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Willis

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[45] **Jan. 21, 1975**

[54] **COINED GROUND STUD**

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[73] Assignee: **Lockheed Aircraft Corporation,** Burbank, Calif.

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[52] **U.S. Cl.** .... **339/14 R,** 339/276 R, 29/511

[51] **Int. Cl.** **H01r 3/06**

[58] **Field of Search** .... 339/14, 276, 220; 29/511; 151/41.72, 41.73, 41.74; 52/758 D, 758 F; 403/274

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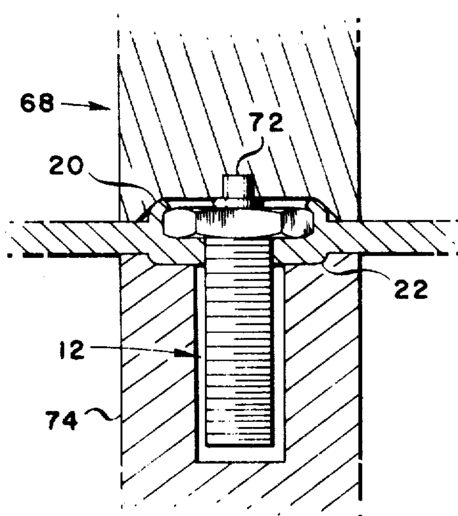
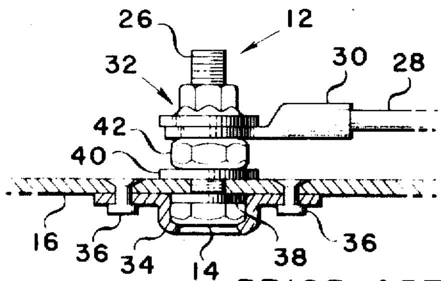
[57] **ABSTRACT**

A ground stud assembly, wherein the base is coined to form a mating cavity to receive the head of the stud and an upstanding flange around the cavity which is later squeezed over onto the head of the stud to secure it in place. The coining operation simultaneously produces a washer-like protrusion opposite the cavity to space the ground wire terminal, which is later mounted on the stud, from the base. The assembly has a single contact surface in the path of flow of the ground current.

5 Claims, 8 Drawing Figures





PRIOR ART

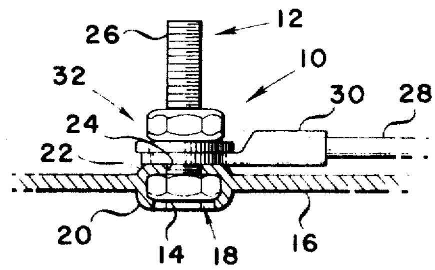


FIG. 1

FIG. 2

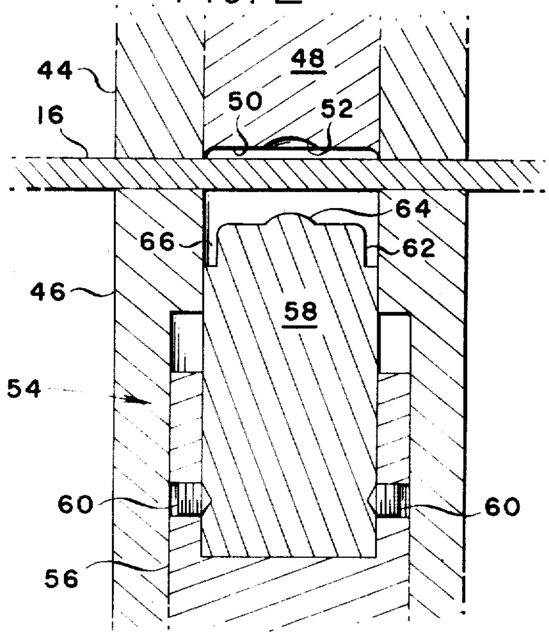
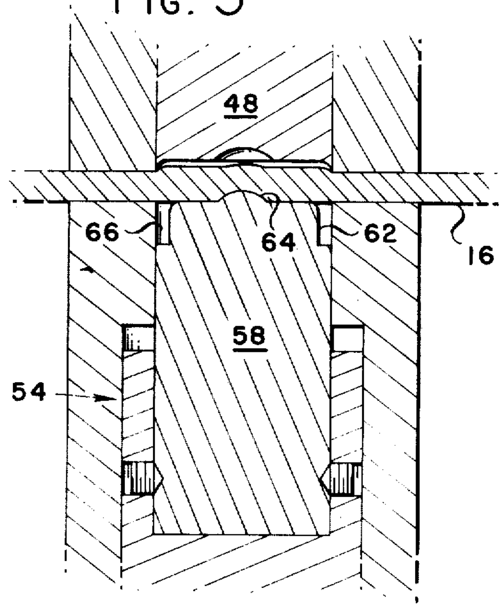


