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(54) METHOD AND APPARATUS FOR WELDING A METAL FASTENER TO A METAL MEMBER

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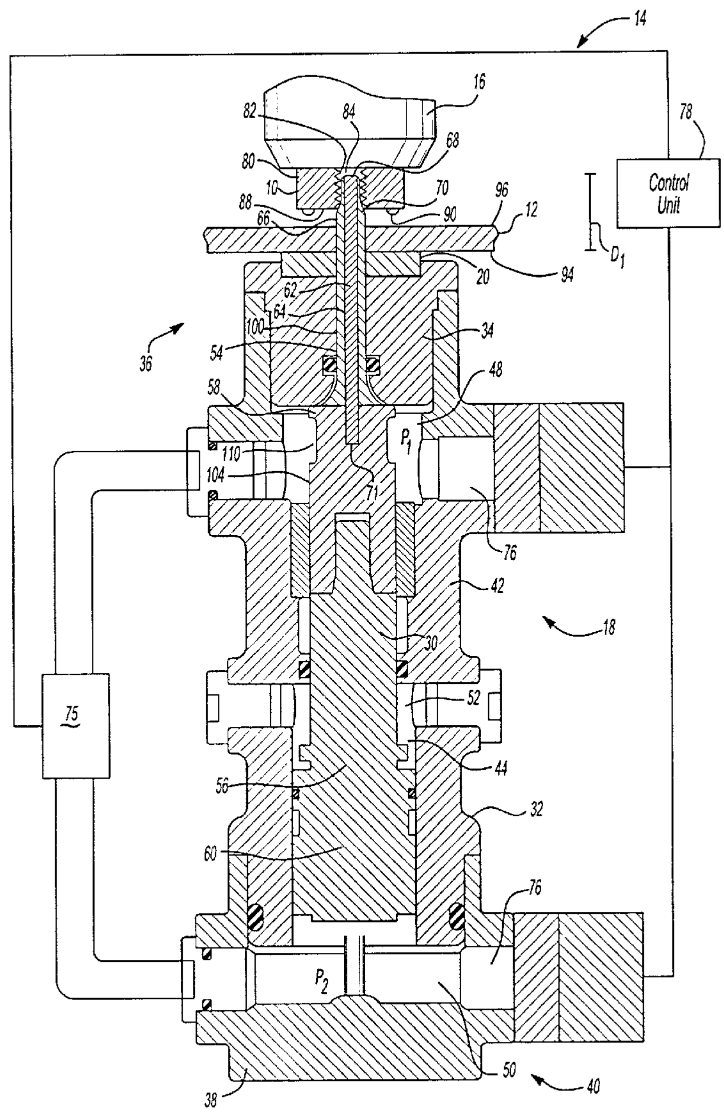
(57) **ABSTRACT**

A method and apparatus for projection welding a metal fastener (e.g., a nut) to a metal member (e.g., a sheet) is disclosed. The apparatus includes a first electrical contact and a locator assembly having a second electrical contact. For welding the fastener to the member, the locator assembly aligns through-holes of the fastener and sheet and a current is passed through protrusions of the fastener. In turn, the protrusions are softened to bond with the member.



