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1 Navy Case No. 75822

2
3 UNDERWATER MATEABLE ELECTRICAL CONNECTOR
4 WITH ANTI-HYDROLOCK FEATURE

5
6 STATEMENT OF GOVERNMENT INTEREST

7 The invention described herein may be manufactured and used
8 by or for the Government of the United States of America for
9 governmental purposes without the payment of any royalties
10 thereon or therefor.

11
12 BACKGROUND OF THE INVENTION

13 (1) Field of the Invention

14 The present invention relates generally to waterproof
15 electrical connectors, and more particularly to a means for
16 achieving full electrical connection between corresponding plug
17 and receptacle sections without hydraulic lock occurring between
18 the sections when sealably connecting the two sections together.

19 (2) Description of the Prior Art

20 It is well-known that many types of electrical connectors
21 are attached to equipment which are deployed underwater such as
22 sonar systems and the like. Such equipment requires repair or
23 routine maintenance from time to time. This repair or
24 maintenance, however, necessitates removal of the equipment from
25 the submerged location and therefor concomitant disconnection of
26 all electrical connectors attached thereto. On occasion

1 connector seals have failed, the connectors by themselves have
2 flooded and then shorted, requiring replacement or refurbishment.
3 In order to then reconnect the removed equipment or repair the
4 connectors, the installation location must somehow be made dry or
5 else one of the present, commercially available, underwater (UW)
6 mateable type electrical connectors must have been used to make
7 the connection. These present underwater mateable connectors,
8 however, are well-known to be bulky, expensive and generally not
9 available in sufficient quantity. Further, when intended for
10 submarine sonar use, present UW mateable connectors are also of
11 limited value due to their not having been designed to meet
12 exacting military specifications.

13 A solution to the foregoing problems identified above can be
14 found in U.S. Patent No. 4,909,751 to Marolda. In this patent,
15 there is disclosed a connector having a plug and a receptacle
16 with an elastomeric electrical isolation membrane positioned
17 therebetween for assisting in completing the electrical isolation
18 of the connection under water. By employing the isolation
19 membrane, the original O-ring was removed and the isolation disk
20 made the connector suitable for underwater use.

21 One problem associated with this connector, however, is that
22 the removal of the O-ring allowed free flooding of the plug and
23 receptacle cavities. By removing the O-ring, the connector is
24 exposed to internal ambient pressure since the O-ring seals the
25 plug and receptacle of the connector so as to prevent this
26 internal ambient pressure. The O-ring also seals the connector

1 before a sufficient amount of water is pushed out of the plug and
2 receptacle cavities. This results in undesirable hydraulic lock
3 ("hydrolock") which prevents an electrical isolation of the
4 connectors since the plug and receptacle are not fully sealed.

6 SUMMARY OF THE INVENTION

7 Accordingly, it is a general purpose and object of the
8 present invention to provide a means for permitting electrical
9 connectors to be mated under water such that full electrical
10 isolation is established without hydrolock occurring between the
11 plug and receptacle of the connector.

12 It is further object that such electrical isolation means be
13 useable in combination with existing, dry-assembly type,
14 underwater electrical connectors.

15 Another object is that such electrical isolation means be
16 producible at low cost.

17 Still another object is that such electrical isolation means
18 exhibit dielectric properties while having a high degree of
19 hydrolytic stability.

20 These objects are accomplished with the present invention by
21 providing an electrical connector comprising a plug section
22 having a body, and a receptacle section adapted to be connected
23 to the plug section. The plug and receptacle sections are formed
24 such that one the sections has a cylindrical extension extending
25 beyond the face and the other section has an annular flange
26 disposed radially outwardly with respect to said cylindrical

1 extension. A circumferential groove formed in a selected one of
2 the plug section and receptacle section, and a collapsible seal
3 is disposed within the groove. The arrangement is such that upon
4 sealingly connecting the receptacle section to the plug section,
5 any hydrostatic forces present in the chamber between the
6 receptacle section and the plug section causes the collapsible
7 seal to collapse within the groove thereby providing a volume
8 defined by the groove which receives fluid therein for preventing
9 hydrostatic lock.

10 11 BRIEF DESCRIPTION OF THE DRAWINGS

12 A more complete understanding of the invention and many of
13 the attendant advantages thereto will be readily appreciated as
14 the same becomes better understood by reference to the following
15 detailed description when considered in conjunction with the
16 accompanying drawings wherein like reference numerals designate
17 identical or corresponding parts throughout the several views and
18 wherein:

19 FIG. 1 is a cross-sectional view of an electrical connector
20 according to the present invention.

21 FIG. 2 shows a cross-sectional view of the connector of FIG.
22 1 illustrating seals of the present invention located in grooves
23 formed in a body section of the connector.

