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(54) Nozzle assembly for plasma spray gun.

(57) A nozzle assembly for a plasma gun is disclosed, containing an annular coolant passage for extended nozzle life, providing for convenient and low cost replacement of the nozzle member and for improved gun operation. To form the assembly a jacket is disposed about the nozzle member in a predetermined coaxial position. An inner surface of the jacket cooperates with the cylindrical exteriority of the nozzle to define an annular coolant passage. The jacket and the nozzle are in relative slidable relationship such that the jacket is removable and replaceable forwardly with respect to the nozzle member, forwardly being in respect to the direction of the plasma flame. Threading means and pilot surfaces engaged between the nozzle member and the jacket at the rearward end of the nozzle assembly cooperate to retain the jacket in its predetermined position relative to the nozzle member. The jacket has coolant ports for the coolant connecting with the annular passage. A seal such as an O-ring is interposed between the forward portion of the nozzle and the jacket. A rear O-ring seal is set in a groove formed cooperatively between a rear annular surface of the jacket and a rim on the nozzle member.

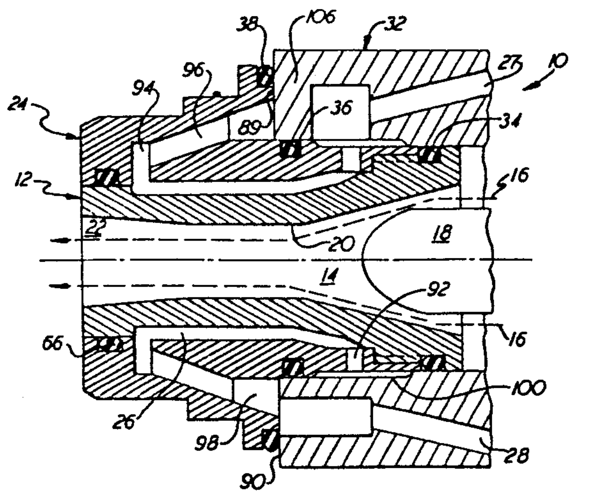

FIG. 1

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NOZZLE ASSEMBLY FOR PLASMA SPRAY GUN

This invention relates to a plasma spray gun and particularly to a nozzle assembly therefore which has an efficient nozzle cooling system and a readily replaceable nozzle.

Background of the Invention

Flame spraying involves the heat softening of a heat fusible material, such as a metal or ceramic, and propelling the softened material in particulate form against a surface which is to be coated. The heated particles strike the surface and bond thereto. A conventional flame spray gun is used for the purpose of both heating and propelling the particles. In one type of flame spray gun, the heat fusible material is supplied to the gun in powder form. Such powders are typically comprised of small particles; e.g., below 100 mesh U.S. standard screen size to about 5 microns.

In typical plasma flame spraying systems for spraying powder, an electric arc is created between a water cooled nozzle (anode) and a centrally located cathode. An inert gas passes through the electric arc and is excited thereby to temperatures of up to 30,000°F. The plasma of at least partially ionized gas issuing from the nozzle resembles an open oxy-acetylene flame. A typical plasma flame spray gun is described in U.S. Patent No. 3,145,287.

The electric arc of such plasma spray guns, being as intense as it is, causes nozzle deterioration and ultimate failure. A cause for such deterioration is the fact that the arc itself strikes the nozzle/anode at a point, thereby causing instantaneous local melting and vaporizing of the nozzle surface. Deterioration is also caused by overheating the nozzle to the melting point so that part of the nozzle material flows to another location which may eventually cause the nozzle to become plugged.

There are varying degrees and rates associated with each cause for nozzle deterioration. Experience has shown that wall erosion, ultimately causing the pressurized coolant to burst through the nozzle wall, is another cause of nozzle failure. When the jacket bursts, coolant water is released into the arc region, resulting in a locally intense electric arc, causing parts to melt. Once a meltdown has occurred, gun repair can be very costly. The nozzle deterioration and failure problem is particularly severe at high power levels.

In seeking to overcome this problem, plasma flame spray guns have been designed with easily changed water cooled nozzles. During operation, water coolant is forced through passages in the nozzle to cool the nozzle walls. Even so, gradual, or sometimes rapid, deterioration occurs and, as a precaution against failure, the nozzles are usually replaced after a given number of hours of service. This practice of replacing the nozzle periodically, however, is quite costly because the interchangeable nozzles are fairly expensive and many nozzles with considerable life remaining are thereby discarded.

