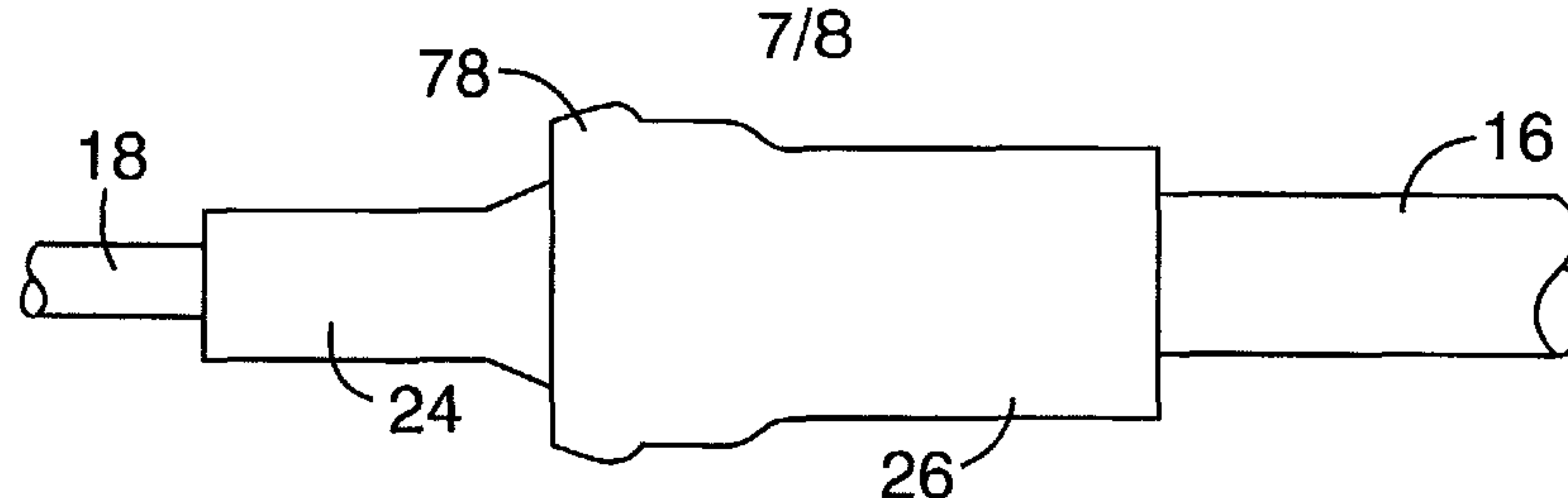




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(57) **Abrégé/Abstract:**

A cold shrink protective cover for a cable junction including a first cable (18) having a first outer diameter and a second cable (16) having a connection to the first cable (18). The second cable (16) has an outer diameter that differs from the outer diameter of the first cable. When shrunk around a cable junction the protective cover comprises a first shrinkable tubular member (24), covering a portion of the first cable (18) and a portion of the connection, and a at least a second shrinkable tubular member (26) covering a portion of the second cable (16) and extending over the connection to at least partially cover an end portion of the first shrinkable tubular member to form an overlapped seam between the two tubular members.



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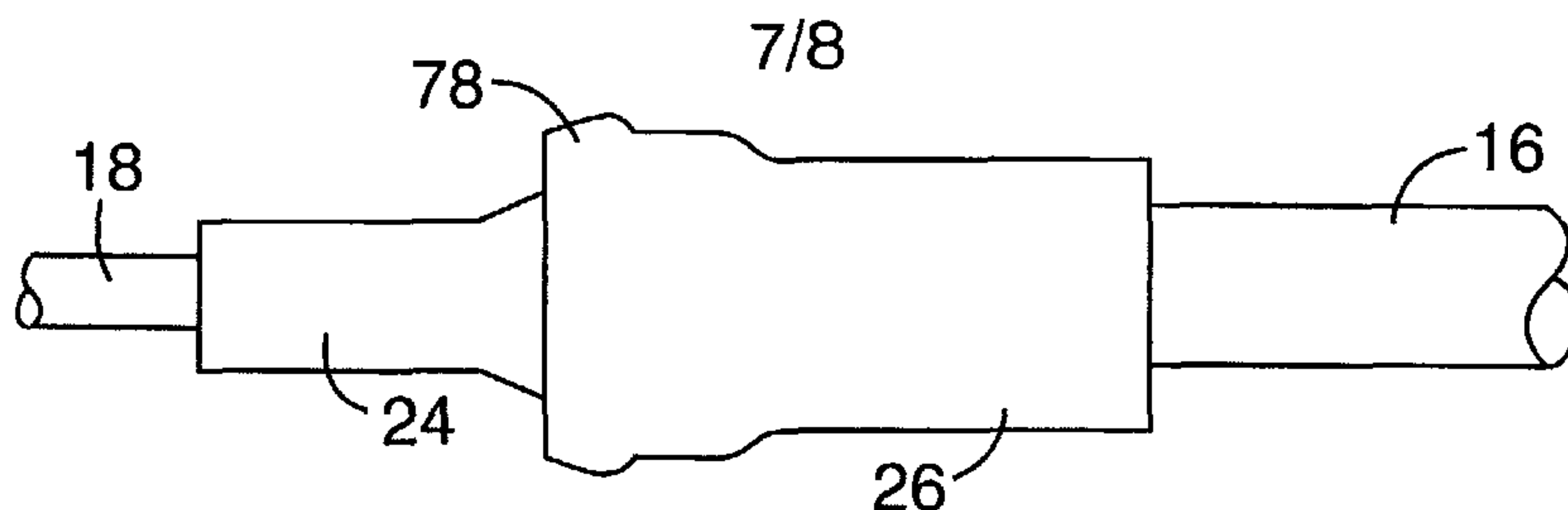
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(54) Title: MULTI-PART INSULATING COVER