24 FIG. 2A is an enlarged cross-sectional view of an electrical
25 isolation device of the connector.

1 FIG. 3A is a schematic view of the connector illustrating an
2 O-ring type seal which seals a plug section and receptacle
3 section of the connector and a collapsible seal of the present
4 invention, the plug section and receptacle section being in a
5 non-sealed, spaced apart position.

6 FIG. 3B is a view similar to FIG. 3A illustrating the plug
7 section and receptacle section in a partially sealed position.

8 FIG. 3C is a view similar to FIGS. 3A and 3B illustrating
9 the plug section and the receptacle section in a fully engaged
10 and sealed position.

11 12 DESCRIPTION OF THE PREFERRED EMBODIMENT

13 Referring now to FIGS. 1, 2 and 2A, and more particularly to
14 FIG. 2A, there is shown an electrical isolation device generally
15 indicated at 10 comprising a thin circular membranous elastomeric
16 disk 12. Disk 12 connects a plurality of protruding cylindrical
17 elastomeric embossments 14 which form apertures 16 (see FIG. 2A).
18 The shape, quantity, spacing and pattern of embossments 14 are
19 selected based on the pin configuration of an electrical
20 connector that device 10 will be used in conjunction therewith.
21 Membrane 12 maintains the selected alignment of embossments 14.
22 Device 10 is formed by molding a dielectric elastomeric material
23 selected to have good hydrolytic stability, i.e., resistance to
24 hydrolysis effects, into the desired shape. The preferred
25 embodiment uses a neoprene rubber of Shore durometer 45-50 but
26 any other dielectric elastomer which is hydrolytically stable may

1 be substituted without deviating from the teachings of the
2 present invention.

3 FIG. 2A shows a cross-sectional view of the electrical
4 isolation device 10 of FIGS. 1 and 2. Disk 12 is of thickness
5 "t" which in the preferred embodiment is 0.030-0.35 inches thick.
6 Disk 12 further comprises a first side 12a and a second side 12b.
7 Each cylindrical embossment 14 further has a first protruding end
8 14a on side 12a, a second protruding end 14b on side 12b and a
9 longitudinal center line parallel to all other embossment 14
10 center lines. Each protruding end 14a and 14b has formed thereon
11 a conical taper of angle "x", which angle is preselected to
12 contact the pin socket recesses of the connector it will be used
13 in conjunction therewith. In the preferred embodiment, angle "x"
14 is selected to be 60 degrees. In addition, first protruding end
15 14a has a cylindrical extension of height "h" where "h" may be
16 selected to be zero or greater.

17 FIG. 1 illustrates electrical isolation device 10 used in
18 combination with a typical, open face pressure tolerant, dry-
19 assembly type electrical connector generally indicated at 20 such
20 as a MIL-C-2431 which, according to the teachings of Patent
21 4,909,751, along with removal of an O-ring, is converted into an
22 underwater mateable connector. This provides electrical
23 isolation between pins which do not physically touch each other.
24 Connector 20 further comprises a male plug section generally
25 indicated at 22 and a female receptacle section generally
26 indicated at 24. Plug section 22 is shown fixedly mounted

1 through a wall or hull 26 but may also be used as part of a free
2 standing coupling system. Plug section 22 further comprises a
3 cylindrical metal body 28 having a groove 29 at one end thereof,
4 which, under normal circumstances, receives an O-ring, and a
5 circular aperture 30 at its other end sized slightly smaller than
6 deep bore 31 which passes almost therethrough.

7 A plurality of electrical wires 32 from a cable, wire
8 harness or the like pass through aperture 30 at the cable end of
9 body 28 of the plug section 22 and into the internal bore 31
10 cavity, each wire being covered with insulation 34. Within body
11 28, each wire 32 conductively attaches to a corresponding pin 36.
12 Plug pins 36 are arranged in a preselected pattern parallel to
13 each other but not in physical contact. Wires 32 and plug pins
14 36 are, except for a portion of each pin opposite the wire end,
15 embedded in a cylindrical elastomer block 38 which fills the
16 remaining volume inside the body 28 cavity formed by bore 31 and
17 provides open face 38a pressure tolerance for plug section 22.
18 This leaves a portion of each pin extending beyond face 38a at
19 the end of body 28 opposite the cable attachment end, hereafter
20 called the pin end. The exterior of metal body 28 has disposed
21 thereabout a threaded section 40 on the extending pin end.

