

- [54] **METHOD AND APPARATUS FOR JOINING CONDUIT**
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- [58] Field of Search **29/421 E, 421 R, 29/464, 525, 526, 254, 237, 200 E; 285/370, 397, 421**

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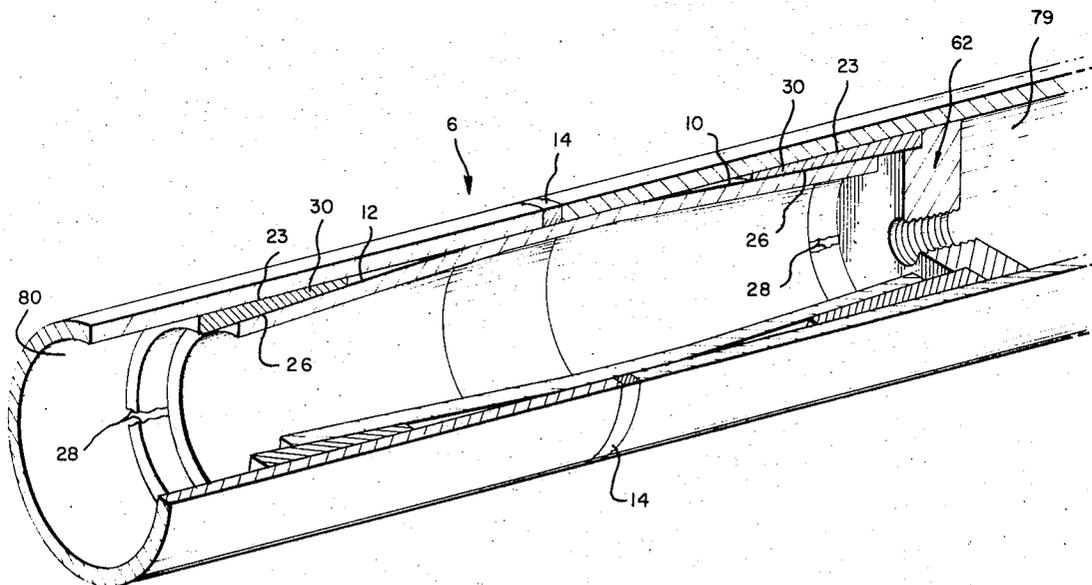
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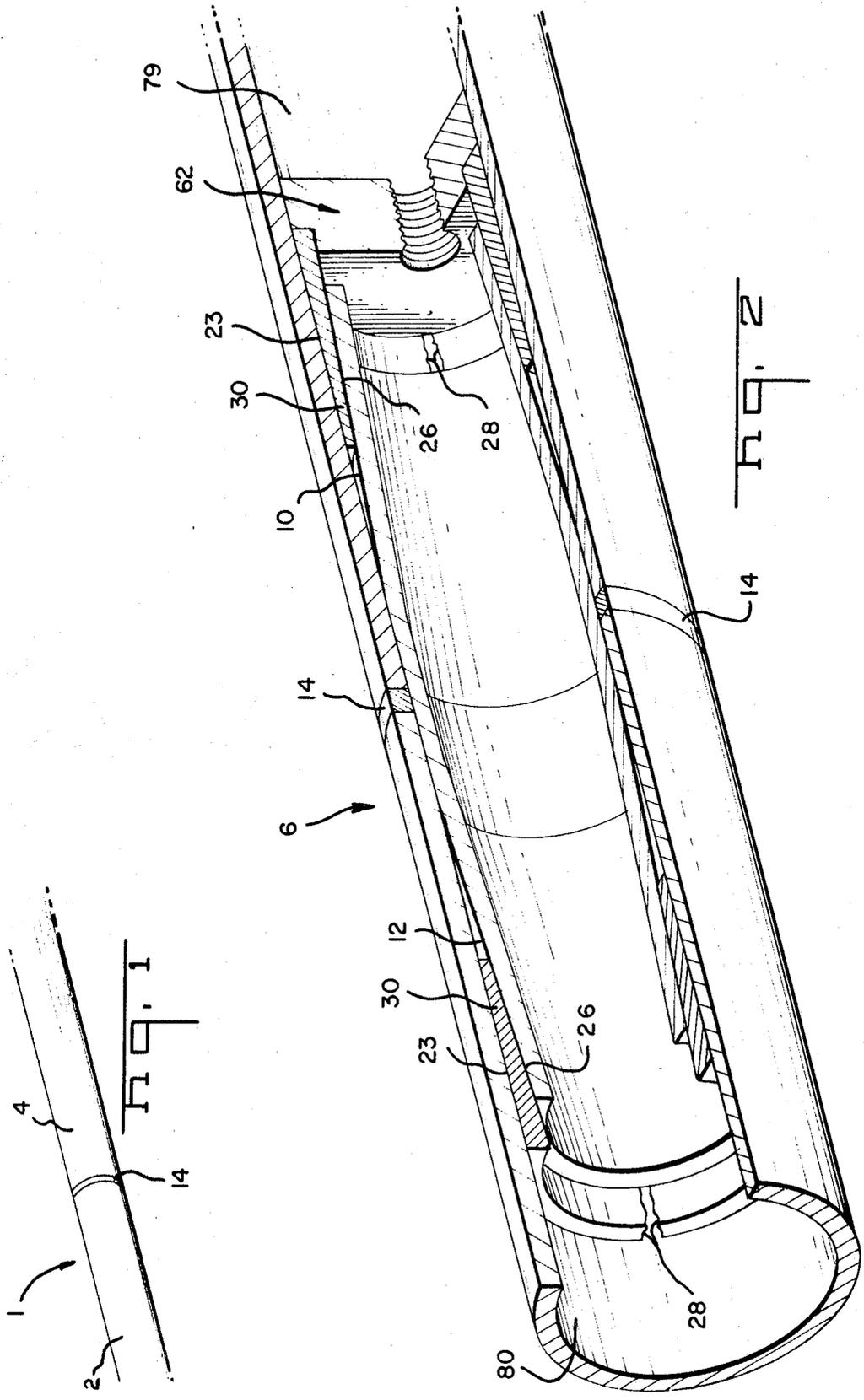
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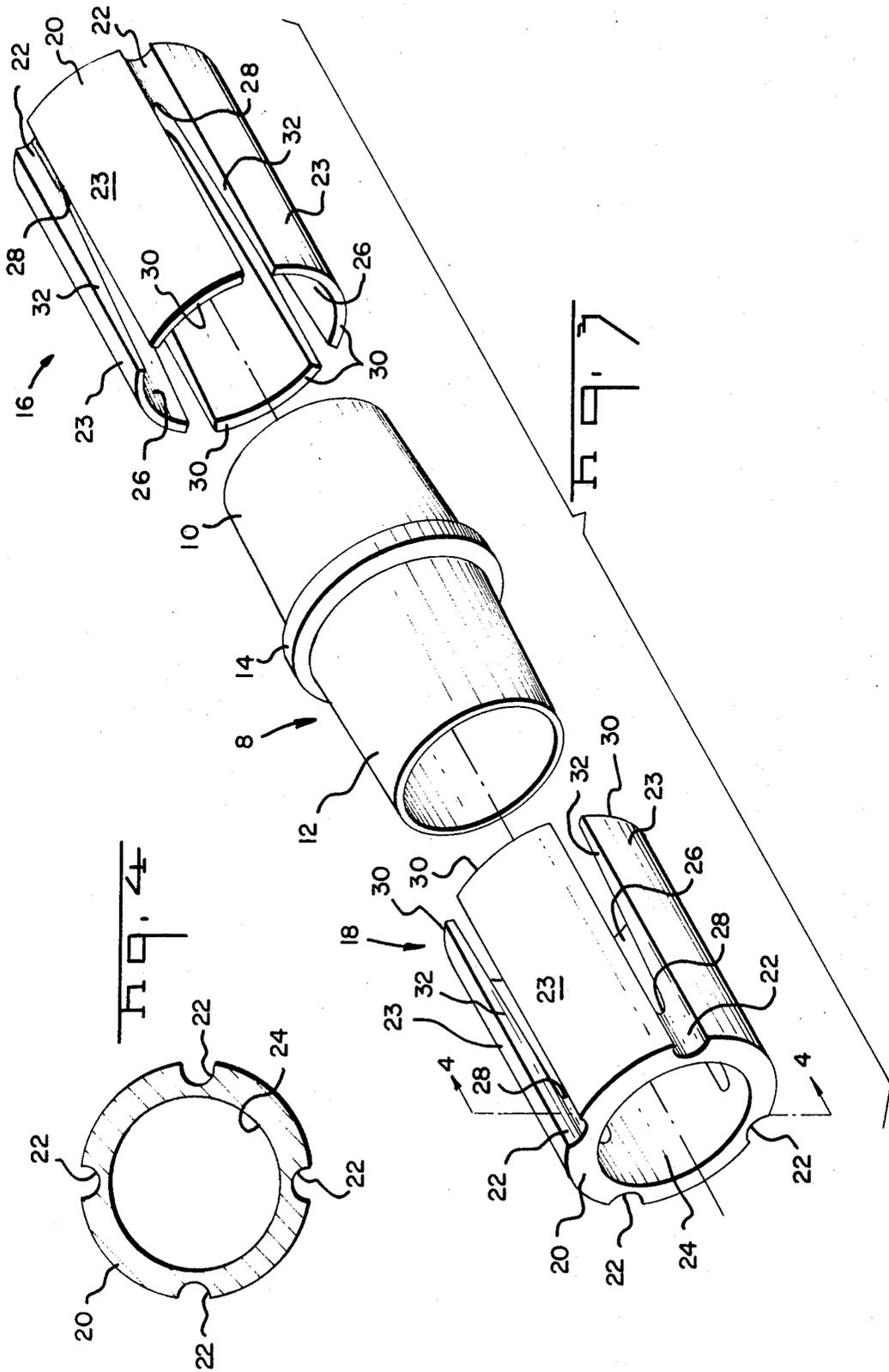