U.S. Patent No. 4,430,546 describes a plasma spray gun nozzle with a thin wall and a thin annular coolant passage to provide extended life. Specific dimensions of the wall and passage are disclosed to assure maximum nozzle life. That development substantially increased the life expectancy of nozzles, especially in heavy duty plasma guns. However, the construction of the nozzle incorporating the coolant passage, as taught therein, is not conducive to achieving low cost for parts, particularly with respect to nozzle replacement. In particular a one-piece unitary nozzle containing cooling passages is expensive. An alternative method suggested in the above-named patent incorporates a pair of "clam shell" parts that fit about the nozzle, but these are not easy to use and can allow by-pass leaking of the coolant.

An improved nozzle assembly is utilized in a plasma gun sold by METCO Inc., Westbury, New York as Type MBN, and is taught in copending Application Serial No. 646,734 filed September 4, 1984 of the present assignee. In such assembly a jacket and nozzle are in relative slidable relationship such that the nozzle member is removable and replaceable forwardly with respect to the jacket, forwardly being in respect to the direction of the plasma flame. The assembly provides for convenient and low cost replacement of nozzle members, including nozzles having different sized bores. However, such flexibility does not allow for the maintaining the aforementioned optimized nozzle wall dimensions with respect to cooling of the different sized nozzles.

Another form of nozzle insert in an arc torch device containing an annular cooling passage is shown in U.S. Patent No. 3,106,631. It has several deficiencies including lack of full structural support between nozzle anode 12 and water sleeve 14. Alignment, a critical factor in plasma guns, could be a problem.

Therefore, it is an objective of the present invention to provide for a plasma spray gun an improved nozzle assembly containing a coolant passage.

It is a further object to provide a novel nozzle assembly which contains a coolant passage for extended nozzle life in a plasma spray gun and which allows convenient and low cost replacement of the nozzle.

It is yet a further object to provide an improved nozzle assembly for a plasma gun having a thin wall and a thin annular coolant passage, which is well aligned in the gun and allows convenient and low cost replacement of the nozzle.

It is another object to provide for a plasma spray gun a nozzle assembly with a coolant passage therein and having improved operation and low cost maintenance.

Brief Description of the Invention

The foregoing and other objects of the present invention are achieved by a nozzle assembly for a plasma gun in which the assembly is comprised of a generally tubular nozzle member and a jacket of generally hollow cylindrical configuration disposed in predetermined coaxial position about the nozzle member. The inside surface of the jacket cooperates with the cylindrical exteriority of the nozzle member to define an annular coolant passage. The jacket and nozzle member are in relative slideable relationship for removal of the jacket forwardly, and subsequent replacement rearwardly, with respect to the nozzle member, forwardly being in the direction of the plasma flame. The jacket has two sets of coolant ports respectively adjacent the cathode and near the distal end, the ports connecting between the annular coolant passage and respective passages in the gun body. A replaceable seal such as an O-ring is interposed between the corresponding forward portions of the nozzle member and the jacket to retain coolant. Additional seals cooperating with the body of the plasma gun are located, respectively, at a flange on the forward section of the jacket, at the central section of the jacket between the respective sets of coolant ports, and at the rear section of the nozzle assembly. Threading means and pilot surfaces engaging between the nozzle member and the jacket at the rearward end of the nozzle assembly cooperate to retain the jacket in its predetermined position relative to the nozzle member. The rear O-ring seal is set in a groove formed cooperatively between the rear annular surface of the jacket and a rim in the nozzle member.

Brief Description of the Drawings

The drawings illustrate various parts of a plasma gun according to the present invention wherein:

Fig. 1 is a longitudinal sectional view of a portion of a plasma gun incorporating the present invention.

Fig. 2 is a longitudinal sectional view of a nozzle assembly of the present invention incorporated in Fig. 1.

Fig. 3 is a longitudinal sectional view of a portion of a plasma gun incorporating an alternative embodiment of the present invention.

Detailed Description of the Invention

Referring to Fig. 1, the nozzle according to the present invention has an overall configuration somewhat like that of U.S. Patent No. 3,145,287 and is designed to fit into a plasma spray gun 10 such as Type 9MB manufactured by METCO Inc., Westbury, New York. The nozzle member 12, also shown in Fig. 2, has a central passage indicated generally at 14 through which gases travel in a direction indicated generally by the arrows 16. Entering central passage 14 from the right is an elongated and rounded (or pointed) tipped cathode member 18 which is electrically isolated from the other elements shown in Fig. 1. When the flame spray gun is operating, an arc extends from cathode 18 to the inner wall of the nozzle indicated generally at 20. It should be noted that the arc contact point with inner wall 20 does not remain at one position but tends to travel over a large portion of inner wall 20. The arc excites the gases causing a plasma flame to issue from the exit end of the nozzle indicated generally at 22.