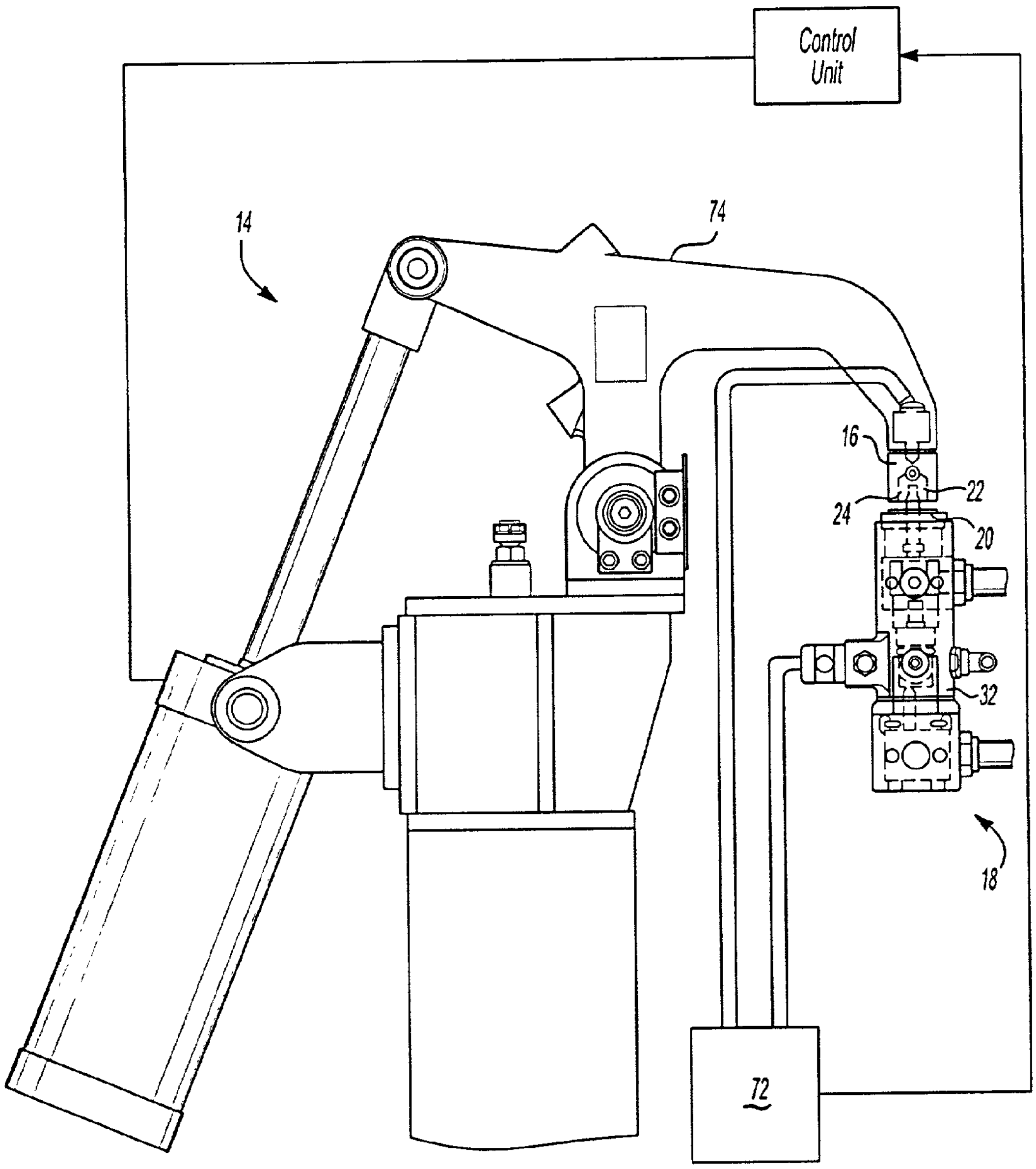


Fig-1

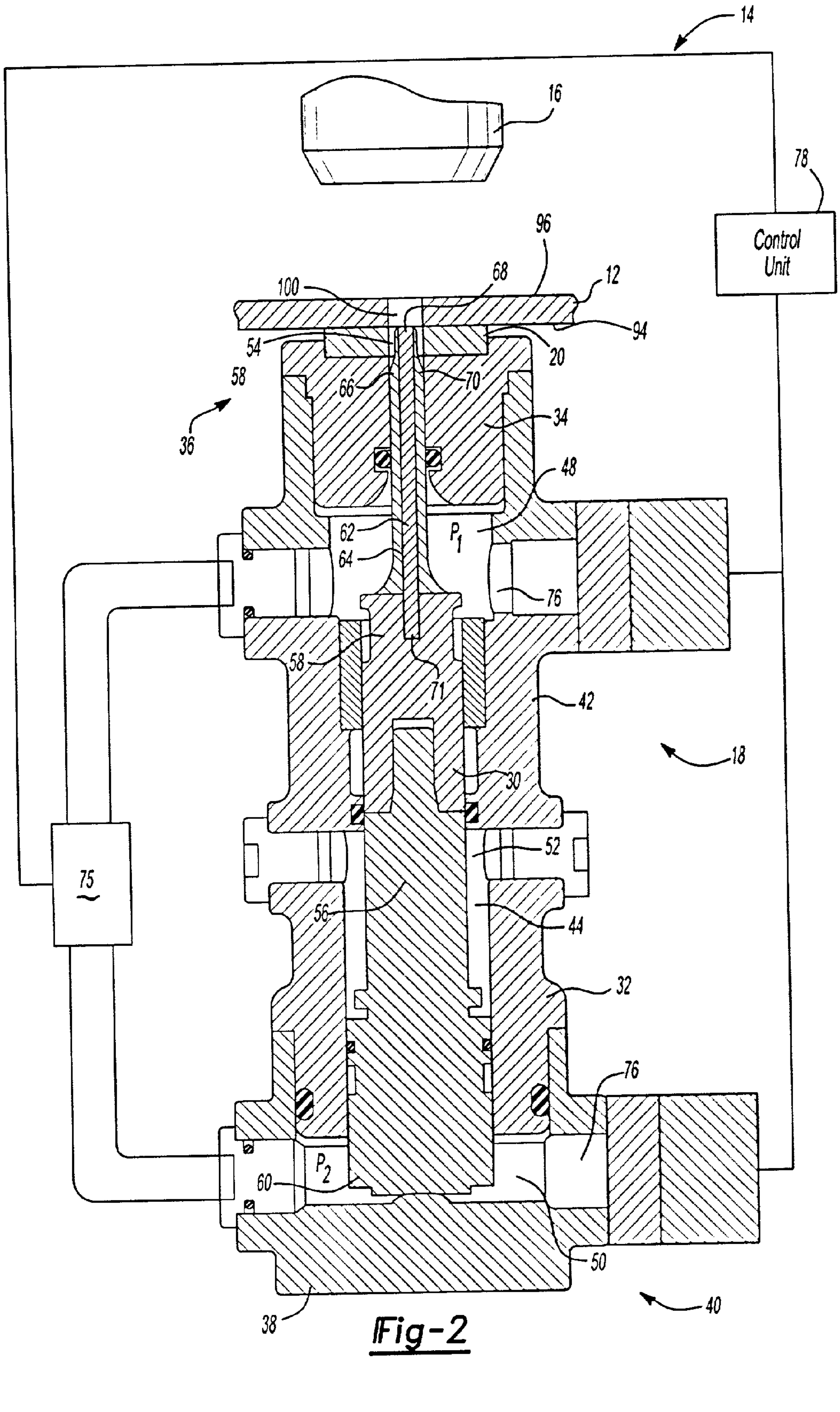

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Fig-2

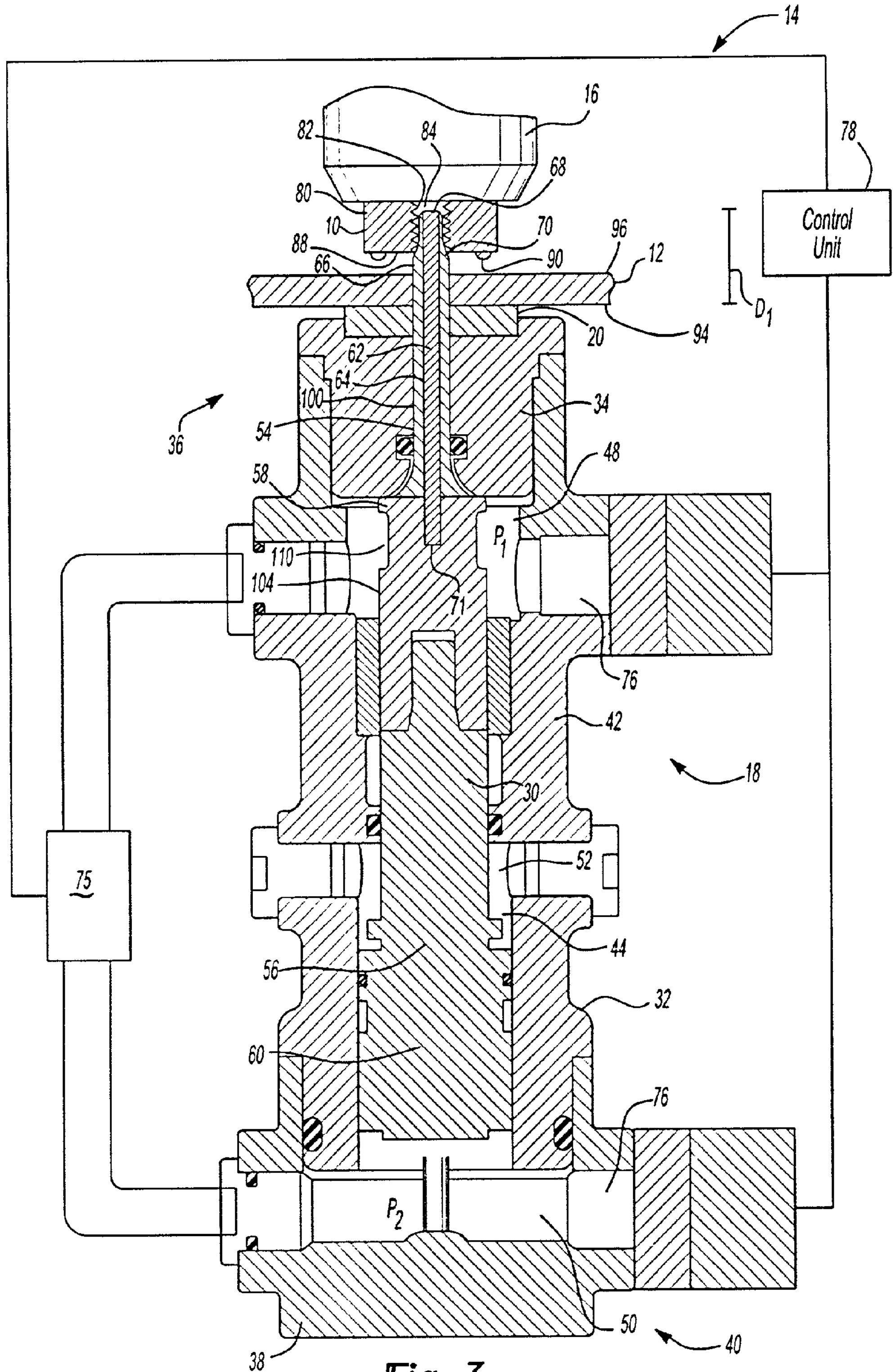
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Fig-3

