener receiving structure including a disc or skirt portion 17 having a central opening 17', and from which depends two concentric hollow ring portions 18 and 20. The first ring 18 is in the form of a hollow cylindrical member which tapers in thickness in a direction away from the skirt, and has formed on the exterior side thereof a plurality of splines 19. Each spline 19 is generally of uniform thickness except for a slight chamfer 19' at the lower end of the cylindrical member 18, and the width of the splines is approximately equal to the space between the finger elements 14 of the body member. The outer diameter of ring 18 is approximately equal to the diameter D_2 of the opening in the honeycomb skin through which the body member is to be inserted as will be further explained hereinafter.

The second ring 20 depending from the skirt 17 comprises a cylindrical lip means which is intended to cooperate with the bevelled end 16 of the threaded insert 15 when the two pieces are in the assembled position.

Also depending from the skirt 17 are a plurality of antirotational bosses 21 having sharp edges for piercing the upper skin surface of the honeycomb panel when the body member and cap locking means are assembled. Alternatively, the cap locking means may be bonded to the upper skin of the honeycomb panel in order to prevent rotation thereof, or other forms of retention means, such as screw fasteners or the like, may be employed to prevent rotation of the cap locking means.

Turning to FIG. 7, the honeycomb panel is generally designated as 22 and consists of first or upper skin member 23 and a second or lower skin member 24 adhesively bonded to a cellular honeycomb core 25 defined by a plurality of cells 26 extending between the two skin sheets. The skin sheets and the core 25 may be made of a plastic, impregnated paper or the like, which is strong and capable of carrying decorative material, for example, on the lower skin member 24.

The honeycomb panel 22 is prepared for the fastener retainer 10 of this invention by removing a circular area 27 (of a diameter D_2) of the first skin surface 23 so as to expose the open ends of the cells 26 of the core 25. The next step in the preparation is to hollow out the exposed cell structure thereby creating a circular cavity 28 having a diameter D_2 in the honeycomb panel. Of course, care should be exercised in the preparation of the panel so as to prevent damage to the opposite or lower skin surface which may be carrying decorative material.

In the assembly of the fastener retainer, the body member 14 (of the type illustrated in FIGS. 2 and 3) is first inserted through opening 27 of the skin into the cavity 28 in the honeycomb panel with the free ends of the fingers pointing towards the opening 27. Because the diameter D_2 of the skin opening 27 is less than the diameter D_1 of the body member, as the body member is inserted through the skin opening 27, the fingers are flexed radially inwardly until the free ends of the fingers pass the first skin surface 23. At such time, the fingers 14 spring radially outwardly as shown by the solid lines of FIG. 9 to their full diameter D_1 within the cavity 28. FIG. 8 illustrates a plan view of the body member fully seated in the honeycomb cavity 28.

Turning to FIG. 10 the next step in the installation of the honeycomb fastener retainer of the invention is the insertion of the cooperating cap locking means 12 into the opening 27 so as to engage with the depending cylindrical hollow ring 18 extending between the fingers 14 and the central portion 13. When the cooperating cap locking means 12 is fully seated, the splines 19 are interlocked with the fingers 14 and the antirotational bosses 21 are disposed through the upper skin sheet 23 to prevent rotation of the body member when a threaded fastener is secured thereto. The fingers 14 are positioned in the spaces formed in the honeycomb core, and since the ends of the fingers are disposed below the skin sheet 23, they transmit the various axial, tension and some torsional loads imposed on the fastener retainer to the honeycomb panel. Compressive loads may be absorbed by the second skin or the cell ends of the core material. Additionally, because the fingers are disposed in an array around the central portion, they exert equal bias on the central portion of the body member, whereby the central portion is centered in the cavity and is disposed generally perpendicular to the skin sheet 23.

The fastener retainer may accept various types of retention elements such as a bayonet-type locating stud 32 (FIG. 11) including a threaded lower portion 32'. Intermediate the length of the stud 32 is a reduced diameter portion 31 including a shoulder 31' which, when the threaded portion 32' is threaded into the threaded insert 15 in the body member, engages the edge of the central opening 17' in skirt 17 causing the locking ring 20 to engage bevel 16 of the threaded insert 15 to form an interference fit with the stud, thereby frictionally locking the stud in place. Of course, other types of fastening studs may be employed such as mounting means for auxiliary equipment, retention elements such as studs, and retension elements which extend through both sides of the panel. In the latter case, a hold would have to be provided through the lower or second surface sheet, and through the lower portion of the central portion 13.