(57) Abstract: A cold shrink protective cover for a cable junction including a first cable (18) having a first outer diameter and a second cable (16) having a connection to the first cable (18). The second cable (16) has an outer diameter that differs from the outer diameter of the first cable. When shrunk around a cable junction the protective cover comprises a first shrinkable tubular member (24),

covering a portion of the first cable (18) and a portion of the connection, and a at least a second shrinkable tubular member (26) covering a portion of the second cable (16) and extending over the connection to at least partially cover an end portion of the first shrinkable tubular member to form an overlapped seam between the two tubular members.



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MULTI-PART INSULATING COVER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a protective cover over a junction of the
5 type formed between wires and optical and electrical cables and the like and more
particularly to at least one elastomeric cover held in expanded condition on a
support for positioning around a junction before crushing or otherwise collapsing
the support core to shrink the elastomeric cover into contact with the junction.
Preferably a protective cover according to the present invention includes multiple
10 overlapping covers selected to insulate and seal e.g. cable junctions having shapes
or sizes requiring a plurality of elastomeric covers for adequate protection.

Description of the Related Art

A wide variety of covers have been developed to protect connections,
splices, and terminations that are part of cable systems for energy distribution and
15 communication networks. Suitable cover materials are known to include
thermoplastic polymers for heat shrink applications and cold-shrink elastomers that
substantially return to their original size and shape after prolonged storage in an
expanded condition, at room temperature.

United States Patent No. 5,844,170 discloses a cold-shrink cable closure
20 assembly including one embodiment comprising an outer elastic tubular member
and an inner elastic tubular member adjacent the outer one. The elastic outer
tubular member extends in longitudinal direction beyond both longitudinal ends of
the inner tubular member. Inside the inner tubular member there is provided a
portion of flowable material. The known assembly provides for a three-component
25 electric stress-control system which is supported in a pre-stretched condition by
means of primary and secondary support cores of helically wound ribbon.
Removal of the support cores from inside the tubular arrangement allows it to
shrink to its original dimensions. The flowable material and the materials of the
two tubular members of the known system are selected to control electrical stress
30 within the tubular arrangement.

World Patent Application WO-A-98/40941 describes a pre-stretched elastic tubular member, which is folded to provide an inner portion and an outer portion. Each portion of the elastic tubular member is held in a radially expanded condition by separate supporting means in the form of hollow cores made from helically wound ribbons. The folded and expanded structure occupies less space than conventional shrinkable sleeves.

United States Patent No. 6,111,200 comprises a cold-shrinkable protection element that is useful for covering a joint between two electrical cable ends. The protection element includes first and second elastic sleeves capable of expanding radially when coaxially superimposed each upon the other. A difference in material composition of the first and second elastic sleeves facilitates installation and repair of cable junctions.

European Patent Applications EP 0 422 567 and EP 0 780 949 disclose expandable sleeves including several coaxial layers wherein each layer is distinguishable from the other layers. The sleeves may be stored in expanded condition as cold-shrink structures for controlling electrical stress associated with power cable splices, including splices formed between cables of different radii.

Prior art covering devices may be used to protect a cable connector, cable termination or cable splice particularly for outdoor cable installations requiring protection against bad weather conditions. Installations requiring such protection include connectors, terminations and splices used to attach cables from antennas to wireless telecommunication systems. In this case two coaxial cables attach the antenna to a radio base station that is wired into a telecommunications network. The location of the base station may be at a significant distance from the antenna that normally occupies a position on top of a support tower. Power losses affecting transmission signals between the radio base station and the antenna may be reduced using a large cable, so-called feeder cable, extending from the radio base station towards the antenna. Due to its large diameter, the feeder cable is rather stiff and may not bend sufficiently to allow the cable to connect to an antenna. This problem may be overcome using a connector between the feeder cable and a smaller coaxial cable or jumper cable, which is smaller in diameter than the feeder

cable. The smaller diameter jumper cable has the flexibility necessary for making connection to the antenna.

Cold shrink covers provide protection for wire connections, terminations and splices. However, problems occur when the connection involves cables
5 differing in radial dimensions e.g. corresponding to those of a large feeder cable and a small jumper cable. It may not be possible to cover this cable combination using a single cold shrink cover. If the jumper cable is smaller in diameter than the minimum diameter to which the covering article can shrink, there is a danger that a gap will occur between the covering article and the outer surface of the jumper
10 cable.