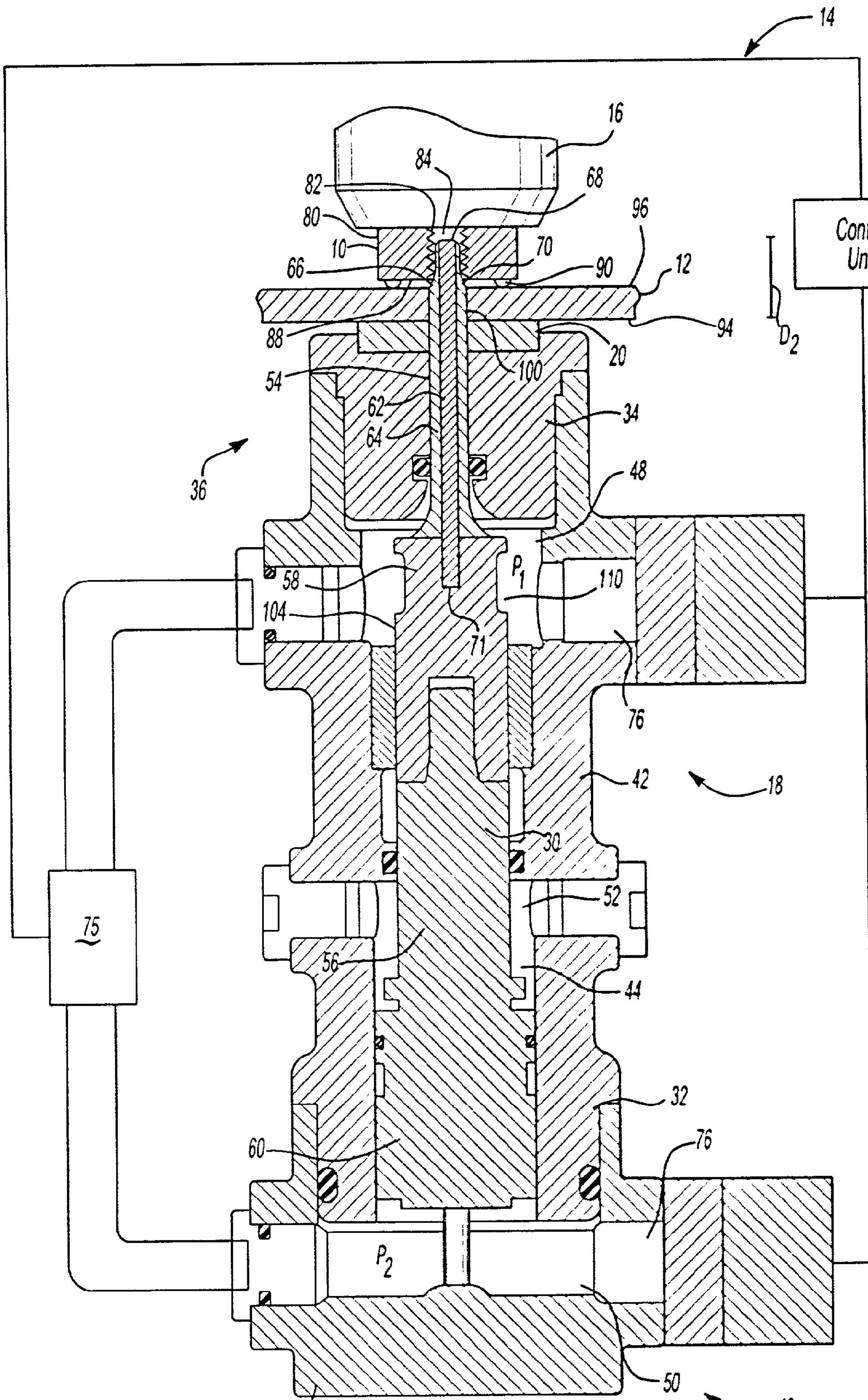
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Fig-4