Nozzle member 12 comprises the anode of the gun and is designed with a certain wall thickness in the region likely to be in direct contact with the arc. The inner member preferably is made out of substantially pure copper (preferably at least 99% pure) and, for this material, should be relatively thin with a uniform wall thickness in the range of about 1.9mm to 2.8mm (0.075 to 0.110 inches).

Copper is a preferred material for many of the parts of the nozzle because of its electrical and thermal properties. That is, copper is a good electrical and thermal conductor and yet has a relatively high melting point. Those of skill in the art will recognize that other metals or alloys with thermal and electrical properties substantially like those of copper can be used for the parts of nozzle assembly according to the present invention although the dimensions may need to be adjusted somewhat to optimize nozzle life. Alternatively nozzle member 12 may include a tungsten liner (not shown) along the inner surface 14, or the entire nozzle member may even be formed of tungsten or the like having a very high melting point to minimize surface melting by the arc.

As disclosed in U.S. Patent No. 4,430,546 the dimensions herein are important at a point radially outward of the location where the arc of the gun strikes the nozzle. This location is determined first by making a nozzle of the desired shape and running it under the desired operating conditions for a short time. The place of maximum erosion will identify the location where the arc strikes the nozzle. The dimensions radially outward of the points where the arc strikes are then decided on.

A jacket 24 may be made of substantially pure copper or other materials including alloys such as brass and is shaped to fit together with the nozzle member 12 to form an annular passage 26 for coolant, which passage communicates with coolant passages 27, 28 of flame spray gun 10 to which the jacket attaches to permit cooling the nozzle during operation thereof.

Nozzle assembly 30, shown per se in Fig. 2, consists of nozzle member 12 and coaxial jacket 24. The assembly closely fits in a cylindrical cavity of the gun body 32 and is insertable and removable forwardly from gun 10. (As used herein, the term "forward" and terms derived therefrom or synonymous or analogous thereto, have reference to the end from which the plasma flame issues from the gun; similarly "rearward" etc. denote the opposite location.) When in place, nozzle assembly 30 is positioned coaxially within the gun body with O-ring seals 34, 36 and 38 (Fig. 1) disposed in respective grooves 40, 42 and 44 (Fig. 2).

Central passage 14 of nozzle member 12 is coaxial with cathode member 18 (Fig. 1) and in the middle portion of the nozzle the middle bore portion of the central passage is preferably of constant diameter. The forward end at exit end 22 of central passage 14 may also be of constant diameter equal to that of the mid-portion or may diverge in the forward direction as shown in Figs. 1 and 2. The rear portion at the inlet end 56 (Fig. 2) of central passage 14 diverges rearwardly and cooperates with cathode member 18 to sustain an arc in plasma-forming gas flowing through the nozzle member. The operative relative dimensions and spacing of the central passage and electrode member for proper plasma gun operation are well known in the art.

With reference to Fig. 2, the nozzle member 12 has a generally cylindrical middle portion having an exteriority 52 coaxial with the bore, and has a rear rim 54 located generally radially outward from the inlet (rearward) end 56. A taper portion 58 of exteriority 52 is situated where central passage 14 begins to diverge rearwardly, conforming to the rearward divergence of central passage 14 at inlet end 56.

Jacket 24 is positioned to generally surround nozzle member 12 in a predetermined coaxial position. The jacket is of generally hollow configuration. The central section 63 of the jacket has a central inside surface 60 cooperating with exteriority 52 of nozzle member 12 to define annular passage 26 for coolant. Desirably the inside surface 60 and the middle portion of exteriority 52 of nozzle member 12, as well as taper portion 58, are of such diameters as to cooperate in forming thin annular passage 26 of uniform height preferably in the range of 0.64mm to 0.27mm (.025 to .050 inches), for example 0.76mm (.030 inches), for the purposes of high coolant velocity and efficient cooling as disclosed in aforementioned U.S. Patent No. 4,430,546.

The forward section 64 of jacket 24 has an inner surface 62 cooperative with a cylindrical outer surface (also at 62) of the forward portion of nozzle member 12 for positioning and alignment. The diameters at 62 are such that the jacket is removable and replaceable from the nozzle member forwardly with respect to the nozzle member. An inner seal 66 to retain coolant is provided between outer surface 62 of the nozzle and forward inner surface (62) of the jacket, capable of detachment for disassembling the nozzle assembly into its main components, the nozzle and jacket. Preferably the forward inner surface 62 of the jacket has an annular groove 68 therein with a standard O-ring seal (at 66) of rubber or the like in sealing contact with the forward cylindrical outer surface of the nozzle member.