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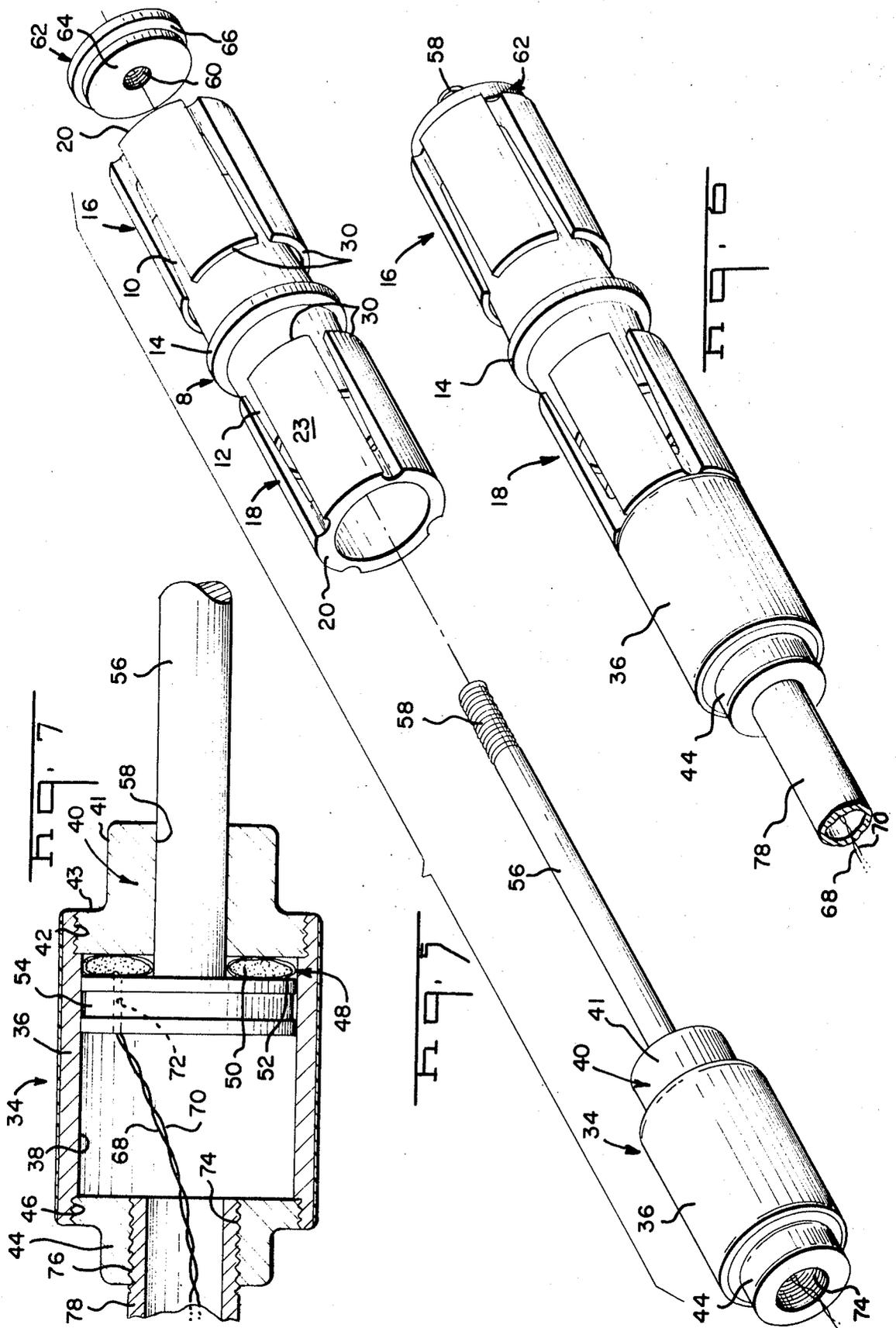
[57] **ABSTRACT**
 The present invention relates to a method and apparatus for connecting a relatively short length of conduit to an end of a substantially continuous length of conduit. More particularly, the invention relates to a method for connecting relatively short lengths of conduit in end-to-end relationship to form a substantially continuous length of conduit useful for conveying fluidic or gaseous media therethrough, or for providing an electrical conductor of substantially tubular or hollow configuration as distinguished from a solid cylindrical conductor or stranded cable. The invention is particularly suited for joining together lengths of such electrically conducting or media-conveying conduit when it is desirable that the surfaces of the joined conduit lengths be relatively smooth and clean or otherwise free of burrs, nicks, abrasion marks and free of residues or contaminant material such as dust or other liquid or solid contaminants.