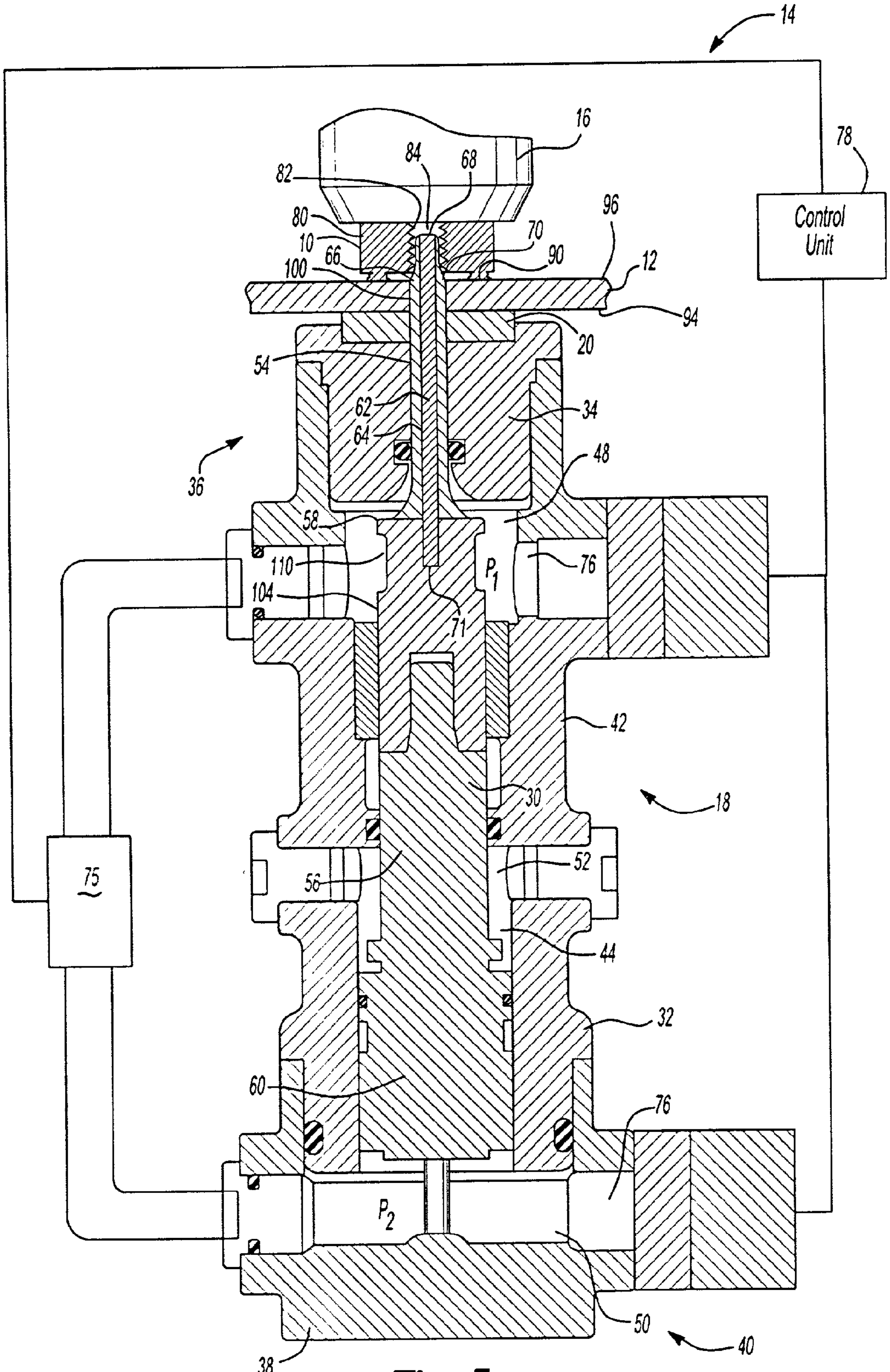
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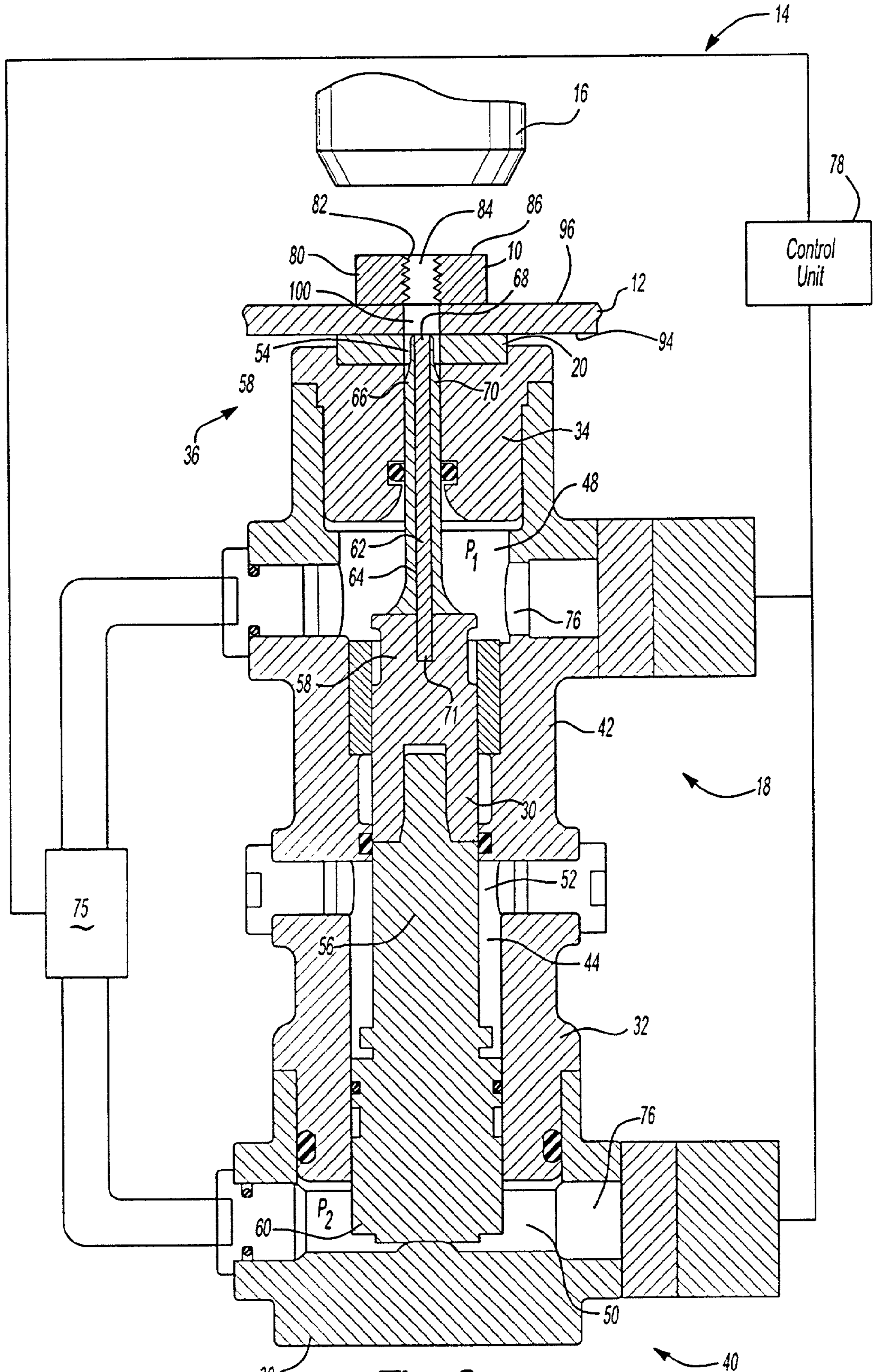
Fig-5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62
P1
64
76
58
71
42
18
30
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56
44
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76
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P2
50
38
40

Fig-6

METHOD AND APPARATUS FOR WELDING A METAL FASTENER TO A METAL MEMBER

FIELD OF THE INVENTION

[0001] The present invention relates to a method and apparatus for welding a fastener to a metal member for assembling automotive vehicle structures.