22 Receptacle section 24 of connector 20 further comprises a
23 generally cylindrical metal body or housing 42 having an aperture
24 44 of a preselected inner diameter formed therethrough. Aperture
25 44 has a cylindrical elastomeric receptacle block 46 in contact
26 therewith, block 46 further comprising a face 46a and a plurality

1 of metal sleeves 48 embedded therein at the face 46a end thereof,
2 extending to within a preselected distance "D" of face 46a.
3 Sleeves 48 are disposed in a pattern corresponding to plug pin 36
4 pattern of plug section 22. A plurality of metal receptacle pins
5 50, one each corresponding to one plug pin 36, are disposed in
6 parallel through block 46, each of pins 50 having hollow ends
7 50a which extend through sleeves 48 flush with the sleeve 48 end
8 nearest to surface 46a of block 46 which is in turn nearest to
9 plug section 22. Block 46 is formed around receptacle pins 50
10 providing open face pressure tolerance for face 46a. A
11 corresponding plurality of cylindrical apertures 52 in block 46
12 align with each hollow end 50a and sleeve 48, each aperture 52
13 being slightly larger in diameter than the outside diameter of
14 the corresponding hollow end 50a and extending a preselected
15 depth "D" in from surface 46a of block 46. Each receptacle pin
16 end opposite hollow end 50a is conductively connected to an
17 attached cable means and potted with an elastomeric material 54.
18 A threaded clamping ring 56 is provided over body 42 having a
19 thread disposed within which mates with thread 40 of body 28.
20 Threaded clamping ring 56 provides a connecting means for
21 securely engaging and connecting plug section 22 to receptacle
22 section 24.

23 In accordance with the teachings of the '751 Patent, when
24 the device 10 is used in conjunction with conventional electrical
25 connectors, such as connector 20, the original O-rings are
26 removed from the groove 29. This allows free flooding of the

1 plug and receptacle cavities between faces 38a and 46a. In
2 operation, the absence of an occlusive seal prevents hydrostatic
3 pressures from being built-up early in the receptacle-plug
4 engagement phase. It also reduces the possibility of cable
5 hosing (i.e., flooding), corrosion and low resistance failure due
6 to pressure built-up while clamping. Thus, before the connector
7 20 of the present invention, sides 12a and 12b, and apertures 16
8 of device 10 are lubricated all over with commercially available
9 underwater dielectric grease, shown generally as 58a and 58b
10 respectively, such as a Dow Corning Corp. MIL-S-8660-C Silicon
11 Compound or the like. Apertures 16 of electrical isolation
12 device 10 are then slipped over the plurality of male plug pins
13 36 with grease 58b coming into contact with face 38a. Female
14 receptacle section 24 is engaged plug pin 36 to receptacle pin 50
15 and tightening is started. As the conical ends of embossments
16 14a come in contact with the bottom of the respective apertures
17 52, a cleansing and purging of dielectric grease and water begins
18 at face 46a. The grease-water mixture is pushed from the male
19 pin 36 up along the conical surface 14a and out of the female
20 cavity 52. When the cavity is completely filled by embossment
21 14a and tightening is continued, grease covered sides 12a and 12b
22 come in contact with faces 46a and 38a respectively at which
23 point hydrostatic pressure causes most grease and water to be
24 squeezed out and once tightening is complete and remaining water
25 is broken up into a discontinuous series of microspheres. Grease
26 58a first comes in contact with face 46a and then as further

1 tightening occurs sides 12a and 12b of membrane 12 also came into
2 contact with faces 46a and 38a respectively, thereby completing
3 electrical isolation for the connector.

4 However, under most circumstances, it is desirable to
5 provide an occlusive seal between the plug section 22 and
6 receptacle section 24, but the likelihood of hydrolock between
7 these two members prevents the inclusion of such a seal. The
8 present invention addresses this problem.

9 Referring to FIGS. 2 and 3A-3C, and more particularly to
10 FIG. 3A, the present invention is directed to placing a
11 collapsible seal in the groove 29 of the plug section 22, and an
12 O-ring 64 between the mating portions of the plug section and the
13 receptacle section 24. The collapsible seal 62 preferably has
14 square-shaped cross-section area. As shown in FIG. 3A, the
15 collapsible seal 62 completely fills or occupies the entire
16 volume of groove 29. With this configuration, the O-ring seal 64
17 can be disposed at the shoulder 66 formed between the threads 40
18 and an extension 68 of the plug section 22.

19 FIG. 3B illustrates the plug section 22 being brought into
20 threaded engagement with the receptacle section 24. As shown, an
21 inner, annular flange 70 of the receptacle section is disposed
22 radially outwardly with respect to the extension 68 of the plug
23 section 22 so that it overlies or covers the groove 29 as the
24 receptacle section and plug section are tightened. Preferably,
25 the end of the flange 70 is chamfered, as shown, so as to provide

1 clean engagement between the flange and the O-ring seal 64 when
2 fully tightening the plug and receptacle sections 22, 24.