FIG. 3



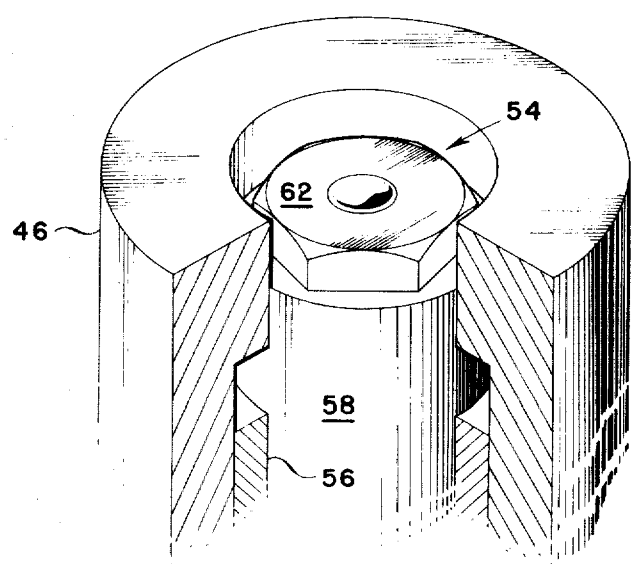


FIG. 5

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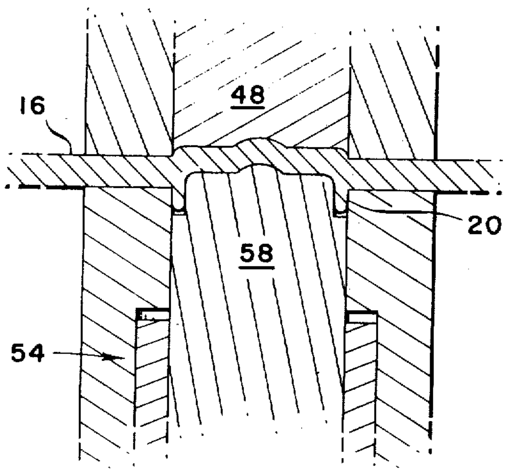