BACKGROUND OF THE INVENTION

[0002] It is known that the manufacture of automotive vehicles often requires that a metal fastener be attached to a metal member to form an automotive vehicle structure. As an example, it is often desirable that a metal nut with a substantially cylindrical through-hole be welded to a metal sheet with a corresponding through-hole such that the through-holes of the nut and sheet are coaxially aligned. Such an arrangement allows a bolt or other fastener to extend at least partially through the through-holes of both the nut and the sheet.

[0003] Projection welding is one potential method of attaching a fastener to a member. Projection welding typically requires the metal fastener to include one or more protrusions, which are contacted with the metal member. Thereafter, electrodes pass a current through the member, the fastener and the protrusions to heat and soften the protrusions. In turn, the protrusions bond to the member for welding the fastener to the member.

[0004] Conventional projection welding processes, however, present several drawbacks. For example, several different tools may be required to position the fastener and member relative to the electrodes, depending upon the sizes and configurations of the fastener, the member or both. Weld consistency and strength may be less than optimal if the various tools are not properly used for welding fasteners and members of corresponding size. Moreover, conventional processes may not provide any automatic assurances that the fastener is welded to the member. Additionally, electrodes and other tools used for welding the fastener to the member may be rapidly worn or damaged. Thus, there is a need for improved projection welding techniques, instruments or both, for overcoming one or more of the above drawbacks and for achieving high integrity attachment of metal fasteners to metal members.

SUMMARY OF THE INVENTION

[0005] The present invention meets these needs by providing an improved apparatus and method of projection welding a metal fastener to a metal member, with particular utility in the formation of components for an automotive vehicle. The apparatus includes a first electrical contact with a cavity defined therein for correspondingly (e.g., matingly) fitting about at least a partial outer perimeter of the fastener, the cavity being at least partially defined by an inner annular surface of the first contact. The apparatus also includes an outer annular housing having a forward end portion, a rearward end portion, and a central portion defining an internal opening extending internally along a length of the housing. The forward end portion supports a second electrical contact. The internal opening includes a first chamber adjacent the forward portion and a second chamber adjacent the rearward portion and an elongated tunnel intermediate the first and second chambers. Additionally, the forward end portion and the second contact cooperatively define a through-hole of the opening.

[0006] The apparatus further includes a piston assembly including a piston and pin disposed within the opening of the housing. The piston includes a first forward end adjacent the forward end portion of the housing and a second rearward end adjacent the rearward end portion of the housing. The pin includes an inner cylindrical steel core surrounded by an annular insulator. The insulator is formed of a ceramic material and the insulator is thinner about the core at a free end of the pin for forming a shoulder thereon. Preferably, the apparatus includes at least one pressurized fluid source in fluid communication with the first and second chambers for translating the pin and piston assembly between an extended position, an intermediate position and a retracted position. It is also preferable for the apparatus to include a first sensor adjacent to the first chamber and a second sensor adjacent to the second chamber, wherein the first and second switches monitor whether the pin and piston assembly are in the extended position, the intermediate position or the retracted position.

[0007] In operation, an electrical energy source is electrically connected to the first electrical contact and the second electrical contact for passing a current between the contacts and through a plurality of protrusions of the fastener. Moreover, a control unit is in communication with the sensores, the electrical energy source and the fluid source for determining whether the pin and piston assembly have been successfully moved to the intermediate position for welding and for determining whether the pin and piston assembly have been successfully moved to the retracted position for removal of the fastener and member.

[0008] The method of projection welding a metal fastener to a metal member, begins by providing a projection welding apparatus having a first electrical contact and a locator assembly including a piston assembly, at least one sensor and a copper housing, wherein the housing substantially surrounds the piston assembly and supports a second electrical contact. A member is then positioned upon the locator assembly wherein a first surface of the member abuttingly contacts the second electrical contact and a pin of the piston assembly extends through a through-hole in the member. A fastener is positioned upon a pin of the piston assembly such that the fastener is spaced away from the member. The fastener is contacted the with the first electrical contact, which urges the fastener toward the member such that the piston is assembly moves from the extended position to an intermediate position and such that a plurality of protrusions of the fastener contact a second surface of the member. The fastener is then welded to the member by passing a current between the electrical contacts and through the protrusions of the fastener if the at least one sensor senses that the piston assembly has been successfully moved to the intermediate position. Thereafter, the first electrical contact is retracted and the piston assembly is moved to a retracted position and removal of the member and fastener is signaled if the at least one sensor senses that the piston assembly remains in the intermediate position after retraction of the first electrical contact.

[0009] The present invention thus provides an improved projection welding apparatus and projection welding technique for consistently attaching metal fasteners to metal members with high structural integrity welds.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0010**] These and other aspects and advantages of the present invention will become apparent upon reading the following detailed description in combination with the accompanying drawings, in which:

[**0011**] **FIG. 1** illustrates a projection welding apparatus for welding a metal fastener to a metal member.

[**0012**] **FIG. 2** illustrates a sectional view of a portion of the apparatus of **FIG. 1** prior to welding a fastener to a member.

[**0013**] **FIG. 3** illustrates a sectional view of the portion of the apparatus depicted in **FIG. 2** prior to welding a fastener to a member.

[**0014**] **FIGS. 4 and 5** illustrate a sectional view of the portion of the apparatus depicted in **FIG. 2** during welding of the fastener to the member.

[**0015**] **FIG. 6** illustrates a sectional view of the portion of the apparatus depicted in **FIG. 2-5** after welding of the nut to the sheet.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[**0016**] Referring to FIGS. **1-6**, a fastener (shown herein as a metal nut **10**) is welded to a metal member (shown herein as a sheet **12**) by a projection welding apparatus **14**. As best seen in **FIG. 3**, the welding apparatus **14** includes a first electrical contact **16** for contacting the nut **10** and a locator assembly **18**. The locator assembly **18** includes a second electrical contact **20** for contacting the sheet **14** and preferably assists in positioning the nut **10** relative to the sheet **12**.