3 FIG. 3C illustrates the plug section 22 and receptacle
4 section in a fully engaged position. The arrangement is such
5 that at the very moment that the plug section 22 makes full
6 engagement with the receptacle section 24, also known as
7 "seating", the O-ring seal 64 is engaged thereby sealing the plug
8 and receptacle sections 22, 24 of connector 20. Once fully
9 engaged, clamping ring 56 provides a means for securely engaging
10 the plug and receptacle sections 22, 24 thereby maintaining the
11 seal created when O-ring seal 64 is engaged.

12 Once the connector 20 is sealed by the O-ring 64, the
13 remaining water is displaced by the seating motion, and under
14 normal circumstances, can cause hydrolock to occur. With the
15 connector 20 of the present invention, the resulting pressure
16 from the seating motion causes the collapsible seal 62 to
17 collapse, thereby providing a holding volume in groove 60 for the
18 water to enter so as to prevent hydrolock and subsequent pressure
19 increase in the volume defined by the plug section 22 and
20 receptacle section 24. It should be understood that the groove
21 29 can be formed either the body 28 of the plug section 22 or the
22 body 42 of the receptacle section 24 and still fall within the
23 scope of the present invention. However, it is important that
24 the groove 29 is located inside the O-ring seal 64 to provide
25 room for the water that is trapped in the connector 20 when the
26 O-ring seal becomes seated.

1 Thus, final tightening and completion of the plug-receptacle
2 sealed engagement can be performed. Hydraulic lock is prevented
3 while providing a means to seal the connector 20 from extreme
4 pressure cycling. To reiterate, FIG. 3A illustrates the plug
5 section 22 and receptacle section 24 in a pre-sealed
6 configuration with the collapsible seal 62 being shown in its
7 expanded configuration. FIG. 3B illustrates the plug section 22
8 and receptacle section 24 in their partially sealed configuration
9 with the collapsible seal 62 being covered by the flange 70 of
10 the receptacle section. FIG. 3C illustrates the plug section 22
11 and the receptacle section in their fully engaged position in
12 which the seal 62 is collapsed to provide the requisite volume in
13 groove 29 for excess sea water to enter so that the seal may be
14 completed. The arrangement is such that upon threadably
15 connecting the receptacle section 24 to the plug section 22, any
16 hydrostatic forces present in the chamber between the receptacle
17 section and the plug section causes the collapsible seal 62 to
18 collapse thereby providing a volume defined by groove 29 which
19 receives fluid therein for preventing hydrostatic lock.

20 It should be noted that the connector 20 of the present
21 invention with its anti-hydrolock feature prevents hydrolock from
22 occurring and prevents the connector 20 from being further
23 exposed to extreme depth pressure cycling.

24 Obviously many modifications and variations of the present
25 invention may become apparent in light of the above teachings.
26 For example, the plug and receptacle sections can be formed such

1 that the cylindrical extension 68 extends beyond the face of the
2 receptacle section and annular flange 70 is attached to the plug
3 section. Similarly, the clamping ring 56 can be any one of
4 several conventional connection means for securely engaging and
5 connecting the plug section to the receptacle section.

6 The advantages of the present invention over the prior art
7 are that standard inexpensive electrical connectors can be easily
8 adapted to underwater use and be reconnected in place without
9 removal or dry-docking needed for the systems to which they
10 attach.

11 In light of the above, it is therefore understood that
12 the invention may be
13 practiced otherwise than as specifically described.

1 Navy Case No. 75822

2
3 UNDERWATER MATEABLE ELECTRICAL CONNECTOR

4 WITH ANTI-HYDROLOCK FEATURE

5
6 ABSTRACT OF THE DISCLOSURE

7 An electrical connector includes a plug section having a
8 body, and a receptacle section which is connected to the plug
9 section. A collapsible seal is disposed within a circumferential
10 groove formed in the plug section. The receptacle section has a
11 cylindrical housing with a clamping ring for securely engaging
12 and connecting the receptacle section to the plug section. Upon
13 connecting the receptacle section to the plug section any
14 hydrostatic forces present in the chamber between the receptacle
15 section and the plug section causes the collapsible seal to
16 collapse within the groove thereby providing a volume defined by
17 the groove which receives fluid therein for preventing
18 hydrostatic lock.