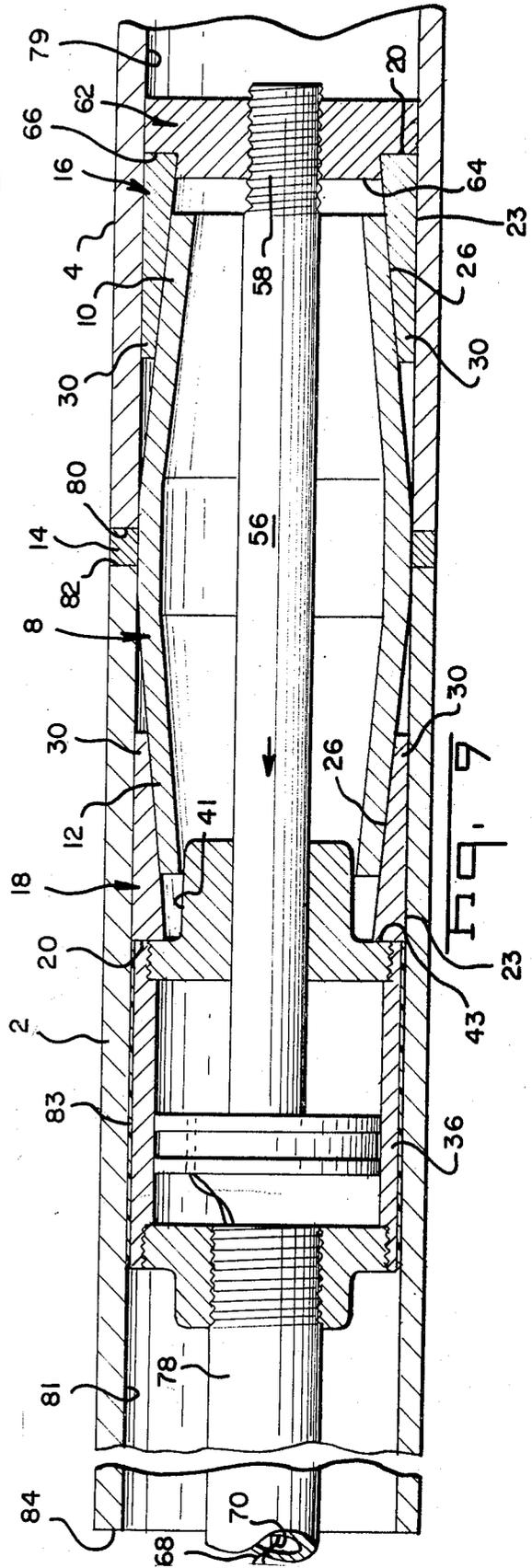
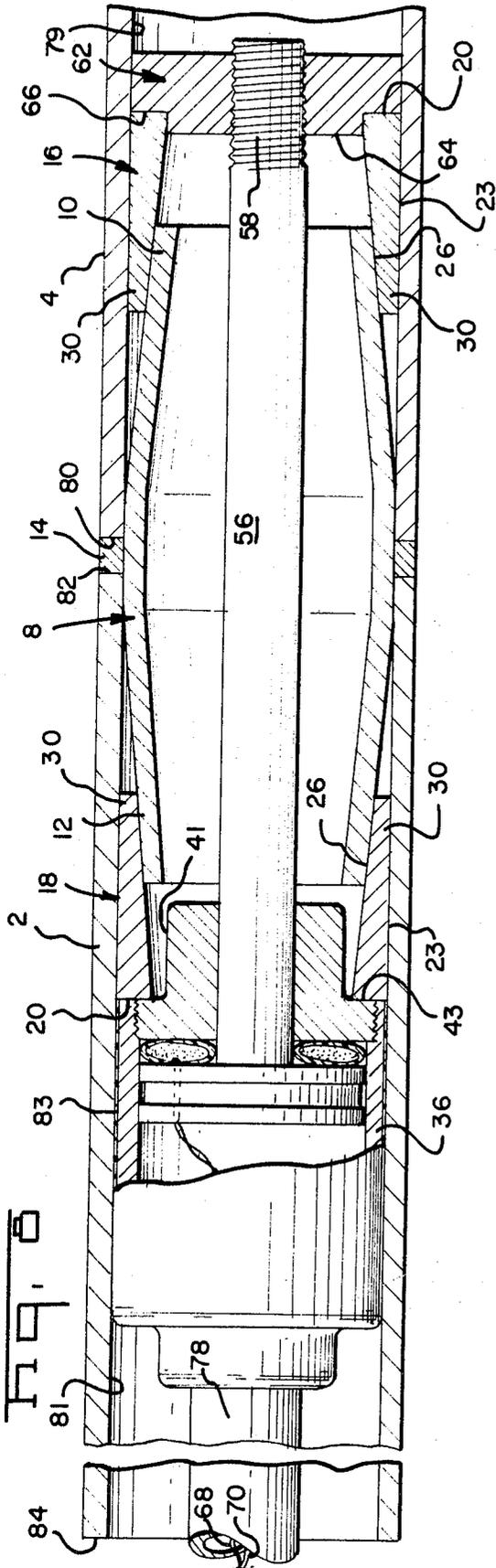
6 Claims, 9 Drawing Figures