[**0017**] As shown in **FIG. 1**, the first electrical contact **16** is a copper alloy electrode, which includes a central cavity **22** that is at least partially defined by an inner wall (e.g., annular surface **24**). As specifically illustrated, the inner wall surface **24** defines the central cavity **22** as generally cylindrical in shape, but the surface **24** may also be partially or fully tapered as to form some or all of the cavity **22** in a conical shape, or otherwise suitably configured. Preferably, the inner surface **24** of the contact **16** is formed of or otherwise includes a class **11** copper or copper alloy (such as ELKONITE® commercially available from Contacts Metal Welding, Inc., Indianapolis, Ind.).

[**0018**] Referring to FIGS. **2-6**, the locator assembly **18** of the apparatus **14** includes a generally centrally located piston assembly **30** within a metal (e.g., a copper or copper alloy) housing **32**. The housing **32** includes a forward generally cylindrical portion **34** at one end **36**, a rearward generally cylindrical portion **38** at an opposite end **40** and a central annular portion **42** therebetween. The forward cylindrical portion **34** supports the second electrical contact **20**, which, as shown, is an disk, sheet or annular wafer formed of a conductive metal, such as a class **11** copper or copper alloy (such as ELKONITE® commercially available from Contacts Metal Welding, Inc., Indianapolis, Ind.). Preferably, the forward cylindrical portion **34** is threadably attached to the central portion **42** of the housing **32** toward an end thereof (e.g., at end portion **36**).

[**0019**] Defined within the housing **32** is a centrally located internal opening **44** extending along a length of the housing **32**. The opening **44** includes a first chamber **48** adjacent the forward portion **34** of the housing **32**, a second chamber **50** adjacent the rearward portion **38** and an elongated tunnel **52** intermediate the chambers **48, 50**. Moreover, the opening **44** includes a through-hole **54** that is cooperatively defined by and extends through the forward end portion **34** of the housing **32** and the second electrical contact **20**.

[**0020**] The piston assembly **30** is located within and is moveable along the opening **44**. The piston assembly **30** includes an elongated generally cylindrical piston **56** with a first forward end **58** adjacent the forward end portion **34** of the housing **32** and a second rearward end **60** adjacent the rearward end portion **38** of the housing **32**. Additionally, the piston assembly **30** includes a pin **62** with an inner cylindrical steel core **64** at least partially surrounded by an annular insulator **66**. The insulator **66** is preferably formed of a suitable ceramic material such as sintered silicon nitride (SiN_2). Preferably, the insulator **66** is thinner about the core **64** at a free end **68** of the pin **62** for forming a shoulder **70** thereon. It is also preferred that the pin **62** be removably attached to the piston **56** with a threaded protrusion **71** (threads not shown) that can be threadably fastened within a correspondingly threaded cavity in forward end **58** of the piston **56** for anchoring it in place.

[**0021**] Referring to **FIG. 1**, each of the electrical contacts **16, 20** is electrically connected to an electrical power source **72** (e.g. one including a transformer), which can induce an electrical potential between the contacts **16, 20**. Preferably, at least a portion of the housing **32** is electrically conductive (e.g., made of copper, a copper alloy or another metal) such that the housing **32** may optionally assist in electrically connecting the electrical contact **20** of the locator assembly **18** with the electrical power source **72**.

[**0022**] It is also preferred for the first electrical contact **16** to be mounted to an apparatus (e.g., a pneumatic actuator, a hydraulic actuator, a robot, a C-frame, hard tooling such as a die set or the like) for moving the contact **16** relative to the locator assembly **18**. In the exemplary embodiment of **FIG. 1**, the contact **16** is attached to a pneumatic actuator **74** that can move the contact **16** as needed or desired and the locator assembly **18** is positioned adjacent the actuator **74**.

[**0023**] Referring to FIGS. **1-6**, each of the chambers **48, 50** of the locator assembly **18** is in fluid communication with one or more fluid pressure sources or supplies **75**. As shown, the locator assembly **18** may include various seals to assist in controlling or restricting fluid flow to and from the chambers **48, 50**. Additionally, a pair of sensors **76** (e.g., proximity switches) is attached to the housing **32** for sensing the position of the piston **56** within the chambers **48, 50**. Preferably, the electrical contacts **16, 20** (e.g. through the power source **72**), the sensors **76** and the fluid pressure supply **75** are in signaling communication with a control unit **78**, which may include a suitable programmable logic controller (PLC), a weld controller or the like.

[**0024**] As seen for instance in FIGS. **3-6**, Preferably, the nut **10** being welded to the sheet **12** is generally cylindrical with an outer smooth annular surface **80** and an inner threaded annular surface **82**. The inner annular surface **82** substantially defines a central through-hole **84** extending through the nut **10**. The nut **10** also includes a top annular surface **86** and bottom annular surface **88**. One or a plurality (e.g., 2, 3, 4, 5, 6 or more) of protrusions **90** (e.g., substantially hemispherical protrusions) extend outwardly from the bottom annular surface **88** of the nut **10**. The protrusions **90** are preferably of the same material as the nut **10**, such that they can be integrally formed on the nut. Alternatively, they may be a different material compatible for joining the nut **10** and the sheet **12**. The protrusions **90** thus serve as a high surface area to unit volume mass of material for rapid heating or melting for assisting in weld and joint formation. The sheet **12** is generally planar and includes a first surface **94**, a second surface **96** and a through-hole **100** extending through the sheet **12** and the surfaces **94**, **96**.

[**0025**] In operation, the piston assembly **30** (i.e., the pin **62** and the piston **56**) of the locator assembly **18** is initially in a first retracted position, as shown in **FIG. 2**. While in the retracted position, the sheet **12** is placed on the locator assembly **18** to abuttingly contact the first surface **94** of the sheet **12** with the electrical contact **20**. Preferably, the through-hole **100** of the sheet **12** is at least generally located above the pin **62**.

[**0026**] Once the sheet **12** is in place, the piston assembly **30** is moved (e.g., actuated) to an second extended position as shown in **FIG. 3**. While the piston assembly **30** is in the extended position, the pin **62** matingly extends through the through-hole **100** of the sheet **12**. Preferably, the piston assembly **30** is moved and maintained in the extended position by supplying a fluid pressure P_2 from the fluid supply **75** to the second chamber **50** of the housing **32** that is greater than fluid pressure P_1 in the first chamber **48**. In the extended position, the pin **62** extends outwardly a first distance D_1 from the electrical contact **20**. Preferably, the electrical contact **20** and the insulator **66** of the pin **62** are the only portions of the locator assembly **18** to contact the sheet **12**.