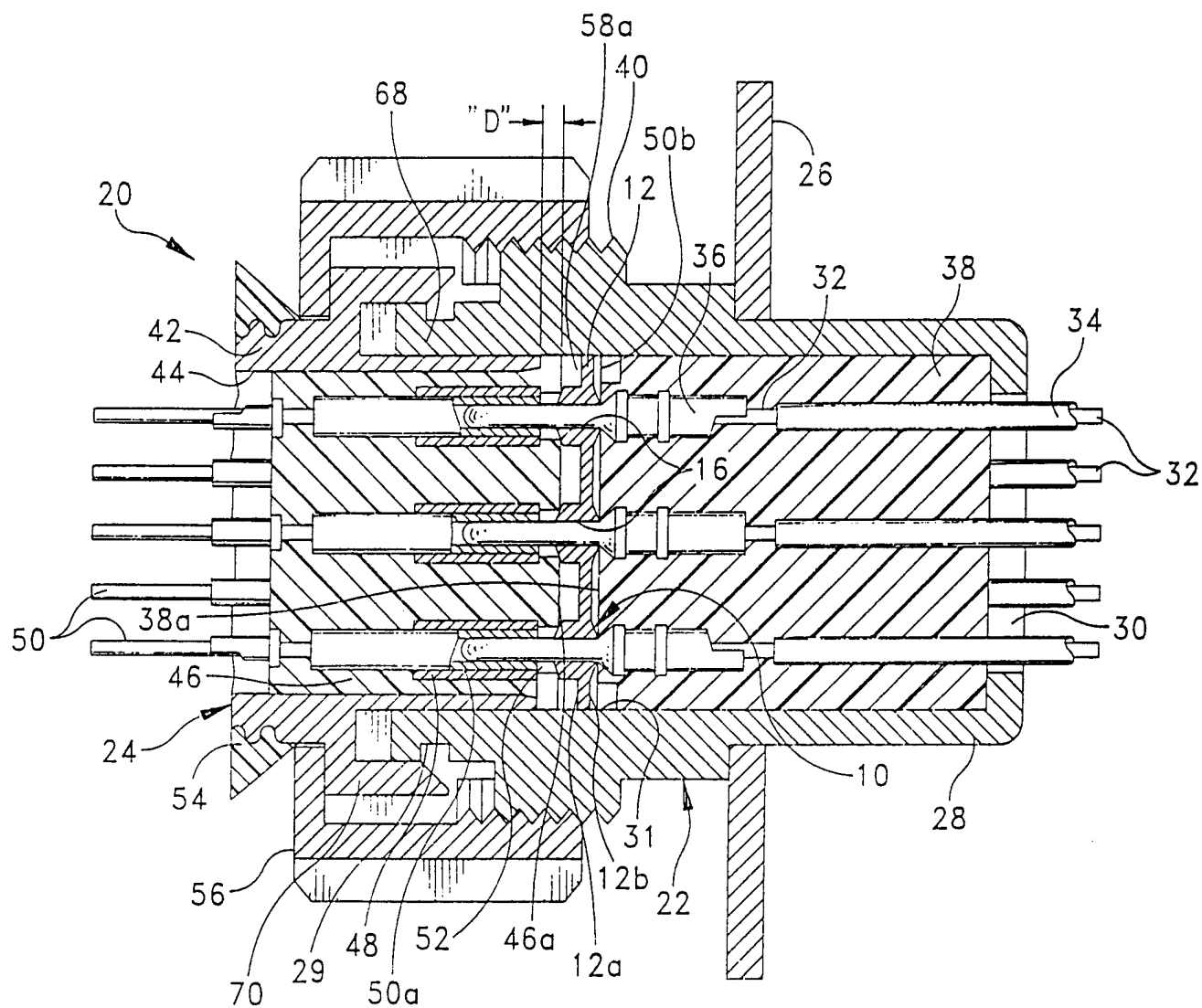


FIG. 1