Internal threading 70 is disposed in the inside surface of the rear section 65 of jacket 24 and is adapted to engage with corresponding external threading (also at 70) of nozzle member 12 to retain the nozzle member in the jacket. Axial positioning is determined by an annular shoulder face 74 located forward of the external threading on the nozzle. Face 74 contacts a seating shoulder 76 similarly located in the inside surface of the jacket. Precise concentricity of the nozzle and jacket at the rear is maintained by a short annular pilot surface 78 on the nozzle member 12 forwardly adjacent to annular face 74. Pilot surface 78 closely fits in the corresponding portion of the inside surface of the jacket (also shown at 74) forwardly adjacent to seating shoulder 76. The threading and contacting surfaces also serve to conduct the arc current between the nozzle member and the power source (not shown).

A flange 88 is located concentrically on the jacket, approximately at mid-point of its length at the longitudinal mid-point. A step 44 on the rear side of the flange provides a groove for O-ring seal 38 (Fig. 1). Flange face 89 and seal 38 coact with front face 90 of gun body 32 to position nozzle assembly 30 axially and to seal against leakage of the coolant. The assembly is held in the gun body by means of a retaining ring (not shown) over flange 88 as depicted in aforementioned U.S. Patent No. 3,145,287.

In a preferred embodiment of the present invention as detailed in Fig. 2, inlet end 56 of nozzle member 12 extends rearward of jacket 24 a distance sufficient to provide for O-ring seal 34. In particular, O-ring groove 40 is defined by three surfaces, namely, the forward-facing annular wall 80 of the rim 54 of nozzle member 12, the outward-facing cylindrical surface segment 82 that forms the inner boundary of rim wall 80, and the rearward facing annular surface 84 that forms the rear end of jacket 24. As indicated hereinabove O-ring 34 engages with body 32 of the gun to retain the coolant.

A plurality of arcuate coolant ports 92 are equiangularly spaced about the circumference of the jacket just forward of seating shoulder 76. Each of the ports 92 is in direct flow communication with annular coolant passage 26. Jacket 24 is further shaped to cooperate in providing a narrow annular passage 100 which acts as a manifold and communicates between ports 92 and at least one channel 27 in body 32 (fig. 1) thereby providing a flow path for the coolant fluid.

Jacket 24 is additionally shaped to define an annular slot 94 which forms an outward extension of annular coolant passage 26 just rearward of inner seal 66. Communicating with slot 94 is a second set of arcuate (in cross-section) cooling ports 96 which are preferably disposed evenly around the jacket to provide a plurality of coolant passages leading from a generally annular-shaped manifold passage 98. Passage 98 is formed between jacket flange 88 and a wall portion 106 of body 32 (Fig. 1) that forms a barrier between the coolant infeed and the coolant outfeed. The plasma spray gun body 32 additionally includes a second coolant channel 28 for coolant flow, which extends rearward from annularly shaped passage 98. O-ring seal 36 in external groove 42 located between the two sets of coolant ports 92 and 96 coacts with gun body 32 to separate the two coolant manifolds 98 and 100.

The arcuate configuration of the respective sets of ports 92 and 96 in communication with annular coolant passage 26 at its forward and rearward ends provides even radial distribution of coolant into and out of passage 26 with minimum physical obstruction. Preferably the cooling fluid enters channel 27 (Fig. 1) and then narrow annular passage 100. From annular passage 100, the fluid flows through the plurality of ports 92 into thin annular passage 26 formed between nozzle member 12 and jacket 24. The coolant flow rate is sufficient to maintain the exterior surface of nozzle 12 at a temperature close to 100° Centigrade. The fluid then passes from thin annular passage 26 through slot 94, ports 96 and annular passage 98 and exits through channel 28.

The nozzle assembly according to the invention yields a structure for efficiently cooling the nozzle giving it longer life, while providing a convenient means for removing and replacing the nozzle in a plasma spray gun for routine maintenance or when the nozzle becomes excessively eroded from the arc. The assembly 30 is removed from the gun body 32 as a unit, and the jacket 24 is readily removed from the nozzle member 12, which is then replaced and the procedure reversed. This method provides for low cost construction and economical maintenance.