FIG. 4

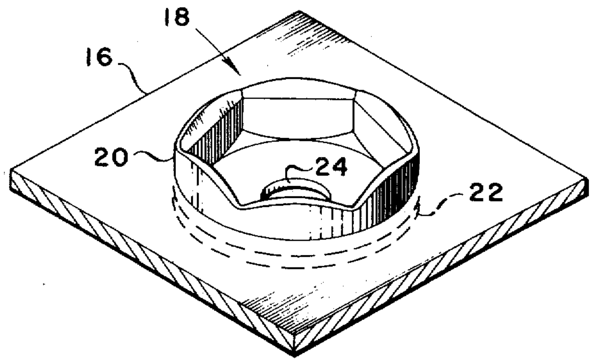


FIG. 6

FIG. 7

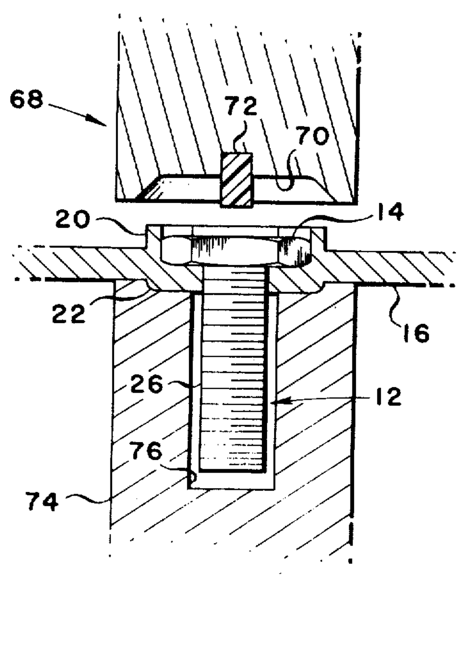
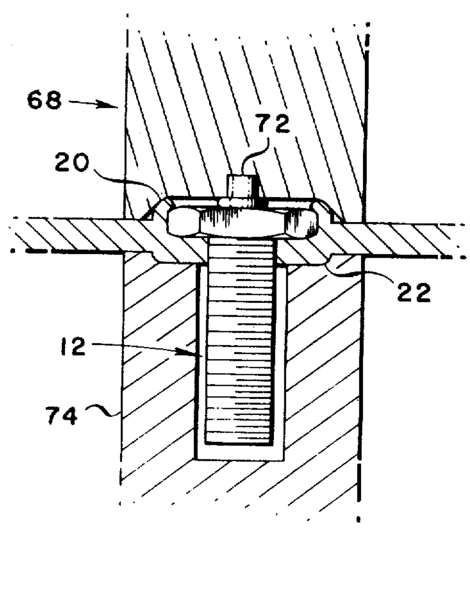


FIG. 8



COINED GROUND STUD

This invention relates to improved ground studs for electrical components, and to methods of making the stud assemblies.

The invention was developed in the environment of aircraft manufacture. The prior art for grounding electrical wires in airplanes had suffered from the severe disadvantages that ground studs were fairly complicated assemblies, were quite heavy, and suffered from a corresponding high cost both in regard to the cost of the parts and the cost of assembling them. From the technical viewpoint, this assemblage or stack of nuts and washers and the like provided an unacceptably large number of interfaces in the path of the electrical ground current, thus providing greater possibilities for electrical discontinuities, in turn increasing the chances of electrical failures in the aircraft.

In the electrical field generally, as opposed to the electrical field in aircraft, there are many different means of providing a ground between a wire and a base. None of these related devices is applicable to use in aircraft for various different reasons. One such popular type is the so-called spring loaded "pop" connector which is not satisfactory for aircraft use because it is difficult to disconnect, and aircraft electronics ground studs must be readily disconnectable. Another type comprises a spade or pin end on a wire which fits into a mating socket. Such types are unacceptable because they are susceptible to being shaken loose during flight, and aircraft ground connections must be very secure and reliable until intentionally disconnected. Another requirement which is not met by many common types of connectors in the electrical field generally is that the terminal on the ground wire must stand off from the base, which stand off is required to accommodate the shape of the terminal, which is typically a transition from flat to round, and to prevent any mechanical damage to the parts.

Aircraft grounding studs must meet several mechanical and performance requirements. The stud itself must be securely but removably fastened to the base, the base in aircraft, of course, is the entire airframe. That is, the stud or bolt must be so fixed in place that it will not move during its own normal operation and that of the aircraft, and yet so fastened that it may be removed from the base if required for maintenance or other purposes. Further, means must be provided to cause the terminal on the ground wire to stand off of the base material, for the reason set forth above. Another requirement is that the ground wire terminal be readily removable from its stud, and that the stud have the capability of accommodating more than one such terminal.

As to performance requirements, the invention must provide the lowest possible electrical resistance path from the terminal contact to the airframe structure. Where a secure interconnection of two or more metal objects is required to establish an electrical path of constant minimum resistance, typical resistance values are 0.001 to 0.0025 ohms. This requirement establishes that the minimum contacting surfaces in the electrical path is most desirable, eliminating the need for protective bonding of those surfaces to prevent oxidization of the surface which would increase the resistance.

Further, the grounding means must accomplish all of these requirements in a simple and fool-proof manner, at low cost, with an assembly having as low a weight as

possible, and yet be capable of withstanding severe vibration and shock loads.