METHOD AND APPARATUS FOR JOINING CONDUIT

The present invention relates to a method and apparatus for connecting a relatively short length of conduit to an end of a substantially continuous length of conduit. More particularly, the invention relates to a method for connecting relatively short lengths of conduit in end-to-end relationship to form a substantially continuous length of conduit useful for conveying fluidic or gaseous media therethrough, or for providing an electrical conductor of substantially tubular or hollow configuration as distinguished from a solid cylindrical conductor or stranded cable. The invention is particularly suited for joining together lengths of such electrically conducting or media-conveying conduit when it is desirable that the surfaces of the joined conduit lengths be relatively smooth and clean or otherwise free of burrs, nicks, abrasion marks and free of residues or contaminant material such as dust or other liquid or solid contaminants.

An object of the present invention is to provide a method and apparatus for connecting a relatively short length of conduit to an end of a substantially continuous length of conduit as well as for connecting relatively short lengths of conduit in end-to-end relationship to form a substantially continuous length of conduit without a need for welding, brazing, or the use of adhesives.

Another object of the present invention relates to method and apparatus for connecting a length of conduit to another length of conduit to provide a conduit connection suitable for conducting electricity or for transmitting media therethrough without abrasion or otherwise deformation of the surfaces of the conduit and without depositing impurities or contaminant residues on the surfaces of the conduit connection.

Another object of the present invention is to provide a method and apparatus for connecting a length of conduit in end-to-end relationship with another length of conduit by the use of a tool having both reusable and purposely expendable parts.

Another object of the present invention is to provide a method and apparatus for joining a length of conduit in end-to-end relationship with another length of conduit to form a continuous length of conduit suitable for conducting electricity or for conveying fluid media by utilizing cold welding joining techniques.

Another object of the present invention is to provide a method and apparatus for connecting a length of conduit in end-to-end relationship with another length of conduit in fabricating a continuous length of conduit suitable for conducting electrical energy or for conveying fluidic media therethrough utilizing cold welding joining techniques and actuation of an explosive operated tool having both expendable and reusable parts, and without leaving residues of contaminants on the surfaces of the conduit lengths and without deforming either the interior or exterior surfaces of the conduit lengths.

Other objects and many attendant advantages of the present invention will become apparent upon perusal of the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a fragmentary reduced perspective of a relatively short length of conduit joined in end-to-end relationship with another length of conduit;

FIG. 2 is an enlarged fragmentary perspective of the preferred embodiment as shown in FIG. 1 with parts broken away to illustrate the details of a coupling utilized to effect the connection of FIG. 1;

FIG. 3 is an exploded perspective of component parts of a coupling as shown in FIG. 2;

FIG. 4 is a section taken along the line 4-4 of FIG. 3;

FIG. 5 is an exploded perspective of the component parts of the coupling as shown in FIG. 3 together with component parts of a preferred embodiment of a propellant actuated tool, with the component parts of the coupling of FIG. 3 illustrated in initially assembled condition;

FIG. 6 is an enlarged fragmentary longitudinal section of a portion of the tool as shown in FIG. 5;

FIG. 7 is a fragmentary perspective of the component parts of the tool as shown in FIG. 5 in assembled condition together with the component parts of the coupling as also illustrated in FIG. 5;

FIG. 8 is a longitudinal section of the preferred embodiment of FIG. 1 and the preferred embodiment as shown in FIG. 7 in initially assembled condition; and

FIG. 9 is the preferred embodiment as shown in FIG. 8 illustrating operation of the tool to form the completed coupling as shown in FIG. 2.