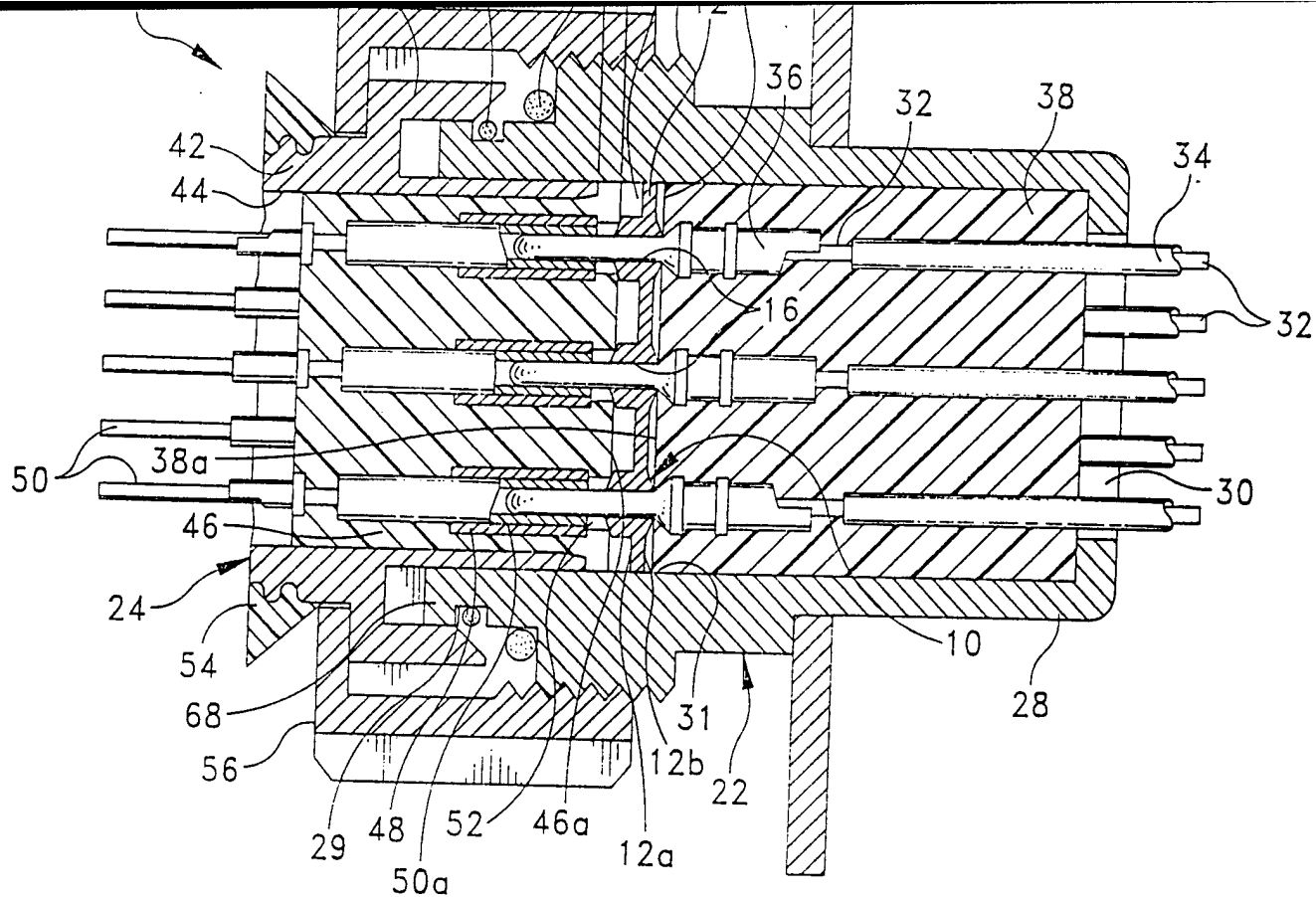


FIG. 2

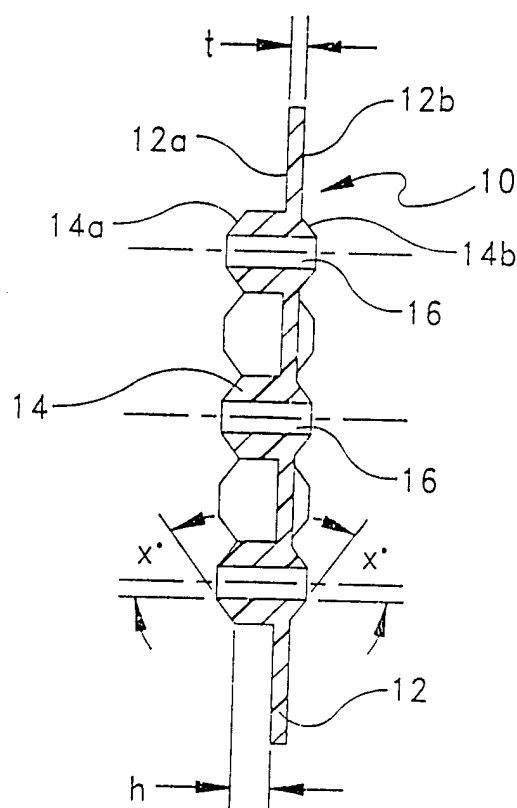