While the foregoing description has emphasized the design of a nozzle assembly for one type of plasma gun as illustrated in Figs. 1 and 2, those of skill in the art will readily recognize that the specific design may take other forms. For example, the nozzle assembly may be designed to fit a plasma gun of the type shown and described in U.S. Patent No. 4,445,021, sold by METCO Inc. as Type 10MB.. Such a nozzle assembly 30' as located in the forward part of gun 10' is shown in Fig. 3. The nozzle member 12' may be the same as that shown in Figs. 1 and 2; however, the jacket 24' is formed of three separable sections juxtaposed axially. (For clarity with reference to Fig. 3, numbers designated with a prime (') denote parts comparable to those shown in Fig. 1 and Fig. 2.)

A central section 63' of jacket 24' has a central inside surface 60' of the configuration described hereinabove with respect to Figs. 1 and 2, said surface cooperating with the nozzle member 12' to define the annular cooling passage 26'. A forward section 64' contains an interior O-ring groove 68' for sealing with the forward cylindrical outer surface 62' of the nozzle member 12'. Forward section 64' also serves to retain the nozzle assembly in the gun by means of internal threads 116 in a forward flange 117 engaging with corresponding threads on the gun body 32'.

A rear section 65' of jacket 24' has internal threading 70' therein that engages with the external threading (also 70') of the nozzle member 12'. In this embodiment the O-ring seal 34' rearward by adjacent the threading retains coolant in the annular cooling passage 26', and an additional O-ring seal 120 is disposed in the back face 122 of rear section 65' to prevent the plasma gas from bypassing its regular channelling which is via a gas manifold 124 and one or more gas ports 126. The groove for O-ring 34' is defined analogonaly to the embodiment of Fig. 2.

The three jacket sections 63', 64' and 65' are juxtaposed axially with close fitting annular shoulder areas 128 and 130 respectively engaging together the forward and central jacket parts and the rear and central jacket parts cooperatively to form jacket 24'.

An inset shoulder on a central flange 88' of central section 63' of jacket 24' receives an O-ring 36' for sealing against body 32' between rear and forward manifolds 100' and 98'. A rearwardly directed rim 132 on forward section 64' of the jacket has a groove with O-ring 38' engaged with the body forward of forward manifold 98' to retain coolant therein. A further O-ring seal 138 is situated in a groove in the outer surface of rear jacket section 65'between rear coolant manifold 100' and gas manifold 124.

A plurality of arcuate forward ports 96' are equiangularly spaced about the circumference of a forward rim 134 of central section 63' communicating between forward annular coolant manifold 98' and the annular cooling passage 26'. A plurality of arcuate rear ports 92' in a rear rim 136 of central section 63' similarly communicate between rear coolant manifold 100' and the annular cooling passage. The forward and rear ports 96', 92' of Fig. 3 are in this embodiment, each in the form of a set of three large dished out sections of the respective rims. Preferably coolant flows from inlet passage 28' through the forward manifold and forward ports, thence rearward through the annular cooling passage and out through the rear manifold and rear ports and outlet passage 27'.

While the invention has been described above in detail with reference to specific embodiments, various changes and modifications which fall within the spirit of the invention and scope of the appended claims will become apparent to those skilled in this art. The invention is therefore only intended to be limited by the appended claims or their equivalents.

What is Claimed is:

1. A nozzle assembly for fitting into the body of a plasma gun, comprising:

a tubular nozzle member having a generally cylindrical exteriority;

a jacket of generally hollow cylindrical configuration, disposed in a predetermined coaxial position about the nozzle member and having a central inside surface cooperating with the cylindrical exteriority of the nozzle member to define an annular coolant passage, the jacket and nozzle member being in relative slidable relationship for axial removal and replacement of the jacket forwardly with respect to the nozzle member;

threading means to retain the nozzle member in the predetermined coaxial position with respect to the jacket; and

fluid seal means interposed between the nozzle member and the jacket at a location forward of the annular coolant passage.

2. A nozzle assembly for fitting into the body of a plasma gun, comprising:

(a) tubular nozzle member comprising a rear portion with external threading thereon, a forward portion with a cylindrical outer surface and, therebetween, a middle portion having a generally cylindrical exteriority;

(b) a jacket of generally hollow cylindrical configuration, disposed in a predetermined coaxial position about the nozzle member, comprising:

a cylindrical central section with an inside surface cooperating with the cylindrical exteriority of the nozzle member to define an annular coolant passage;

a cylindrical rear section with internal threading therein engaged with the external threading of the nozzle member to retain the jacket in the predetermined position relative to the nozzle member;

a cylindrical forward section with a forward inside surface;

a rear portal section disposed between the central section and the rear section, having one or more first coolant ports communicating with the annular coolant passage; and

a forward portal section disposed adjacent the central section and the cylindrical forward section, having one or more second coolant ports communicating with the annular coolant passage;

the jacket and nozzle member being in relative slidable relationship for axial removal and replacement of the jacket forwardly with respect to the nozzle member; and

(c) a first detachable means for sealing to retain coolant, interposed between the outer surface of the forward portion of the nozzle member and the inside surface of the forward section of the jacket.