Earlier solutions to this problem include wrapping tape or layering tubes around the smaller diameter cable to reduce the amount of shrinkage required of a cold-shrink covering article. A pre-stretched tube, manufactured to have a narrow opening at one end and a wide opening at the other, also overcomes the problem of
15 protecting connections between cables of differing radii. The pre-stretched tube having longitudinal portions of different radius in its structure may be known generally as a pre-molded tubular article or commercially as a cold shrink boot represented by products available from 3M Company. Typically, a cold shrink boot uses a support structure suitable for the larger and smaller radial dimensions
20 of the end portions of the pre-molded article. The support structure holds the molded boot in a stretched condition that does not cause the elastic material of the cold shrink boot to split or develop a permanent set. Although cold shrink boots solve the problem of protecting junctions between cables of differing radii, it will be appreciated that a selection of many different boots would be required to
25 effectively protect all the conceivable combinations of cable diameters.

Available solutions for protecting connections, terminations and splices, involving cables of different radii, require further improvement. For example, application of a modular concept for sealing e.g. cables that differ in diameter is not known. To avoid problems with sealing cable junctions involving cables
30 differing significantly in diameter, there is a need for cable covers that are convenient to apply and provide suitable protection without the need to meet specific design criteria based upon cable radius.

SUMMARY OF THE INVENTION

The present invention provides improved covers for protecting cable connections and splices and related structures, particularly when such structures include differing shapes and dimensions. Preferably, covers according to the present invention comprise at least two shrinkable tubular members for covering different portions of a cable junction formed between cables of different diameter or held together using a cable connector of selected dimensions. Sequential application of shrinkable tubular members produces, for example, a two-part cover that optionally includes a region in the center of the cover where the edge of a first cold-shrink tube touches and overlaps the edge of a second cold-shrink tube. The first tube has a size to shrink snugly around one cable or fitting on one side of the cable junction. The second tube shrinks to grip the surface of a second cable on the other side of the cable junction. The radial dimension of the second tube is significantly different from that of the first tube, after both have shrunk.

Positioning of the first tube and the second tube produces the required overlapped cover portion, if this is needed for forming a seal against penetration by fluids or other contaminants. Preferably the overlapped cover portion forms an off-center seam having displacement towards the smaller diameter tube. The length and dimensions of a connection or termination determines whether a multipart cover according to the present invention includes two or more individual cold shrink tubes.

A preferred multi-part cover according to the present invention uses two pre-stretched tubes having different diameters, as described above. Another embodiment of the present invention uses three pre-stretched tubes of varying dimensions. The three-part cover may be used to protect, for example, a pair of cables of different diameter that are held together using a connector that is wider than either of the cables it connects. A connection of this type requires a suitably sized cold-shrink tube to cover an end portion of each cable and connector terminal portion. The space occupied by the connector, between the connected cables, should also be covered using a cold-shrink tubular member positioned with its ends overlapping the previously applied cold-shrink tubes. Application of cold-shrink tubes to a cable produces a covered cable having a thickness that includes the

thickness of the tubular element and materials such as sealant or mastic and fragments from collapsed supports that remain trapped underneath a tubular element after it shrinks. In the embodiment using a three-part cover, the ends of the center member form overlapping seams with smaller diameter tubular members
5 on either side of it. The covered cable, described above, has an outer dimension that reduces the amount that the center member needs to shrink. Other overlapping arrangements may be used providing that a multi-part cold-shrink cover gives sufficient protection to an underlying connection.

It is possible to envision the use of heat shrink sleeves for overlapped
10 multipart covers according to the present invention. For a variety of reasons the use of cold shrink tubes is preferred and particularly cold shrink tubes initially supported in expanded condition using crushable cores. Advantages of cold shrink tubes include the elimination of a heating step that might either damage a cable junction or release toxic combustion products. In addition, expandable cold shrink
15 sleeves may have thicker walls than heat shrink sleeves, which require wall thickness restrictions for process safety and optimum rate of heat conduction through the heat shrink material.

Cold shrink, pre-stretched tubes are essentially two part structures comprising an elastic tube supported in an expanded condition by a support that
20 collapses under stress. Materials suitable for manufacture of the elastic tube include flexible polymers and elastomers including silicone elastomers and ethylene propylene diene monomer (EPDM) terpolymers. The elastic properties, inherent to elastomeric materials, cause the elastic tube to shrink or recover substantially to its original dimensions following collapse of the support.

25 Known supports for expanded cold shrink tubular members include helically wound ribbon cores and cores referred to herein as crushable cores that disintegrate into fragments when squeezed with sufficient force. Further description of helically wound ribbon cores exists in a number of references including DE 39 43 296, EP 291 213, EP 0 399 263, EP 0 500 216, EP 0 631 357,
30 EP 0 637 117, EP 0 702 444, U.S. 3,515,798, U.S. 4,503,105, U.S. 5,098,752, WO 95/11542, and WO 95/31845.