The prior art in aviation ground studs is quite complicated having many separate parts, involved interlocks, and the like, with all of the concommitant disadvantages flowing therefrom, as pointed out above. The invention improves upon the prior art and fulfills all of these requirements primarily by providing a specially coined cavity in the base. The shape of this cavity is such as to snugly receive the head of the ground stud or bolt, thereby preventing turning of said bolt about its own axis. Means are also provided in the method of the invention to form an upstanding flange of the metal flowed out from the cavity during its coining. This flange is later squeezed inwardly over the head of the bolt to thereby hold the bolt securely in the coined cavity. Simultaneous with the coining of the cavity and the creation of the flange, the coining operation also forms a washer-like protrusion in the base metal on the side thereof opposite the upstanding flange. This protrusion also defines the bottom of the cavity. Thus, the coining operation forms, in the base material itself, portions therein which serve the functions of six separate parts in a particular very popular prior art military and commercial aircraft ground stud assembly, as will be set forth in greater detail below.

The invention was developed for use as an electrical ground stud for aircraft. However, it has other utility, a ground stud other than in aircraft, other than as a ground stud, and other uses which will present themselves to persons skilled in various arts. It is presently thought that the invention is limited to a metallic base member since no other materials coin as well, and it may not be practical or feasible to coin other materials for various reasons.

The method of the invention further includes the use of more ordinary techniques to pierce or drill or punch a hole in the washer-like protrusion for passage of the shank of the bolt, and certain plating or coating operations which are performed in the usual manner for the usual reasons.

An important advantage is the single contact surface in the invention, between the wire terminal and the base washer protrusion, as opposed to a minimum of three such surfaces in the prior art, with all the attendant disadvantages of such a plurality of interfaces.

The above and other advantages of the invention will be pointed out or will become evident in the following detailed description and claims, and in the accompanying drawing also forming a part of the disclosure in which: FIG. **1** is a partial cross-sectional view of a ground stud assembly embodying the invention; the drawing to the left of FIG. 1 marked "PRIOR ART" is a view of the specific prior known and used ground stud assembly replaced by the invention; FIGS. **2, 3** and **4** are sequential diagrams illustrating the coining of the cavity in the base; FIG. **5** is a perspective view partly in cross-section of the coining tool shown in FIGS. **2, 3** and **4**; FIG. **6** is a perspective view of the completed coined cavity before the stud is mounted therein; and FIGS. **7** and **8** are sequential views showing the manner in which the upstanding flange is squeezed over the head of the bolt.

Referring now in detail to the drawing, reference numeral **10** indicates an assembled ground stud including the electrical terminal in accordance with a preferred embodiment of the invention. Assembly **10** comprises a stud **12** having a head **14** which is mounted in the base **16** by means of the coined cavity **18**, which cavity is best shown in FIG. **6**. The cavity **18** includes an upstanding flange **20** which is squeezed over onto the head **14** of the bolt **12** to hold it in place, and a washer-like protrusion **22** formed with a central opening **24** for passage of the shank **26** of the bolt. The squeezing of flange **20** and the forming of hole **24** are done after the coining operation. The ground wire **28** is provided with a conventional terminal **30** whose central opening is slipped over the stud shank **26**. The terminal **30** is held in place by a combined self-locking nut and washer assembly **32**, such devices being well known and widely commercially available.

Use of the invention should be manifest from FIG. **1**. After the stud **12** is fixed into cavity **18** in the base **16**, as will be described in detail below, the terminal **30** is tightened down onto the washer-like protrusion **22** by screwing assembly **32** down along shank **26**, in the usual manner. Of course, a plurality of terminals **30** could be mounted on a single shank **26**, the exact number being controlled by the electrical requirements and standards of any particular application. In actual use of the invention in aircraft, the base **16** is often a bracket having a large number of ground stud assemblies **10** on it. Another advantage of the invention is that the squeezed over flange **20** is of such a thickness that a sharp blow or a force of about **25** pounds on the free end of the shank **26** will break the flange thereby permitting removal of ground stud **10**. Alternatively, the break may occur around the washer-like protrusion whereby the stud and the entire coined cavity secured thereto will be removed. Thereafter, in either case, as a field replacement procedure, the hole remaining can be used for a conventional type of ground stud, such as the "PRIOR ART" assembly shown to the left of FIG. **1**, or for another coined type of ground stud on a separate base fixed to the old base.