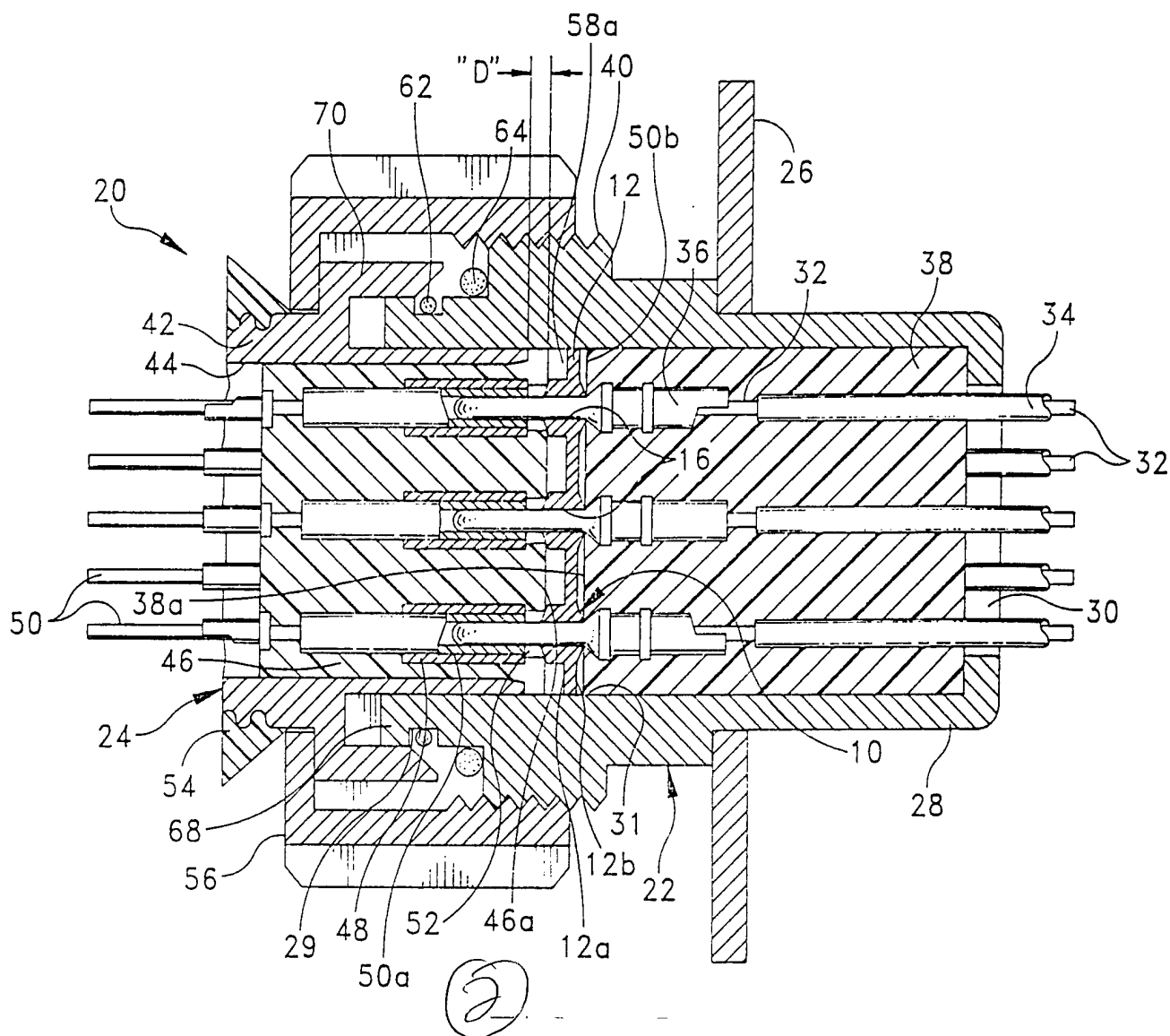