A variety of references describe structures and materials useful for fabrication of crushable cores. Relevant information is available from references such as EP-A-530 952, EP-A-750 381, U.S. 5,406,871 and U.S. 5,746,253. Protective covers according to the present invention preferably use crushable supports, which have advantages when compared to supports of helically wound ribbon. A significant advantage is the retention of crushed core fragments by elastic cover tubes after shrinking from their expanded condition. Retention of core fragments within a recovered elastomeric tube overcomes the problem of disposal of discarded ribbons produced by collapsed helically wound support cores. Also, cold shrink tubular members using crushable supports require less space for installation because shrinkage occurs simply by squeezing the exterior of the expanded tube, causing the underlying support to disintegrate into fragments. Collapse of a helically wound support requires enough space to withdraw an extended length of ribbon from inside the body of the support. Ease of installation is a benefit when space for access is limited or the application of a protective cover requires an installer to operate at an elevated location or otherwise precarious position.

Previous description of protective covers according to the present invention indicates the need for at least two cold shrink tubes that differ in their radial dimension. The radius of each tube depends upon the radii of the cables used to form a cable junction. Formation of a sealed protective cover requires positioning of the expanded tubes so that, after shrinking, one of the cold shrink tubes overlaps the other. The skill of the installer has a significant influence upon the correct positioning of the expanded tubes before they shrink to provide a protective cover.

Elimination of the need for multiple cold shrink sleeves would further improve the process of installing protective covers according to the present invention. This is possible using an embodiment of the present invention, using a modular concept, in which a one-piece, crushable support has a design that includes at least two crushable portions that may differ in diameter. The crushable portions lie on either side of a non-crushable transition zone. Cold shrink tubes, held in an expanded condition around the crushable portions of the support also extend towards each other to provide an overlapping seam over the non-crushable

transition zone. An overlapped seam may be used even though the transition zone also provides protection. The overlapped seam is not needed when the material used for the transition zone has sufficient strength to resist damage during handling and normal use.

5 When used for protective covering of a cable junction the one-piece cold shrink structure, that includes at least two pre-stretched tubes, may be moved so that the transition zone is centrally located between cables that form the cable junction. Application of pressure, by squeezing the ends of the one-piece cold shrink structure, causes collapse of the crushable portions accompanied by
10 recovery of the expanded elastic tubes to grip the covered portions of the cables. There is no change in the size and shape of the transition zone, which continues to provide support for the ends of the elastic tubes. As described, the use of a single, crushable support core, including solid transition zones, facilitates installation of multiple cold shrink tubes around junctions between cables. Pre-positioning of
15 overlapped pre-stretched tubes on a single support, referred to herein as a pre-formed cover, increases the probability of forming a watertight seam when a protective cover shrinks around a cable junction.

More particularly the present invention provides a cold shrink cover for a cable junction including a first cable having a first outer diameter joined to a
20 second cable having a second outer diameter that is greater than the first outer diameter. The cold shrink cover comprises a first elastic tubular member held in expanded condition over a first hollow collapsible support that has a size to receive a portion of the first cable and a first portion of the cable junction. Also the cold shrink cover includes a second elastic tubular member held in expanded condition
25 over a second hollow collapsible support that is sized to receive a portion of the second cable, a second portion of the cable junction and an end portion of the first elastic tubular member. The first support is adapted to collapse during application of force to allow the first elastic tubular member to shrink for covering the portion of the first cable and the first portion of the cable junction. The second support is
30 also adapted to collapse during application of force to allow the second elastic tubular member to shrink for covering the portion of the second cable, the second portion of the cable junction and the end portion of the first elastic tubular member.

One embodiment of a cold shrink cover according to the present invention may include a multi-zone support core having the first hollow collapsible support integrally formed with the second hollow collapsible support. A multi-zone support allows the formation of a pre-mounted protective cover as a modular,
5 unitary structure that includes multiple elastic tubular members held in expanded condition. The multi-zone support core may include a crush resistant transition zone separating a first hollow collapsible support from a second hollow collapsible support.

Another embodiment of the present invention provides a cold shrink cover
10 for a cable junction including a first cable having a first outer diameter joined to a second cable having a second outer diameter greater than the first outer diameter. The cold shrink cover comprises an adapter including an inner tubular extension opposite a tubular projection and further including a junction receiving channel sized to surround at least a portion of the cable junction. The cold shrink cover
15 further includes a first elastic tubular member held in expanded condition over a first hollow collapsible support sized to receive a portion of the first cable and a portion of the inner tubular extension. A second elastic tubular member held in expanded condition over a second hollow collapsible support has a size to receive a portion of the second cable, and a portion of the tubular projection. The first
20 support is adapted to collapse during application of force to allow the first elastic tubular member to shrink for covering the portion of the first cable and the portion of the inner tubular extension. The second support is adapted to collapse during application of force to allow the second elastic tubular member to shrink for covering the portion of the second cable, and the portion of the tubular projection,
25 thereby holding the adapter between the first elastic tubular member and the second elastic tubular member for covering the cable junction.

Terms used herein have the meanings indicated as follows:

Terms including “support” or “support core” or “support structure” or “core” or the like may be used interchangeably herein to describe an article
30 suitable for placement inside an expanded elastic cover to hold the elastic cover in an expanded condition. One or more supports may be included with cold shrink covers according to the present invention.