Those parts in said prior art assembly which are the same as in FIG. **1** are indicated by the same reference numerals. This is not exactly true as to bolt **12** in that the invention permits use of a slightly shorter bolt thus effecting an additional small cost and weight savings. This assembly includes several additional parts, each of which has a function which is performed by the invention ground stud assembly **10** of FIG. **1**. A retainer **34** is held to the underside of base **16** by a pair of rivets **36**. This retainer **34** mates with and serves to hold the head **14** against rotation as the remaining parts are assembled onto the shank **26** of the stud **12**. Holding the stud against rotation is an important requirement because the base **16**, be it a simple tab or part of a large complex grounding bracket, is often mounted on the aircraft in close quarters and in such a way that it would be difficult and often impossible to put a tool on the head **14** to hold it against rotation in assembling the remaining parts. In a large bracket carrying many studs there is frequently no wrench clearance at all. A washer **38** is provided between nut **14** and base **16** in order to assure that head **14** fits snugly into retainer **34**. On the opposite side of base **16**, this older assembly comprises a washer **40** and a nut **42**, which parts are provided for tightening the bolt in position and protecting the base material **16** from damage which might be caused by such tightening. The remaining structure is the same as the invention, comprising a ground wire terminal **30** and a lock nut and washer assembly **32**.

The head **14** and its mating cavity have been shown hexagonal in the drawing for the reason that this is the commmonly used shape. The invention, of course, could be used with square headed bolts, which would dictate square cavities, or a mating ten sided shape, or in fact with any non-round shape so that the head when in its cavity could not turn about the stud axis.

The side-by-side comparison of FIG. **1** and the PRIOR ART figure very clearly shows how the invention eliminates six parts and the labor associated therewith; namely, retainer **34**, the two rivets **36**, washer **38**, washer **40**, and nut **42**. It should be pointed out, however, that it is possible in the prior art to eliminate washer **38**, depending upon requirements in a particular aircraft and the nature of retainer **34**. The invention also eliminates the requirement of oxidation protection sealing between the washer and the base, and between the washer and the nut contacting surfaces.

FIGS. **2, 3** and **4** illustrate the sequential steps in the coining of the base **16** as shown in FIG. **1**. It is noteworthy that the invention utilizes a coining operation to form the cavity, the washer, and the upstanding flange in the base, and does not use a stamping or pressing or other more conventional manufacturing method. In TOOL ENGINEERS HANDBOOK, Second Edition, published by McGraw-Hill Book Co., Inc., Copyright 1959, at page 55–23, under Compression Operations, it succinctly states, to wit:

"**3.** Coining operations usually force metal to flow within a die, but not out from it, so that all work surfaces are confined. The distances through which the metal flows are comparatively short, but most or all of the metal flows to form new surface contours, thus necessitating high pressures. Portions of a blank or workpiece may be coined; corners of previously formed or drawn cups may be built up or filled in, or indented or raised sections of a blank may be formed by coining dies...."

It is this confining of the work, in combination with the high pressure of coining, which controls the flow of the metal out of the cavity and forces this material to be formed into the upstanding flange **20** and the washer **22**. Ordinary stamping and the like wherein the material which is moved out of the cavity is uncontrolled, could not be used in the invention in that such outflow material is simply randomly pushed aside or cut out and would not form itself in the manner required by the invention. Therefore, the term "coining" and the like as used in the specification and claims herein shall be understood to limit the invention to coining of metal in the technical sense, and any other metal or other material forming process in which the material of the base is flowed and controlled so as to form the cavity, the flange and the washer. In other applications, other materials could be used as the base, such as other ductile metals such as aluminum, copper, and the like. Further along this line of thought, ordinary hydraulic presses will not be satisfactory for coining, in that such machines are not intended to operate with the high pressures which coining requires, and the tools will deflect, or the die and/or the punch will be "spongy," and other such difficulties would be experienced, all of which problems would result in a poor flow of the base material. For this reason, it is thought that only the very rigid high quality coining presses can be used in practicing the invention.