With more particular reference to the drawings, there is shown in FIG. 1, generally at 1, a completed joining of a relatively short length of conduit 2 in end-to-end relationship with another length of conduit 4. As will be explained hereinafter, such joining is effected by a coupling connection without the use of conventional welding brazing or adhesive techniques, with the surfaces of the conduit and the coupling being substantially free of nicks or other unsuitable deformations and also substantially free of contaminant residues. As shown in FIG. 2, the joining is accomplished by a suitable coupling, the component parts of which and the assembly of which will be described in detail with reference to FIG. 3. As shown in FIG. 3, the coupling 6 includes a relatively short metal tubular member 8 having a first externally tapered end portion 10 and a second externally tapered end portion 12. The medial portion of the tubular member 8 between the tapered end portions 10 and 12 accordingly has a larger external diameter and is provided thereover with a radially projecting encircling collar 14 which may be force-fit permanently in place. Associated with the end portion 10 is a first group 16 of peripherally spaced and frangibly interconnected wedge segments. In similar fashion, associated with the end portion 12 is a second group of peripherally arranged frangibly interconnected wedge segments 18. With reference to FIGS. 3 and 4, each of the groups 16 and 18 is fabricated from a length of tubular extrusion having the cross sectional shape of the end portion 20 of the wedge segment groups 16 and 18. The tubular extrusion is provided with a plurality of spaced longitudinal flutes or grooves 22. To provide a wedge shape, the initial internal sidewall 24 of the extrusion is reamed at one end to provide an internal sidewall surface which is enlarged and flared as shown at 26. The flared internal portion 26 removes away a substantial length of the flutes 22 leaving relatively short lengths of fluted portions defining frangible webs 28 remaining adjacent the end 20. By removal of substantial amounts of the flutes 28, a plurality of wedge segments 30 are formed. As shown in FIG. 3, the wedge segments

30 are in adjacent peripherally spaced relationship with adjacent ones of said segments 30 being joined together by the remaining fluted portions 28. Each of the wedge segments is characterized with a tapered wedge shaped cross section 32 defined between the outer surface 23 of the extrusion and the flared or inclined internal surface 26.

As shown in FIG. 5, the groups 16 and 18 of the wedge segments 30 are assembled over the respective externally tapered end portions 10 and 12 of the tubular member 8. Accordingly, the groups 16 and 18 of wedge segments are wedgingly retained over the respective end portions 10 and 12 with the ends of the segments 30 being substantially spaced longitudinally from the collar 14. With reference yet to FIG. 5, taken in conjunction with FIG. 6, there is shown generally at 34 an explosively operated tool. The tool is characterized by a generally tubular chamber block 36 having an internal sidewall 38. A first end block 40 is threadably secured at 42 to one end of the chamber block 36. Another end block 44 is threadably secured at 46 to the other end of the chamber block 36. An internal chamber is defined by the sidewall 38 and the two end blocks 44. The end block 44 is removable to insert therein a charge or cartridge generally shown at 48 containing a quantity of propellant 50 inside a frangible shell or casing 52. The charge 48 is seated against the end block 40. A reciprocating piston 54 is freely received internally of the chamber and substantially spans the space defined by the chamber sidewall 38. The piston 54 is provided with a substantially elongated piston rod 56 reciprocably received within an opening 58 in the chamber block 40. As shown, the charge 48 may be of toroidal or donut configuration to thereby encircle the piston rod 56.

As shown in FIG. 6, the end portion 58 of the piston rod 56 is provided with external threads thereon and is freely insertable through the tubular member 8 and its assembled groups 16 and 18 of wedge segments 30. The end portion 58 of the piston rod is threadably received in a threaded aperture 60 provided in an end cap 62. The end cap 62 is characterized with a reduced diameter stepped portion 64 and an immediately adjacent enlarged diameter stepped portion 66. As shown in FIG. 7, taken in conjunction with FIG. 8, the reduced diameter portion 41 of the end block 40 will be received internally of the end portion 20 of the group 18 of wedge segments and also internally of the tapered end portion 12 of the tubular member 8. The enlarged diameter end portion 43 will be stopped or seated against the end portion 20 of the group 18 of wedge segments. The end cap 62 is threadably driven on the threaded end portion 58 of the piston rod 56 until the piston is stopped or seated against the charge or cartridge 48 with the cartridge sandwiched between the piston and the end block 40. Additionally, the reduced diameter portion 64 of the end cap is received internally of the end 20 of the group 16 of wedge segments 30. The outer diameter portion 66 of the end cap is stopped or seated against the end portion 20 of the group 16 of wedge segments. A pair of insulated electrical lead wires 68 and 70 are operatively connected to the propellant 50 through the casing 52. The lead wires 68 and 70 are passed through a reduced diameter vent passageway 72 provided through the piston 54. Additionally, the lead wires extend through a threaded aperture 74 provided in the end block 44. The threaded

end portion 76 of a reduced diameter elongated extension tube 78 is threadably received in the threaded aperture 74.

Together the described component coupling parts and the component tool parts comprise a subassembly as shown in FIG. 7. As shown in FIG. 8, the subassembly is inserted within the length of conduit 4, with the end cap 62, the group of wedge segments 16 and the tapered end 12 of the coupling member 8 being freely received internally of the interior sidewall 79 of the length of conduit 4. As shown in the Figure, the terminal end 80 of the length of conduit 4 is stopped against the outwardly radially projecting collar 14. In similar fashion, the length of conduit 2 includes a terminal end 82 stopped against the collar 14 and is generally in end-to-end relationship with the end 80 of the length of conduit 4. More specifically, the length of conduit 2 includes an inner sidewall 81 freely receiving therein the extension tube 78, the chamber block 36, the second group 18 of wedge segments 30 and the tapered end 12 of the tubular member 8. In a typical application, the extension tube 78 will protrude from the other terminal end 84 of the length of conduit 2, with the lead wires 68 and 70 extending through the tubular extension 78 for connection to an electrical voltage source (not shown).