The term “collapsible support” and related terms refer to a support adapted to collapse during application of force to allow an expanded elastic cover, held around the support, to shrink towards its original dimensions. Collapsible supports include those formed by molding that produces a “crushable support or core,”
5 which collapses under compressive force, and those formed by spot-welding together wraps of a plastic strip, spirally wound as a helix, to produce a tube also referred to herein as a “ribbon core.” Ribbon cores collapse under tensile force that destroys spot-welds between wraps, unzipping the core and returning it to its original ribbon form.

10 The term “modular” is used for describing unitary structures that may include support elements, adapters, including multiple part adapters, and elastic tubular elements needed for covering cable junctions according to the present invention.

The term “multi-zone” applies to a particular type of crushable support that
15 includes perforated or lattice portions and continuous wall, crush-resistant portions between perforated or lattice portions.

Use of the term “cable junction” identifies a point in a cable structure at which a first cable is connected or joined to a second cable. In the case of the present invention the diameter of the first cable is different, and may be
20 significantly different, from the diameter of the second cable. Cable conductors may be joined directly together in a cable junction or may be attached to each other using an intervening cable connector.

The term “protective cover” refers to structures that enclose cable junctions to seal out fluids and other environmental contaminants that may impair signal
25 transmission in communications networks and energy transmission grids. A protective cover may include a “sealant” material as a further barrier against ingress of undesirable contaminants. Suitable sealant materials include commonly used mastic compounds. A fluid sealant provides a containment matrix around fragments of a crushed support.

30 A “multipart cover,” as used herein, means a protective cover that uses two or more elastic tubular elements to enclose and protect a cable junction.

Terms such as “pre-mounted cover,” “pre-formed cover,” and “pre-assembled cover” and the like, refer to elastic tubular elements held in expanded condition on a support. Pre-mounted tubes may be stored until needed to protect a cable or cable junction at which time the support collapses, during application of
5 force, to allow the elastic tubular element to shrink into gripping contact with the cable or cable junction.

The term “crush resistant” refers to portions of a multi-zone support and particularly to the portion of the support that, being substantially non-crushable, withstands application of force sufficient to cause collapse of collapsible support
10 structures.

Terms including “cold shrink tube” “pre-stretched tube” “cold shrink tubular element” and the like refer to structures comprising at least one elastic tube supported in an expanded condition by a support that collapses under compressive or tensile stress.

15 BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in greater detail with reference to the attached drawings in which:

Figure 1 provides an isometric, schematic representation of an application using multi-part cold shrink covers according to the present invention to protect
20 cable junctions between a signal antenna and a communications base station.

Figure 2 illustrates a combination of coaxial cables having different radii that may be used to provide connection between communications base stations and signal antennas.

Figure 3 is a schematic illustration of coaxial cables of markedly different
25 radii that may be used to connect communications base stations to signal antennas.

Figure 4 shows a side view of a pair of cables of differing diameter (see Figure 2) before formation of a connection between them.

Figure 5 is a side view of a pair of cables of Figure 2 after formation of a connection between them.

30 Figure 6 provides a side view of a pair of cables of Figure 2 showing the positioning and partial collapse of a cold shrink tube around the cable of smaller diameter.

Figure 7 provides a side view of a pair of cables of Figure 2 showing the positioning and partial collapse of a cold shrink tube around a portion of a previously applied cold shrink tube and a portion of the cable of larger diameter.

5 Figure 8 is a side view of a completed multi-part cover according to the present invention showing protection of cables of Figure 2 and overlap of tubular members shrunk around the connection.

Figure 9 shows a side view of a pair of cables of markedly differing diameter (see Figure 3) before formation of a connection between them.

10 Figure 10 is a side view of a pair of cables of Figure 3 after formation of a connection between them.

Figure 11 provides a side view of a pair of cables of Figure 3 showing the positioning and partial collapse of a cold shrink tube around the cable of smaller diameter.

15 Figure 12 provides a side view of a pair of cables of Figure 3 showing the positioning and partial collapse of a cold shrink tube around a portion of a previously applied cold shrink tube and a portion of the cable of significantly larger diameter.

20 Figure 13 is a side view of a completed multi-part cover according to the present invention showing protection of cables of Figure 3 and overlap of tubular members shrunk around the connection.

Figure 14 shows a side view of a coaxial cable positioned for termination at an antenna.

Figure 15 is a side view of a termination between a coaxial cable and an antenna.

25 Figure 16 provides a side view showing the positioning and partial collapse of a cold shrink tube over a termination between a cable and an antenna.

Figure 17 is a side view of cold shrink tube shrunk around a termination to protect the termination from the environment.

30 Figure 18 is a side view of another embodiment of a completed multi-part cover showing overlap of tubular members to protect two coaxial cables and a connector body used to connect the cables together.

Figure 19 is a schematic representation of a support according to the present invention including crushable end portions separated by a crush resistant transition zone.

5 Figure 20 shows a partially cut-away side view illustrating the positioning of overlapping cold-shrink tubes held in expanded condition by crushable support portions.