The steps to form the coined cavity, washer and flange are illustrated by the sequential steps shown in FIGS. 2, 3 and 4. Referring to FIG. 2, the first step comprises clamping the work between a pair of pressure plates or collars **44** and **46**. This first step is the confining of the work so that the material flow can be controlled. Collar **44** is associated with a die **48**, and these two parts are securely fixed together but the die is removable to facilitate its replacement or servicing. The die **48** is formed with a compound cavity having a major annular die portion **50** surrounding a center deeper die portion **52**. Portion **50** defines the washer-like protrusion **22**. Portion **52** locates the central opening **24** which will be formed later and also serves another purpose which will be set forth below. The collar and die **44** and **48** moves together. The distance between the surface of the annular face of collar **44** and the annular portion **50** and the clamped work as shown in FIG. 2 defines the thickness of the washer-like protrusion **22**, and helps to define the cavity depth. These dies may be made of conventional material such as tool steel.

On the opposite side of the work or base material **16**, collar **46** slidably mounts a punch assembly **54** which is shown in more detail in FIG. 5. The punch assembly **54** comprises a holder **56** in which is mounted the punch proper **58**. A pair of set screws **60** permit simple replacement or renewal of the punch **58**. In this manner, the punch assembly can be moved by the coining press independently of the pressure plate **46**. The working head of the punch **58** is a male impression **62** of the cavity **18**, and is sized to permit the head **14** of the bolt **12** to seat in the cavity which will be formed in the base. The working face of the punch on portion **62** is formed with a relatively small protrusion **64** of a configuration similar to the center die portion cavity **52** in the die **48**. An annular space **66** is formed between the inside of the punch pressure plate **46** and the male impression or punch **62**, and it is this annular space which defines the annular flange **20**. It should be noted that the outside surface of flange **20** is cylindrical as defined by the pressure collar **46**, and that the inside surface of the flange is of a shape matching that of the stud head **14** as defined by the punch portion **62**; usually hexagonal.

Referring now to FIG. 3, the small protrusion **64** is important in the coining operation in that it starts the base metal flowing in a more gradual manner than would a simply flat surfaced punch **62**. Thus, protrusion **64** may be thought of as a pilot for the coining operation in that it first contacts the confined base material and starts that material flowing. Additionally, this protrusion **64** serves another useful purpose in that it simultaneously forms a depression which serves as a pilot for the piercing or drilling or punching of the hole **24** in a subsequent operation. In regard to the hole **24**, a subsequent operation is required in that attempts to form this hole during coining would result in the metal flowing back into that hole or up onto that punch rather than flowing in the desired directions to form the flange and the washer.

The height of the protrusion **64** is a sensitive dimension in any particular application; consideration must be given to all of the dimensions, the materials being worked, the nature of the press being used, and the like. If the height is too short, then excessively large forces are required to start the coining process. If this height is too great, the metal flow is too harsh and a poor flange **20** is formed. In the successful use of the invention, working with aluminum sheets, alloy 6,000 series, having a thickness of 0.060 inch, using a diameter of the protrusion **64** of approximately 3/16th of an inch (to serve as a pilot for a quarter inch bolt), the protrusion height on the punch was between about 0.015 to 0.018 inch.

The axial length of the male punch portion **62** defines the length of the space **66**, which in turn defines the height of the upstanding flange **20**. Persons skilled in the art can control these dimensions in the die and the punch in order to produce a cavity, washer and flange for any particular application. Coining presses typically have vernier stroke adjustment allowing control of dimensions in the work to plus or minus 0.001 inch.

FIG. 4 illustrates the final stage in the coining operation, the punch has moved to just short of its final position, in which final position the top edge of the flange will contact the shoulder in the punch **58** at the end of the space **66** to thereby square off the top of the flange **20**, as shown in FIGS. 6 and 7.