[**0027**] While the piston assembly remains in the extended position, the nut **10** is loaded to the locator assembly **18** by matingly fitting the free end **68** of the pin **62** into the through-hole **84** of the nut **10** such that the nut **10** is supported by the shoulder **70** of the pin **62** and is spaced away from the second surface **96** of the sheet **12**.

[**0028**] For welding, the actuator **74** moves the first electrical contact **16** into contact with the nut **10** and the contact **16** applies a force to the nut **10** urging the nut **10** toward the sheet **12**. Preferably, the inner annular surface **24** of the contact **16** substantially matingly fits about the outer annular surface **80** of the nut **10**. The force applied by the contact **16** overcomes the pressure P_2 in the second chamber **50** to translate the pin **62** along with the piston assembly **30** toward the rearward portion **38** of the housing **32** to a third intermediate position, as shown in **FIG. 4**.

[**0029**] In the intermediate position, the protrusions **90** are brought into abutting contact with the second surface **96** of the sheet **12**. The pin **62** is partially retracted into the through-hole **54** of the second electrical contact **20** and the forward portion **34** of the housing **32** such that the pin **62** extends a second distance D_2 away from the second electrical contact **20**. As shown the second distance D_2 is shorter than the first distance D_1 in **FIG. 3**.

[**0030**] Once the piston assembly **30** is in the intermediate position, the power source **72** passes a current between the electrical contacts **16**, **20**. The current passes through the nut **10**, through the protrusions **90** and through the sheet **12**. Advantageously, the insulating material **66** of the pin **62** electrically isolates the core **64** of the pin **62** from the nut **10** and the sheet **12** thereby assists in forcing the electrical current to pass through and heat to soften and/or melt the protrusions **90**. The voltage producing the current is preferably between about 10.5 to about 36 volt, but may be higher or lower.

[**0031**] The current elevates the temperature of the protrusions **90** thereby softening the protrusions **90**. The heated and softened protrusions **90** are then deformed by and bonded (e.g., metallurgically bonded, welded, solid state welded or the like) to the nut **10** and the sheet **12** by compressing and spreading the softened protrusions **90** between the nut **10** and the sheet **12** as shown in **FIG. 5**. Preferably, the force compressing the protrusions **90** is provided by the actuator **74** urging the nut **10** toward the sheet **12**. The actuator **74** is preferably capable of providing the force (and such force is provided by it) at from about 950 lbs to about 1200 lbs although higher and lower amounts may also be possible.

[**0032**] Prior to passing current through the protrusions **90** as described above, it is preferable for one of the sensors **76** to sense the piston **56** and determine if the piston assembly **30** has been successfully moved to the intermediate position. In the exemplary embodiment of **FIG. 4**, the switch **76** that is adjacent the first chamber **48** continually senses an outer wall **104** of the piston **56** until the piston assembly **30** is moved to the intermediate position. In the intermediate position, a cavity **110** of the piston **56** aligns with the sensor **76** such that the switch **76** no longer senses the piston **56**.

[**0033**] If the switch **76** senses that the actuator **74** has successfully moved the piston assembly **30** to the intermediate position, it typically indicates that the sheet **12** and nut **10** have been properly loaded on the locator assembly **18**. In that situation, the switch **76** signals the control unit **78** and the control unit **78** signals the power source **72** to pass current through the protrusions **90** to weld the nut **10** to the sheet **12**.

[**0034**] If the switch **76** does not sense that the actuator **74** has successfully moved the piston assembly **30** to the intermediate position (i.e., it has stayed in the extended position), it typically indicates that the sheet **12**, the nut **10** or both have been improperly loaded on the locator assembly **18**. For example, there may have been failure to load the nut **10** onto the shoulder **70** of the pin **62**. In this situation, the switch **76** does not signal the power source **72** to pass current through the protrusions **90** and, preferably, the control unit **78** initiates a signal designed to inform that the nut **10** has not been contacted with the sheet **12**.

[**0035**] During welding, the pressure P_2 in the second chamber **50** is sufficient for maintaining the shoulder **70** of the pin **62** biased against the nut **10**, which, in turn, substantially maintains the piston assembly **30** in the intermediate position. After welding, the actuator **74** retracts the first electrical contact **16** away from the sheet **12** and the nut **10**.

[**0036**] If, after retraction of the electrical contact **16**, the nut **10** is welded to the sheet **12**, the pin **62** remains biased against the nut **10** in the intermediate position. In this situation, the control unit **78** signals the one or more fluid pressure supplies **72** to lower the pressure P_2 in the second chamber **50** to below the pressure P_1 in the first chamber **48** such that the piston assembly **30** is moved back to the retracted position as shown in **FIG. 6**.

[**0037**] If the nut **10** is not welded to the sheet **12**, the pressure P_2 in the second chamber **50** will push the piston assembly **30** and the pin **62** back to the extended position of **FIG. 3**. In this situation, the sensor **76** senses the wall **104** of the piston **56** and sends a signal to the control unit **78**, which, preferably, initiates a signal designed to inform that the nut **10** has not been properly welded to the sheet **12**.

[**0038**] In the case of proper welding and upon retraction of the piston assembly **30**, the other sensor **76** (e.g., the switch **76** adjacent the rear portion **38** of the housing **32**) senses the presence of the piston **56** within the second chamber **50**. Upon sensing the piston **56**, the sensor **76** signals the control unit **78**, which, preferably, initiates a signal designed to inform that the nut **10** has been welded to the sheet **12** and that the sheet **12** and nut **10** combination may be removed from the locator assembly **18**. Once the sheet and nut combination is removed, the piston assembly **30** may remain in the retracted position of **FIG. 2** to load a new sheet on the locator assembly **18** and repeat the welding process.

[**0039**] Advantageously, by retracting the piston assembly **30** to the retracted position prior to loading the sheet **12** on the locator assembly **18** and prior to removing the sheet **12** and nut **10** combination from the locator assembly **18**, the pin **62** is substantially surrounded by the upper portion **34** of the housing **32** and the second electrical contact **20**. In this manner, the pin **62** is protected from potential damage, which might otherwise be caused by the loading or removal of the sheet **12** and nut **10** if the pin **62** were extended.