FIG. 2A



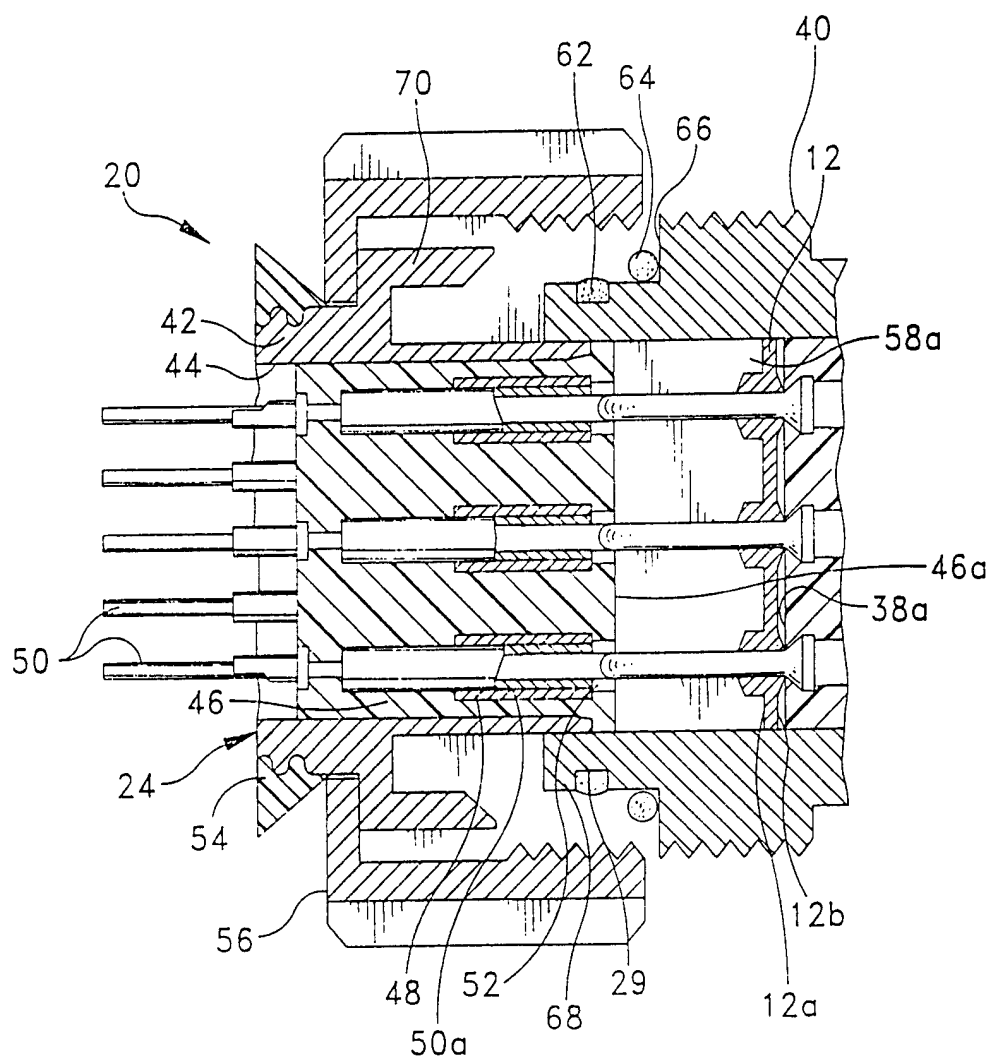


FIG. 3A

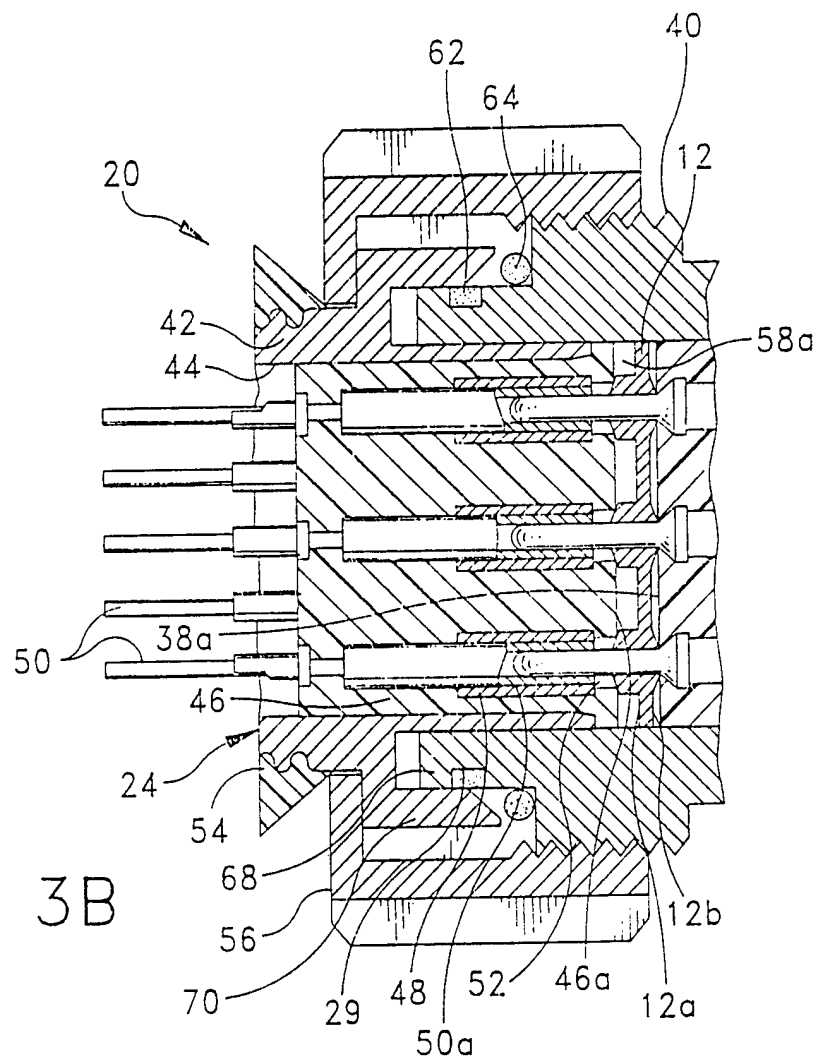


FIG. 3B