Reference will be made to FIGS. 8 and 9, so that the details of joining the conduit lengths 2 and 4 together in end-to-end relationship will be described in detail. With the coupling component parts and the tool component parts received in the lengths of conduit 2 and 4 as described and shown in FIG. 8, a voltage is impressed across the lead wires 68 and 70 igniting or otherwise detonating the propellant charge. As shown in FIG. 9, such action causes relative reciprocation of the piston with respect to the chamber block 36. In practice, the piston will reciprocate upon detonation of the propellant to forcibly displace and urge the end cap 62 in compression against the group 16 of wedge segments 30. Accordingly, the wedge segments 30 will be forcibly impulse-displaced into positive wedging relationship between the tapered external surface 12 and the interior sidewall 79 of the conduit 4. In similar fashion, the detonation of propellant causes displacement of the chamber block 36 in compression against the end 20 of the group 18 of wedge segments 30. The wedge segments 30 are thus forcibly impulse-displaced into positive wedging engagement between the tapered end 12 of the tubular member 8 and the interior sidewall 81 of the length of conduit 2. In practice therefore, the end cap 62 and the chamber block 36 are forcibly impulse-displaced toward each other. This is accomplished by comparing the inertia effects of the collective mass of the tubular extension 78, the chamber block 36 and the group 18 of wedge segments, with the inertia effect of the collective mass of the piston, the piston rod 56, the end cap 62 and the group 16 of wedge segments 30. Such collective mass comparison need not result in an equal division or distribution of mass, but should be sufficiently divided such that the desired displacement of both the end cap 62 and the chamber block 36 toward each other will occur upon propellant detonation. If desired, the extension tube 78 may be removed from the chamber block 36 prior to propellant detonation in order to achieve the desired mass distribution.

With the wedge segments accordingly displaced into wedging engagement as described, the tool component

parts may then be removed. This is accomplished by an operator rotating the extension tube 78, causing the piston rod 56 to threadably disengage from the end cap 62. The piston rod 56, the chamber block 36 and the extension tube 78 may then be removed from the conduit lengths 2 and 4 through the end 84 of the conduit length 2. As shown in FIG. 2, the end cap 62 will thus remain as an expendable part of the tool internally of the length of conduit 4. If this is undesirable, the end cap 62 may be selected from a material which is frangible upon propellant detonation, or is relatively malleable and collapsible upon detonation, to permit its removal together with the other tool component parts. Also, if the end cap 62 remains in the preferred embodiment shown in FIG. 2, a subsequent operation of fragmenting and removing the end cap 62 may be employed.

In the finished connection, the tapered surface 26 of the wedge segments abrade a considerable length of the tapered external surfaces of the end portions 10 and 12 of the tubular member 8. If fabricated from a metal such as steel or aluminum, considerable scouring and cold welding is achieved between such surfaces over a considerable surface area. In addition, the external surfaces 23 of the wedge segments abrade a substantially large surface area of the internal sidewalls 79 and 81 of the lengths of conduits 4 and 2 respectively. This also causes considerable scouring and, if fabricated from metal, cold welding between such surfaces. By virtue of the cold welding, the coupling provides not only a mechanical but also an electrical connection between the conduit lengths 4 and 2. This allows the joined conduit lengths to serve as a tubular or hollow electrical conductor or as a conduit for carrying fluid media. For optimum scouring over a large area, the internal surfaces 26 of the wedge segments should be selected with a complementary surface configuration as that of the externally tapered surface of the corresponding end portions 10 and 12. Such a technique also insures that no bulging or burrs or other undesirable surface deformations other than scouring or cold welding will occur. In similar fashion, the external surfaces 23 of the wedge segments should be complementary and corresponding to the internal sidewall surfaces 81 and 79 of the conduit lengths 2 and 4. In addition, as shown in FIG. 2, the web portions 28 are frangible upon propellant detonation allowing the wedge segments to become independent from one another and to become displaced a considerable distance over the surfaces tapered end portions 10 and 12 of the tubular member 8 in order to scour and cold weld a substantial surface area thereof. Since the wedge segment groups 16 and 18 are displaced toward one another, compressing on the end portions of the tubular member 8, a medial portion of the tubular member adjacent to the collar 14 will have a tendency for residual compression radially outwardly against the collar 14 to retain the collar in fixed position. In addition, the displacement of the wedge segments 30 tends to radially compress the end portions 10 and 12 of the tubular member 8, resulting in a residual tendency of the tubular member to expand radially in compression against the wedge sections 30, thereby improving the desired compression and wedging relationships. Aside from the areas of desired scouring and cold welding, the remaining internal and external surfaces of the conduit lengths 2 and 4, as well as the surfaces of the coupling component parts, are free of abra-