[**0040**] In a highly preferred embodiment of the invention, a standardized set of through-hole sizes (e.g. 2, 3, 4, 5 or more sizes) for the nuts and sheets may be provided such that a standard set of pins corresponding to the through-hole sizes may also be provided. Preferably, the pins of the set are easily interchangeable to and from the locator assembly **18**. In the exemplary embodiment of FIGS. **2-4**, the upper portion **34** of the housing **32** is threadably attached to the intermediate portion **42** of the housing **32** and the pin **62** is interchanged with another pin by threadably removing the upper portion **34** and pin **62** and replacing them with a second upper portion and pin.

[**0041**] It shall be appreciated that the apparatus and method described above may be used for welding nuts to several different automotive components that have sheet metal or sheet metal portions. Examples include various vehicle panels such as door panels, decklids, hoods, floorboards, floorpans, rear seat back panels, roof panels or the like. It should be further understood that the apparatus and method described above may be used to attach nuts and other fasteners such as a stud or the like to other metal members other than sheets.

[**0042**] It should be understood that the invention is not limited to the exact embodiment or construction that has been illustrated and described, but that various changes may be made without departing from the spirit and the scope of the invention.

What is claimed is:

1. A projection welding apparatus for welding a metal fastener to a metal member, the fastener including a plurality of protrusions, the apparatus comprising:

(a) a first electrical contact with a cavity for matingly fitting an outer perimeter of the fastener, the cavity being a least partially defined by an inner annular surface of the first contact;

(b) an outer annular housing having a forward end portion, a rearward end portion and a central annular portion defining an internal opening extending internally along a length of the housing, wherein:

i) the forward end portion supports a second electrical contact;

ii) the internal opening includes a first chamber adjacent the forward portion and a second chamber adjacent the rearward portion and an elongated tunnel intermediate the first and second chambers; and

iii) the forward end portion and the second contact cooperatively define a through-hole of the opening;

(c) a piston assembly disposed within the opening of the housing, the piston assembly including a piston and a pin wherein;

i) the piston includes a first forward end adjacent the forward end portion of the housing and a second rearward end adjacent the rearward end portion of the housing;

ii) the pin includes an inner cylindrical steel core surrounded by an annular insulator, the insulator formed of a ceramic material, the insulator being thinner about the core at a free end of the pin for forming a shoulder thereon

(d) at least one pressurized fluid source in fluid communication with said first and second chambers for translating the pin and piston assembly between an extended position, an intermediate position and a retracted position;

(e) a first sensor adjacent to said first chamber and a second sensor adjacent to said second chamber, said first and second switches for monitoring whether the pin and piston assembly are in the extended position, the intermediate position or the retracted position;

(f) an electrical energy source electrically connected to the first electrical contact and the second electrical contact for passing a current between the contacts and through the plurality of protrusions; and

(g) a control unit in communication with the sensors, the electrical energy source and the fluid source for determining whether the pin and piston assembly have been successfully moved to the intermediate position for welding and for determining whether the pin and piston assembly have been successfully moved to the retracted position for removal of the fastener and member.

2. A projection welding apparatus as in claim 1 wherein the fastener is a nut.

3. A projection welding apparatus as in claim 2 wherein the metal member is a sheet.

4. A projection welding apparatus as in claim 1 wherein the fastener is a stud.

5. A projection welding apparatus as in claim 4 wherein the metal member is a sheet.

6. A projection welding apparatus as in claim 1 wherein the inner annular surface of the first electrical contact is at least partially formed of a class **11** copper alloy and the second electrical contact is a wafer formed of class **11** copper alloy.

7. A projection welding apparatus as in claim 1 wherein the outer annular housing includes copper.

8. A locator assembly for positioning a fastener and a member for projection welding of the fastener to the member, the assembly comprising:

(a) a copper outer annular housing having a forward end portion, a rearward end portion and a central annular portion defining an internal opening extending internally along a length of the housing, wherein:

i) the forward end portion supports a second electrical contact;

ii) the internal opening includes a first chamber adjacent the forward portion and a second chamber adjacent the rearward portion and an elongated tunnel intermediate the first and second chambers, the first and second chambers adapted for receiving pressurized fluid from at least one fluid source; and

iii) the forward end portion and the second contact cooperatively define a through-hole of the opening;

(c) a piston assembly disposed within the opening of the housing, the piston assembly including a piston and a pin wherein;

i) the piston includes a first forward end adjacent the forward end portion of the housing and a second rearward end adjacent the rearward end portion of the housing;

ii) the pin includes an inner cylindrical steel core surrounded by an annular insulator, the insulator being thinner about the core at a free end of the pin for forming a shoulder thereon.

9. A locator assembly as in claim 8 wherein the fastener is a nut.

10. A locator assembly as in claim 9 wherein the metal member is a sheet.

11. A locator assembly as in claim 8 wherein the fastener is a stud.

12. A locator assembly as in claim 11 wherein the metal member is a sheet.

13. A locator assembly as in claim 8 wherein the inner annular surface of the first electrical contact is at least partially formed of a class **11** copper alloy and the second electrical contact is a wafer formed of class **11** copper alloy.

14. A locator assembly as in claim 8 wherein the outer annular housing includes copper.

15. A method of projection welding a metal fastener to a metal member, comprising the steps of:

(a) providing a projection welding apparatus having a first electrical contact and a locator assembly, the locator assembly including a piston assembly, at least one sensor and a copper housing, the housing substantially surrounding the piston assembly and supporting a second electrical contact;

(b) positioning a member upon the locator assembly wherein a first surface of the member abuttingly contacts the second electrical contact and a pin of the piston assembly extends through a through-hole in the member;

(c) positioning a fastener upon a pin of the piston assembly such that the fastener is spaced away from the member;

(d) contacting the fastener with the first electrical contact to urge the fastener toward the member such that the piston assembly moves from the extended position to an intermediate position and such that a plurality of protrusions of the fastener contact a second surface of the member;

(e) welding the fastener to the member by passing a current between the electrical contacts and through the protrusions of the fastener if the at least one sensor senses that the piston assembly has been successfully moved to the intermediate position;

(f) retracting the first electrical contact; and

(g) moving the piston assembly to a retracted position and signaling for the removal of the member and fastener if the at least one sensor senses that the piston assembly remains in the intermediate position after retraction of the first electrical contact.

16. A method as in claim 15 wherein the fastener is a nut.

17. A method as in claim 16 wherein the metal member is a sheet.

18. A method as in claim 15 wherein the fastener is a stud.

19. A method as in claim 18 wherein the metal member is a sheet.

20. A method as in claim 15 wherein the inner annular surface of the first electrical contact is at least partially formed of a class **11** copper alloy and the second electrical contact is a wafer formed of class **11** copper alloy.

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