Figure 21 is a schematic representation of a one-piece cold shrink structure that includes a pair of overlapping cold shrink tubes held in expanded condition using a crushable support that includes a crush resistant transition zone between
10 crushable portions of different diameter.

Figure 22 provides a schematic representation of cable junction protected by a cover according to the present invention that may be used with cables of different radii.

Figure 23 is a schematic cross sectional view showing a support including
15 crushable end sections covered with overlapping cold shrink tubes held in expanded condition.

Figure 24 is a schematic cross sectional view similar to Figure 23 without overlap of cold shrink tubes held in expanded condition on a support core including crushable end sections.

20 Figure 25 is a schematic cross sectional view for a cable junction cover arrangement including a small diameter cold shrink member partially inserted into a support for a larger diameter cold shrink member.

Figure 26 provides a schematic cross sectional view of cold shrink members of differing diameter placed in alignment using a stepped adapter.

25 Figure 27 provides a schematic cross sectional view of cold shrink members of differing diameter placed in alignment using a two-part stepped adapter.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention provides articles that may be used individually or
30 combined in a variety of ways to provide protective coverings that seal out fluids and other environmental contaminants from junctions required in the formation of communications networks and energy distribution grids. Referring now to the

figures wherein like numbers refer to like parts throughout the several views, Figure 1 provides a schematic illustration of structures that form part of a wireless communications network. A base station 10 requires connection to a tower 12 that supports several antennas 14. As illustrated, Figure 1 includes three antennas 14 as
5 signal emitters or receivers. Each antenna 14 fulfils the need for two-way communication using two main cables that connect the antenna 14 to the radio base station 10. One main cable transmits signals from the radio base station 10 to an antenna 14. The other main cable carries signals, received by the antenna 14, to the radio base station 10 for processing into the communications network.

10 Although addressing only one antenna 14, the following discussion applies to any number of antennas that may be part of a wireless communications tower 12. Each main cable connecting an antenna 14 to a radio base station 10 uses at least two coaxial cables 16, 18. A coaxial cable 16, also referred to herein as a feeder cable or a second cable, has a diameter that is larger than a first cable 18,
15 which may be referred to as a jumper cable. The increased size of the feeder cable 16 compared to the jumper cable 18 relates to distance between the antenna 14 and the base station 10. Power losses affecting transmission signals between the radio base station and the antenna may be reduced when the cable 16 is a large diameter feeder cable that reaches close to the antenna 14. Large diameter cables 16 tend to
20 be too rigid and inflexible to bend sufficiently for direct attachment to an antenna 14. The smaller diameter, more flexible, first cable 18 overcomes this problem to provide a continuous signal carrier from the antenna 14 to the base station 10.

Figure 2 and Figure 3 provide schematic illustrations showing combination of cables 16, 18 for connecting an antenna 14 to a base station 10. As shown, the
25 feeder cable 16 portion of the main cable varies in diameter between the figures but the jumper cable 18 appears to be the same in both figures. This is for example only and is not intended to be limiting in any way. The need for connection of a feeder cable 16 to a jumper cable 18 may be satisfied using a coaxial cable connector 20. Circled portions of each figure, identified by letter codes A and B
30 respectively, indicate cable 16, 18 and connector 20 portions that require protection by multi-part covers according to the present invention.

The following discussion of cable dimensions is intended for example only to show differences in the radii of cables that may form the link or main cable between a base station 10 and an antenna 14. A first cable 18 may have an outer diameter of 1.3 cm (1/2 inch) while the outer diameter of the second cable 16 may be between 2.2 cm (7/8 inch) and 4.1 cm (1.63 inch). Coaxial cable diameters may vary further depending on other factors such as thickness of the cable outer wall, which may differ from cable manufacturer to cable manufacturer. The need to join cables of varying diameter may be met using suitable cable connectors that have internal dimensions corresponding to differences in cable radii.

Figure 2 and Figure 3 illustrate two types of connection including a cable junction formed between cables 16, 18 using a cable connector 20, and a cable termination designated by letter code C that includes a jumper cable 18 and a terminal portion of an antenna 14. Covers according to the present invention provide suitable protection for both types of connection using the least possible number of parts to cover and accommodate differences in cable sizes.

Figures 4, 5, 6, 7 and 8 illustrate the steps required to install a protective cover over a cable junction between a feeder cable 16 and a smaller diameter jumper cable 18. A cover according to the present invention comprises a first cold shrinkable elastic tubular member 24 and a second cold shrinkable elastic tubular member 26. Materials suitable for manufacture of elastic tubular members include flexible polymers and elastomers including silicone elastomers and ethylene propylene diene monomer (EPDM) terpolymers. The elastic properties, inherent to an elastomeric material, causes a cold shrink elastic tubular member, held in expanded condition on a support, to shrink or recover towards its original dimensions following collapse of the support.

After placing the cold shrink elastic tubular members 24, 26 over the feeder cable 16 and jumper cable 18 respectively, the formation of a junction between the two coaxial cables 16, 18 includes screwing the threads of the female fitting 48 over threaded male fitting 50. The assembled connector 20 appears as in Figure 5, before positioning and collapsing the cold shrink elastic tubular members 24, 26 to form a protective cover. Each tubular member 24, 26 includes an elastic tube held in expanded condition on a collapsible support 32, 34, preferably a crushable core

made from plastics material and having points of weakness that fracture under pressure. Application of sufficient squeezing force to a crushable core 32, 34 causes a plurality of points to fracture producing cracks in the support.