3. The nozzle assembly of Claim 2, wherein the middle portion of the nozzle member has a wall thickness in the range of about 1.9 to about 2.8mm, and the width of the annular coolant passage is in the range of about 0.84mm to about 1.27mm, said wall thickness and width ranges being in substantially the entire region outward of the area of where the arc terminates.

4. The nozzle assembly of Claim 2, wherein:

the nozzle member has a central passage with a middle bore portion that is substantially uniform in diameter and an inlet portion that diverges rearwardly;

the cylindrical exteriority of the nozzle member has a central portion that is substantially uniform in diameter and has a tapered portion that diverges rearwardly such that the wall thickness in the central portion and the tapered portion is generally uniform in substantially the entire region outward of the area where the arc terminates;

the cylindrical central section of the jacket cooperates with the central portion of the nozzle exteriority and with the tapered exteriority of the nozzle such that the width of the annular coolant passage in the region of the middle portion and the tapered portion is generally uniform in substantially the entire region outward of the area where the arc terminates.

5. The nozzle assembly of Claim 2 wherein the first detachable sealing means comprises the inner surface of the forward section of the jacket having a first annular groove therein to receive a first O-ring seal.

6. The nozzle assembly of Claim 2, further comprising a flange on the central section of the jacket, and additionally comprising second, third and fourth detachable means cooperative with the gun body for sealing to retain coolant, interposed between the gun body and, respectively, the jacket flange, the cylindrical central section of the jacket and a position adjacent the cylindrical rear section of the jacket.

7. The nozzle assembly of Claim 6 wherein:

the second detachable sealing means comprises the flange having a second annular groove therein to receive a second O-ring seal; and

the third detachable sealing means comprises the cylindrical central section of the jacket having a third annular groove therein to receive a third O-ring seal.

8. The nozzle assembly of Claim 6, wherein:

the nozzle member further comprises a rear rim located at the inlet end of the nozzle, the rear rim being formed on its forward side by an annular rim wall bounded inwardly by a cylindrical surface segment; and the fourth detachable sealing means comprises the jacket being terminated at its rear end by an annular surface such that in the nozzle assembly the rim wall and the cylindrical surface segment of the nozzle member and the annular surface of the jacket form an annular groove to receive a rear O-ring.

9. The nozzle assembly of Claim 2, wherein the nozzle member further comprises an annular face forwardly adjacent the external threading, and the jacket further comprises a seating shoulder forwardly adjacent the internal threading, the seating shoulder being adapted to contact the annular face while the nozzle member and jacket are in threaded engagement, said contact serving to position the nozzle axially with respect to the jacket.

10. The nozzle assembly of Claim 9, wherein the nozzle member further comprises an annular pilot surface forwardly adjacent the annular face, and the jacket further comprises a portion of inside surface forwardly adjacent the seating shoulder, the portion of inside surface closely fitting over the pilot surface while the nozzle member and jacket are in threaded engagement so as to maintain concentricity of the nozzle member and jacket.

11. The nozzle assembly of Claim 2, wherein:

the rear portal section of the jacket has a plurality of first coolant ports spaced uniformly around the circumference of the jacket and directed radially inward in communication with the annular passage; and the forward portal section of the jacket includes an annular slot opening into the annular passage adjacent to the cylindrical forward section of the jacket, and further includes a plurality of second coolant ports spaced uniformly around the circumference of the jacket and extending rearward and radially outward so as to exit the jacket between the second and third detachable sealing means.