sion, deformation and contaminants. Although relative motion occurs between the conduit surfaces and chamber block 36 and the end cap 62, the surfaces of the chamber block and the end cap may be provided with a coating 83 of material having a low coefficient of friction, such as Teflon, to prevent abrasion, nicking or other deformation of the conduit sidewalls 79 and 81. The component parts of the coupling remain free of deformation since compressive force is directed only on the ends 20 of the wedge segments 30, with no parts of the tool touching elsewhere on the coupling component parts. Any contaminants remaining from detonation of the propellant charge and its casing will either remain in the chamber block 36 or be vented slowly after detonation through the vent 72 provided in the piston and conveyed internally of the extension tube 78 away from the end 84 of the conduit length 2. Thus the connection and the conduit lengths remain free of contamination. Although, the preferred embodiments described herein as tubular are either cylindrical or tapered cylindrical, the term "tubular" is selected to mean a structure having a hollow interior and a cross section of any desired shape which may be other than cylindrical.

Although preferred embodiments of the present invention have been described and shown in detail, other embodiments and modifications thereof which would be obvious to an artisan are intended to be covered in the spirit and scope of the appended claims, wherein:

What is claimed is:

1. A method of connecting a relatively short length of conduit to an end of a substantially continuous length of conduit, comprising the steps of: providing a collar on a tubular member intermediate two tapered ends of said tubular member, providing a plurality of frangibly interconnected peripherally spaced wedge segments in two groups with one group initially assembled over each tapered end of said tubular member, providing a chamber block with an ignitable propellant charge, providing a reciprocating piston internally of said chamber block, providing an elongated piston rod on said piston, assembling said piston rod internally through said tubular member and said assembled groups of wedge segments, removably fastening an end cap to the end of said piston rod, seating said end cap against one group of wedge segments, seating said chamber block against the other group of wedge segments to form a subassembly of coupling component parts and tool component parts, partially receiving said subassembly into an end of said substantially continuous length of conduit and also partially into an end of said relatively short length of conduit, igniting said charge of propellant and causing said chamber block and said end cap to be forcibly reciprocated toward each other in compression against respective groups of wedge segments, forcibly urging said first group of wedge segments into wedging relationship between said tapered end of said tube and said end of said substantially continuous length of conduit, forcibly urging said second group of wedge segments into wedging relationship between said tapered end of said tube and said relatively short length of conduit, thereby joining said relatively short length of conduit to said substantially continuous length of conduit in end-to-end relationship, and removing said chamber block, said piston, said piston rod and said end cap from said joined conduit.

2. The method as recited in claim 1, and further including the steps of: connecting an extension to said chamber block, and removing said extension, said chamber block, said piston, said piston rod and said end cap from said conduit subsequent to joining said relatively short length of conduit in end-to-end relationship with said substantially continuous length of conduit.

3. The method as recited in claim 1, and further including the step of: comparing the collective mass of said chamber block and said second group of wedge segments with the collective mass of said piston, said piston rod, said end cap and said first group of wedge segments to cause displacement of both said chamber block and said end cap toward each other upon detonation of said charge of propellant.

4. The method as recited in claim 2, and further including the step of: comparing the collective mass of said chamber block, said extension and said second group of wedge segments with the collective mass of said piston, said piston rod, said end cap and said first group of wedge segments to cause displacement of both said chamber block and said end cap toward each other upon detonation of said charge of propellant.

5. The method as recited in claim 1, and further including the step of: cold welding together said tubular member with said wedge segments, and cold welding together said wedge segments with the corresponding relatively short length of conduit and the substantially continuous length of conduit during said steps of forcibly urging said groups of wedge segments into wedging relationship.

6. An apparatus for joining the ends of two conduit together comprising;

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- a. an elongated tubular member having two externally tapered end portions and a mid section of a diameter which is equal to the inner diameter of said conduit;
- b. a first and second groups of peripherally arranged wedge segments interconnected by frangible webs and each group assembled over one of said tapered end portions, said wedge segments when so assembled having an outer diameter equal to the inner diameter of said conduit;
- c. a chamber block seated at one end of said tubular member and against said second group of wedge segments, said block having a chamber therein;
- d. a charge of propellant positioned in said chamber;
- e. means to detonate said propellant;
- f. a piston reciprocally mounted in said chamber and seated against said charge of propellant;
- g. an elongated piston rod attached to said piston and extending through said tubular member and said first group of wedge segments assembled at another end thereof;
- h. an end cap connected to the free end of said piston rod and seated against said first group of wedge segments so that as said propellant is detonated, said end cap on said piston rod is moved toward said chamber block thereby driving said first group of wedge segments into wedging relationship between and end of one of said conduit and one end of said tubular member and said chamber block is moved toward said end cap thereby driving said second group of wedge segments into wedging relationship between an end of another of said conduit and another end of said tubular member.

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