FIG. 6 is a perspective view of the completed coined cavity prior to insertion and securing of the stud in the cavity. The hole **24** is made by punching or piercing or drilling or other conventional techniques, using the depression formed by the protrusion **64** as a pilot if desired. Of course, drill jigs of numerical control drilling machines may not require this pilot.

Prior to insertion of the bolt in the completed cavity, use in the aviation industry requires application of a thin film of a suitable substance to provide corrosion protection. This step is wholly conventional and need be no further described herein. In this regard, still another advantage over the PRIOR ART structure shown to the left of FIG. 1 is that the washer **40** therein must be separately coated to protect it against corrosion. Thus, the invention eliminates not only the washer **40** but also the step of protecting that washer, and also thus eliminates another possible source of corrosion, and eliminates some electrical resistance.

The length of the holder **56** above the set screw **60** with respect to the undercut in the inside wall of the pressure plate **46** is such that the end of the holder will not bottom against the shoulder formed by the undercut. The bottom or end of the coining stroke is defined by the stroke of the coining press itself in conjunction with flow of the coined metal to form all of the parts of the coined cavity.

After the cavity is complete and coated, the screw **12** is seated herein, and is then secured therein as shown in FIGS. 7 and 8. It should be noted that it is desirable to squeeze the upper part of the flange **20** above the bolt head **14** uniformly all around the head inwardly onto the head. The tool **68** having a cavity defined by a conical surface **70** provides this squeezing action. A resilient hold down stud **72** is secured into the tool **68** by any suitable means and serves to first contact the head **14** to hold the screw **12** in place while the squeezing operation is performed. In the successful use of the invention, this stud was made of a suitable tooling plastic. A fixed base support **74** having a suitably formed opening **76** to receive the shank **26** of bolt **12** is provided and is also suitably formed to snugly receive and support the coined cavity on the washer side thereof. The completed product of the squeezing operation is shown in FIG. 8. It should be noted that the relatively sharp edges of the outer end of the flange **20** are rounded as a result of the squeezing operation, thus avoiding any deburring problems. A uniform all-around squeezing of the flange **20** is preferred to any other sort of securing technique, such as peening or staking or pining or adhesive bonding, or the like, in that such other types of securing systems result in discontinuities, higher labor costs, and in a very firmly fixed assemblage. The bolt held in place by a squeezed over flange in the manner of the invention has the advantage over a peened or staked or the like bolt in that, in the invention method, the bolt **12** can be removed by a sharp blow or by pressure in the event the ground stud assembly should become faulty or it should be desired to replace it for any other reason. As mentioned above, the yield may be at the flange or around the washer, and in either case a hole is left which will help in making a field replacement.

While the invention has been described in detail above, it is to be understood that this detailed description is by way of example only, and the protection granted is to be limited only within the spirit of the invention and the scope of the following claims.

I claim:

1. An electrical ground stud assembly comprising a metallic base member, a cavity of a predetermined shape coined into said base member comprising an upstanding flange unitary with said base member, surrounding the opening of the cavity and extending to one side of said base member and a washer-like protrusion defining the bottom of the cavity and extending from and unitary with the opposite side of said base member, said assembly further comprising a stud having a non-round cross-sectional shaped head and a threaded shank, the head of said stud being located within said cavity and snugly filling said cavity in planes perpendicular to the axis of said stud, said flange comprising a portion overlying the outside surface of said stud head, whereby said stud is non-rotatably secured within said cavity, and an opening formed within said washer-like protrusion receiving and passing the shank portion of said stud.

2. The assembly of claim **1**, an electrical ground terminal fitted over said stud shank, and means to secure said terminal against said washer-like protrusion.

3. The assembly of claim **2**, wherein said securing means comprises a combined lock nut and washer assembly with said washer portion against said terminal and said nut portion threadedly received on said stud shank portion.

4. The assembly of claim **3**, said base member comprising an aircraft electrical grounding bracket, and a plurality of said ground stud assemblies formed in said bracket.

5. The assembly of claim **1**, wherein said stud head and said cavity are of mating hexagonal shapes.

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