12. A nozzle assembly for fitting into the body of a plasma gun, comprising:

(a) a tubular nozzle member comprising:

a rear portion with external threading thereon, a forward portion with a cylindrical outer surface and, therebetween, a middle portion having generally cylindrical exteriority:

a rear rim located at the inlet end of the nozzle and formed on its forward side by an annular rim wall bounded inwardly by a cylindrical surface segment;

(b) a jacket of generally hollow cylindrical configuration, disposed in a predetermined coaxial position about a the nozzle member, comprising:

a cylindrical central section with a flange thereon and an inside surface cooperative with the cylindrical exteriority of the nozzle member to define an annular coolant passage;

a cylindrical rear section with internal threading therein engaged with the external threading of the nozzle member to retain the jacket in the predetermined position relative to the nozzle member;

a cylindrical forward section with a forward inside surface;

a rear portal section disposed between the cylindrical central section and the cylindrical rear section, having one or more first coolant ports communicating with the annular passage; and

a forward portal section disposed adjacent the cylindrical central section and the cylindrical forward section, having one or more second coolant ports communicating with the annular passage;

the jacket and nozzle member being in relative slidable relationship for axial removal and replacement of the jacket forwardly with respect to the nozzle member;

(c) a first detachable means for sealing to retain coolant, interposed between the outer surface of the forward portion of the nozzle member and the inside surface of the forward section of the jacket, comprising the inside surface having a first annular groove therein to receive a first O-ring seal; and

(d) second and third sealing means cooperative with the gun body for sealing to retain coolant, interposed between the gun body and, respectively, the jacket flange and the cylindrical central section of the jacket, the second sealing means comprising the flange having a second annular groove therein to receive a second O-ring seal, and the third sealing means comprising the cylindrical central section of the jacket having a third annular groove therein to receive a third O-ring seal;

(e) the jacket being terminated at its rear end by an annular surface cooperating with the rim wall and the cylindrical surface segment of the nozzle member to form an annular groove to receive a rear O-ring seal cooperative with the gun body for sealing to retain coolant.

13. A nozzle assembly for fitting into the body of a plasma gun, comprising:

a tubular nozzle member having a generally cylindrical exteriority and comprising a rear rim located at the inlet end of the nozzle, the rear rim being formed on its forward side by an annular rim wall bounded inwardly by a cylindrical surface segment;

a jacket of generally hollow cylindrical configuration, disposed in a predetermined coaxial position about the nozzle member and having a central inside surface cooperating with the cylindrical exteriority of the nozzle member to define an annular coolant passage, the jacket and nozzle member being in relative slidable relationship for axial removal and replacement of the jacket forwardly with respect to the nozzle member;

threading means to retain the nozzle member in the predetermined coaxial position with respect to the jacket; and

fluid seal means interposed between the nozzle member and the jacket at a location forward of the annular coolant passage;

the jacket being bounded at its rear end by an annular surface cooperating with the rim wall and the cylindrical face of the nozzle member to form an annular groove to receive a rear O-ring seal cooperative with the gun body for sealing to retain coolant.

14. A nozzle assembly for fitting into the body of a plasma gun, comprising:

(a) a tubular nozzle member comprising a rear portion with external threading thereon, a forward portion with a cylindrical outer surface and, therebetween, a middle portion having a generally cylindrical exteriority;

(b) a jacket of generally hollow cylindrical configuration, disposed in a predetermined coaxial position about a the nozzle member, comprising;

a cylindrical central section with a central flange thereon and an inside surface cooperative with the cylindrical exteriority of the nozzle member to define an annular coolant passage;

a cylindrical rear section with internal threading therein engaged with the external threading of the nozzle member to retain the jacket in the predetermined position relative to the nozzle member, the rear section having one or more first coolant ports therein communicating with the annular passage; and a cylindrical forward section with an inner flange, a forward inside surface and one or more second coolant ports therein communicating with the annular passage;

the forward and rear section each being adapted for separable close fitting concentrically with the central section forward and rearward thereof respectively; and

the jacket and nozzle member being in relative slidable relationship for axial removal and replacement of the jacket forwardly with respect to the nozzle member;

(c) a first sealing means to retain coolant, interposed between the outer surface of the forward portion of the nozzle member and the inside surface of the forward section of the jacket, comprising the inside surface of the forward section having a first annular groove therein to receive a first O-ring seal; and

(d) second, third and fourth sealing means cooperative with the gun body for sealing to retain coolant, interposed between the gun body and, respectively, the inner flange of the forward section, the central flange of the central section and the second detachable sealing means comprising the inner flange having a second annular groove therein to receive a second O-ring seal, the third detachable sealing means comprising the central flange having a third annular groove therein to receive a third O-ring seal, and the fourth detachable sealing means comprising the rear section having a fourth annual groove therein to receive a fourth O-ring seal.

(e) a rear detachable means for sealing to retain coolant, comprising the nozzle member and rear section cooperating rearward of the internal and external threading to form an annulus between the nozzle member and rear section to receive a rear O-ring seal.

15. The nozzle assembly of Claim 14 wherein the forward section has an outer flange with threads therein adapted to engage with the gun body to retain the nozzle assembly in the gun.