Propagation of cracks causes collapse of the support core 32, 34. As the core
5 collapses the expanded tube 24, 26 shrinks to grip and protect a portion of the surface of the cable junction. Fragments of the crushable supports 32, 34 remain between the cold shrink tubular elements 24, 26 and the outer surfaces of the cable junction.

Preferred crushable supports according to the present invention are lattice
10 type support cores produced using injection molding of plastics including polymethylmethacrylate (PMMA), and polystyrene and mixtures thereof. A lattice type support core has transverse members that connect longitudinal members together. The transverse members include points of weakness resulting from the flow characteristics of molten plastic as it fills the mold. During injection, molten
15 plastic enters from an annulus at one end of the support mold so that material flows preferentially to form longitudinal members from one end of the mold to the other before flowing into parts of the mold corresponding to the transverse members. This method of injection molding creates a join or weld line between two fronts of molten plastic material flowing from adjacent longitudinal members into a
20 particular, connecting, transverse member. The join or weld lines lie substantially at the middle of each transverse members to produce discrete points of weakness compared to the remainder of the support core structure. When placed under compressive force an injection molded, crushable support will collapse producing fragments by preferential fracture at the weakened join lines.

25 Figure 6 shows the result of positioning a cold shrink tubular member 24 around the female fitting 48 of the connector 20 and an end portion of the jumper cable 18, followed by squeezing the outer end 58 of the cold shrink tubular member 24 to cause its collapse around the jumper cable 18. Application of pressure by squeezing the other end 52 of the cold shrink tubular member 24
30 completes installation of a first part of a multi-part protective cover according to the present invention.

Figure 7 illustrates positioning of the second cold shrink tubular member 26 into an overlapping relationship with the first cold shrink tubular member 24 before squeezing and collapsing the support 34 to allow the tubular member 26 to shrink around the male fitting 50 of the cable connector 20 and the feeder cable 16.

5 The sealing capacity of a recovered cold shrink tube may be improved, and a tight seal provided around a cable junction, using mastic or gasket material as a seal 46 at the ends of the elastic tubular members 24, 26 supported in its radially expanded condition by the crushable core. Such use of mastic and gasket materials is known in the art for improving seals between a protective cover and the object that is
10 covered.

Figure 8 shows the result of applying a protective cover, including overlapped elastic tubes 24, 26, to a cable junction that has a complex shape produced by joining cables 16, 18 of differing diameter using a relatively bulky coaxial cable connector 20. Fragments of the crushable supports 32, 34 remain
15 between the cold shrink tubular elements 24, 26 and the outer surfaces of the cable junction. This provides the advantage of cover installation without generation of waste such as plastic ribbon produced during application of cold shrink tubes supported on helically wound cores.

Figures 9, 10, 11, 12 and 13 illustrate the steps required to install a
20 protective cover over a cable junction between a jumper cable 18 similar to that of Figure 4 and a feeder cable 16 of larger diameter as depicted in Figure 3. Figure 10 shows the positioning of cold shrink tubular elements 24, 26 around the respective cables 16, 18, before screwing the male fitting 50 of the coaxial cable connector 20 into the female fitting 48 to form a cable junction. The positioning of
25 cold shrink tubular elements around the cable junction (see Figure 11 and Figure 12) precedes collapse of the crushable supports 32, 34 allowing the tubular elements to shrink into a gripping relationship with the outer surfaces of the cable junction. A fully installed cover, as illustrated in Figure 13, includes overlap of one tubular element 24 by the other tubular element 26. This provides a seam that
30 prevents water and other contaminants from seeping under the protective cover. Preferably a band of mastic, at each end of each tubular element 24, 26, provides an added seal 46 for more effective protection of the cable junction.

Figures 14, 15, 16, and 17 show the sequence of installing a cold shrink tubular element 24 to provide a covering over the cable termination joining the jumper cable 18 and the antenna 14. In this case a tubular element 24, placed in expanded condition around the jumper cable 18, has an internal diameter large enough to contain the cable and the male threaded antenna fitting 62. Figure 15 shows assembly of the termination by screwing the female fitting 60 of the jumper cable 18 on to the antenna fitting 62 before moving the cold shrink tubular element 24 into position. The cold shrink tube 24, upon application of force by squeezing, shrinks to grip the jumper cable, as shown in Figure 16. Figure 17 illustrates a covered termination produced by crushing the support 32 over the antenna fitting 62 to allow the tubular element 24 to shrink around this fitting 62. Improved sealing may be obtained by including a seal 46 at either end of the cold shrink tubular member 24. Preferably the seal comprises a material that flows around fragments of the crushed core 32 to aid retention of the core fragments inside the tube that has shrunk around the termination. Previously described cable junction covers according to the present invention may also use a fluid sealant material as a containment matrix around fragments of a crushed support.