It is noted that the fastener provides a completely mechanical connection to the panel, is self-centering, and, because of the design of the fastener retainer, and the materials used in making the body member and the cooperating cap locking means, the total weight of the resulting fastener retainer is less than the weight of the previously described encapsulant and threaded metal insert of the prior art. Furthermore, since the fastener is a mechanical connection to the honeycomb panel, it is both rapidly installed and immediately available for use as a structural element.

It is noted that the installation of a honeycomb fastener retainer of the invention utilizing the body member 11' of the type illustrated in FIG. 4 is substantially identical to that installation previously described above. Of course, when using

body member 11', the fingers 14' need not flex radially outwardly during the initial insertion of body member 11' since the diameter of the body member 11' is equal to the diameter D_2 of the cavity in the honeycomb panel. However, when the cooperating cap locking means 12 is installed, the cylindrical ring 18 will force the displaceable fingers 14' radially outwardly to position under the upper skin sheet 23, substantially as shown in FIG. 9. At such time, the splines will be interlocked with and positioned between the fingers 14' of body member 11'.

Turning to FIG. 12 there is illustrated an alternate form of the body member in which a stud 33 is mounted in the body portion 40 prior to installation into the honeycomb panel. The body member 40 includes an aperture 42 which extends through the entire length of the central portion 41 and includes an enlarged diameter portion 43 adjacent the lower end of the body member. The stud 33 includes an enlarged diameter portion 33' which seats in the enlarged diameter portion 43, when the stud is positioned in the body member.

Another modification of the body member is illustrated in FIG. 13, and comprises an integral construction of a body member 50 and a locating stud 51. In this integral construction, the cooperating cap locking means could include a central opening which may be enlarged (e.g., by providing radial slits extending from the opening) whereby the cap could readily be forced over the locating stud portion 51 and snapped into place in a suitable groove 52 formed in the shank of the locating stud 51. Alternatively, the cooperating cap locking means may be adhesively bonded to the body member, as may be the cooperating cap locking means employed in combination with the body member illustrated in FIG. 12. Also, the stud 33 (FIG. 12) may include a suitable locking groove in the periphery thereof for retaining a cooperating cap locking means having an expandable central opening, similar to the construction described above in conjunction with FIG. 13.

Another embodiment of the honeycomb fastener retainer of the invention is illustrated in FIGS. 14 through 16. In this embodiment, the body member 60 includes a central portion 61 and an array of flexible finger elements 62 which are generally U-shaped in configuration, and which are connected at one end of the U to the upper portion of the central portion 61. This construction enables the placement of the body member in a honeycomb panel having a cellular core construction without the removal of the core below the skin cutout in the first skin sheet. The cutout in the surface skin sheet of the honeycomb panel is centrally located with respect to one of the cells of the panel, thereby providing an entire open cell 70 (see FIG. 14) for the reception of the central portion 61, while the adjacent cells 71 accommodate the U-shaped flexible fingers 62. The cooperating cap locking means 80 comprises a skirt 81 and a plurality of depending fingers 82, each of which is positioned between the upstanding legs of each U-shaped finger 62 to force the free or outer leg of the U-shaped finger under the skin surface of the honeycomb panel thereby completing the mechanical connection of the fastener retainer to the honeycomb panel.

It is noted that when the fastener retainer of the present invention is made of a plastic material, it may be designed to have a limited amount of resiliency which is especially important in applications where the fastener retainer is connected to a locating-type stud.

If desired, an adhesive may be used on the surfaces of the parts of the honeycomb fastener retainer of the present invention at the time of installation to assist further in holding the stud or fastener in place.

Although the various embodiments of the fastener retainer of the invention have been described and illustrated as being generally circular in plan form, it is readily appreciated that other plan form configurations (e.g., elliptical, hexagonal etc.) of the cooperating body member and cooperating cap locking means are contemplated within the scope of the present invention. Additionally, it is appreciated that the number of finger elements may be varied depending upon the particular requirements of the fastener retainer. In certain low-load applications, three fingers, equally angularly spaced about the central portion, may be sufficient to satisfy the requirements of the installation.

Having thus described the invention, it is not intended that it be so limited as changes may be readily made therein without departing from the scope of the invention. Accordingly, it is intended that the Abstract of the Disclosure and the subject matter described above and shown in the drawings be interpreted as illustrative and not in a limiting sense.