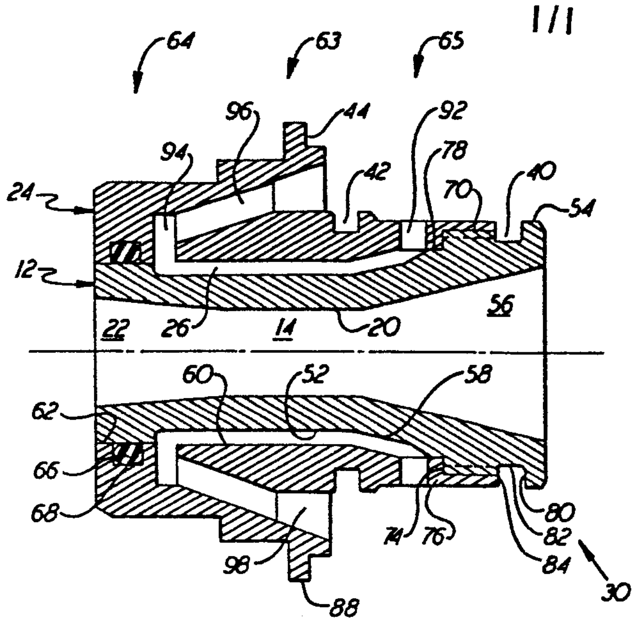

FIG. 2

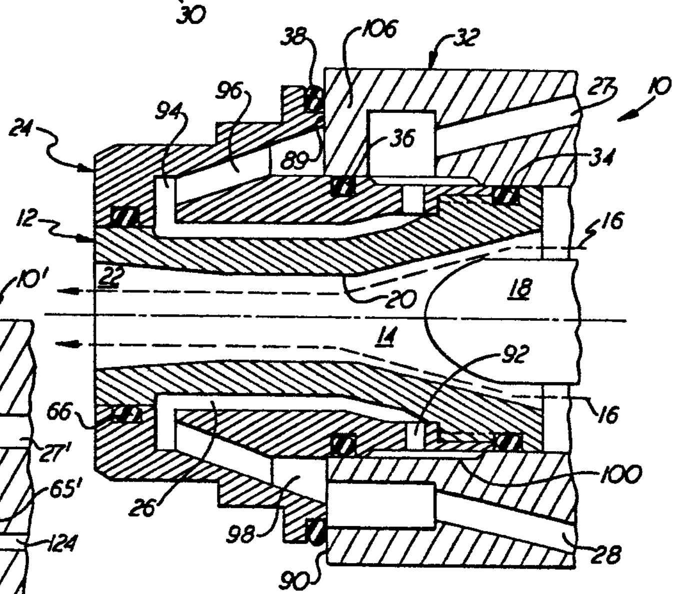

FIG. 1

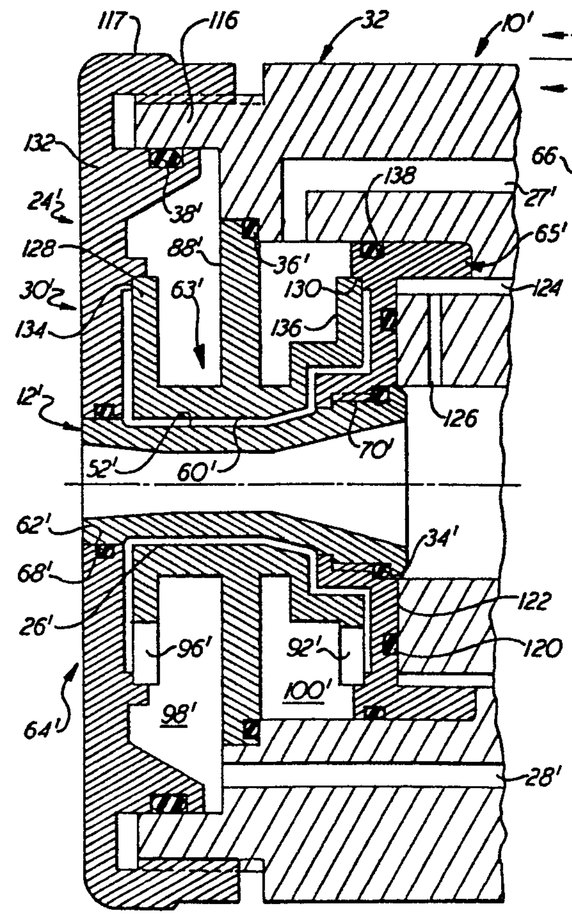

FIG. 3