I claim:

1. A fastener retainer for use with honeycomb sandwich panelling including a central cellular core and opposed first and second skin sheets, the first skin sheet having an aperture therein, and the core area underlying the aperture being removed to provide a cavity, the fastener retainer comprising:

a body member having a central, axial, fastener receiving opening substantially in alignment with said skin aperture and being disposed centrally within said core cavity between the first and second panel skin sheets, said body member further having generally radially and axially extending finger elements extending from the end area of the body member furthest removed from the said skin aperture and towards the under surface of the first skin sheet in the immediate area of said aperture;

a cap member having a central fastener receiving opening and including axially and radially extending splines extending through the said skin aperture and radially engaging the said fingers of the said body member within the said core cavity; and

a means for positively securing the said cap member from rotation relative to the panel.

2. The fastener retainer of claim 1 wherein said finger elements are flexible at least in a radial sense but capable of withstanding compressive collapsing forces along their lengths, and are normally disposed to either side of a central portion of said body member in such a manner that the diametrical spacing between opposed fingers is slightly larger than the diameter of said skin aperture, and wherein the said central portion and finger elements of said body member are proportioned to fit axially through the said skin aperture upon radial bending of the finger elements inwardly towards the central portion of said body member.

3. The fastener retainer of claim 2 wherein the cap member further includes a central, axially depending hollow portion having internal dimensions substantially corresponding to the external dimensions of said central portion of said body member, and including the said splines on the outer surface of said hollow portion, said hollow portion of the cap member extending over and closely fitting the central portion of said body member, the said hollow portion further having external dimensions corresponding substantially to the dimensions of said skin aperture whereby the hollow portion of the cap member of the retainer assembly tends to retain the assembly centered with respect to the said skin aperture.

4. The fastener retainer of claim 1 wherein said cap member further includes a laterally extending skirt portion which bridges the said skin aperture, said skirt portion further including skin piercing and engaging means constituting the said means for securing the said cap member from rotation relative to the panel.

5. The fastener retainer of claim 1 in combination with a threaded fastener, wherein the said fastener receiving opening in said body member is circular and threaded for receiving the threaded fastener, and further includes an outwardly bevelled area at its end adjacent the said skin aperture, and wherein said cap member includes a flexible, circular, depending lip portion adjacent the fastener receiving opening in said cap member, the said lip portion having a diameter slightly larger than the diameter of said fastener receiving opening in the said body member, said lip portion of the cap member being nor-

mally disposed partially within the said bevelled area of the fastener receiving opening of said body member; and wherein said fastener extends through the fastener receiving opening of said cap member and threadably engages the opening in said body member, said fastener also including a shoulder portion for axially engaging the edge area of the opening in said cap member when the fastener is fully received in the body member, the distal end of said cylindrical lip portion of said cap being urged radially inwardly into contact with the threaded fastener and the fastener is fully received in the body member by camming against the said bevelled area to thereby provide a frictional antirotational means between the said cap and fastener.

6. A fastener retainer for use with honeycomb sandwich panelling including a central cellular core and opposed first and second skin sheets, said honeycomb panelling including a cutout portion extending through only one side of said panelling, the fastener retainer comprising:

a body member having a central, axial, fastener receiving opening being disposed centrally within said cutout portion and between the first and second panel skin sheets, said body member further having generally radially and axially extending finger elements extending from the body member and towards the under surface of the first skin sheet in the immediate area of said cutout portion;

a cap member having a central fastener receiving opening and including axially and radially extending splines extending through the said cutout portion and radially engaging the said fingers of said body member intermediate the first and second skin sheets of the honeycomb panel; and

a means for positively securing said body member from rotation relative to the panel.

7. The fastener retainer of claim **6** wherein each finger element is generally U-shaped, with the free end of one leg of the U-shaped finger element extending from the end area of the body member nearest to the cutout portion in the honeycomb panelling, and the free end of the other leg being disposed towards the under surface of the second sheet through which the cutout portion extends.

8. The fastener retainer of claim **6** wherein the body member is integrally formed with a fastener extending from the central, axial portion thereof.

9. The fastener retainer of claim **6** wherein said cap member further includes a laterally extending skirt portion which bridges the said cutout portion, said skirt portion further including skin piercing and engaging means constituting the said means for securing the cap member from rotation relative to the panel.

10. The fastener retainer of claim **6** wherein the cap member is adhesively bonded to the honeycomb panel.