Fig. 18 shows another embodiment of a cold shrinkable cover 22' according to the present invention for covering a cable junction formed by connecting two coaxial cables 18 of the same or different outer diameters. In this case the length of the cable junction requires application of three cold shrink tubular elements 24, 26 to form a multi-part protective cover. This three part cover uses two cold shrinkable first tubular members 24 and one cold shrinkable second tubular member 26. The first tubular members 24 with their cable covering portions 58 cover the coaxial cables 18 while the connector covering portions 52 of the first tubular members 24 cover the portions of the connector 20 used to join the cables 18. The space occupied by the connector 20 between the connector covering portions 52 of the first tubular members 24 requires the second tubular member 26 as a protective cover with its opposite ends overlapping the first tubular members 24. A seal and sealant material may be used as described previously for improved sealing and retention of fragments produced by collapse of the crushable supports used to hold the three cold shrink tubular elements 24, 26 in expanded condition.

Another embodiment of multi-part covers according to the present invention provides a pre-mounted cover using at least two elastic tubular elements placed in expanded condition around a single crushable support that includes multiple crushable portions separated by at least one crush resistant transition zone.

5 This special support may also be referred to herein as a multi-zone support core. A multi-zone support core supports overlapping elastic tubes in expanded condition. A distinguishing feature of a pre-mounted multi-part cover is the benefit it gives to the installer. Wireless communications antennas usually occupy an elevated position. Cable connections to an antenna frequently require the use of a raised

10 platform to allow an installer to reach a cable connection or termination to install a protective cover. The difficulty of installation and the time to install a cover may be reduced using the minimum number of parts. Two part covers, previously discussed, require two separate cold shrink tubular elements. Placement of an effective multi-part protective cover around a connection requires correct

15 positioning of the cold shrink tubes with sufficient overlap to provide a weather-tight seam after shrinkage. Operator skill is required for consistent installation of protective covers using separate cold shrink tubular elements.

Figure 19 illustrates a single multi-zone core 70 that accommodates at least two cold shrink tubular elements 24, 26. As shown, the support 70 has a design

20 including a first crushable portion 72 of a first diameter and a second crushable portion 74 having a second diameter. A substantially non-crushable, transition zone 76 separates the first crushable portion 72 from the second crushable portion 74. The support 70 may be molded from plastic so that the crushable portions 72, 74 have a lattice structure that includes points of weakness to facilitate

25 disintegration of the first 72 and second 74 crushable portions of the support during application of pressure.

Figure 20 is a partial cutaway side view showing positioning of a first expanded elastic tube 24 on one side of a multi-zone core 70 to cover the first crushable portion 72 and part of the transition zone 76. A larger diameter

30 expanded elastic tube 26 occupies a position around the second crushable portion 74, extending over a portion of the transition zone 76 to form an overlapping seam

78 with the first expanded elastic tube 24. This completes the assembly of a pre-mounted cover 80 according to the present invention.

Figure 21 illustrates positioning of a pre-mounted cover 80 over a cable, e.g. a coaxial jumper cable 18 that is part of a cable junction 82 between a small diameter cable 18 and a larger diameter cable 16. The junction may be formed using a cable connector as described previously. After joining the cables together, the premounted cover 80 may be moved in the direction indicated by the arrows until it occupies a position at which the crushable portions 72, 74 are squeezed to allow the elastic tubular elements 24, 26 to shrink around the cables and the centrally located cable junction. The resulting covered junction is shown in Figure 22. Although the first crushable portion 72 and the second crushable portion 74 have collapsed, the transition zone 76 remains unbroken. The outline of the transition zone 76 is visible under the shrunk protective cover formed by the first and second elastic tubular elements 24, 26. The use of a pre-mounted cold shrink cover according to the present invention increases the probability of forming an effective overlapping seam 78 for each protective cover installed.

Figure 23 provides a cross sectional view corresponding to the pre-mounted cover structure 80 depicted in Figure 20. The figure includes a multi-zone support core 70, having a crush resistant transition zone 76 separating crushable portions 72, 74 covered by first and second elastic tubular elements 24, 26 including overlap 78 between the two.

Figure 24 uses the support 70 having multiple crush zones similar to that shown in Figures 20 and 23. In this case there is a gap 84 between the elastic tubular elements 24, 26. It is possible to use this embodiment of a premounted cover when the transition zone 76 is strong enough to protect an underlying wire or cable junction without collapsing. Although illustrated as changing gradually from a small diameter to a larger diameter, the funnel-shaped transition zone 76 of a single multi-zone support core 70 may optionally adopt a variety of shapes including a stepped transition zone. A stepped transition zone includes a plate having an orifice corresponding to the internal diameter of a small diameter tube that extends on one side of the plate. The perimeter or diameter of the plate

corresponds to the inner dimension of a large diameter tube extending opposite the small diameter tube.

Although described in terms of cylindrical tubes, it will be appreciated that the cross section of a multi-zone support core 70 may have any one of a variety of geometrical shapes including circular, oval, triangular and square cross section. This is also true of crushable cores such as those shown in Figure 25 that includes two separate crushable cores supported tubular elements 86, 88 the smaller 86 of which has an overall diameter sized to fit inside the larger tubular element 88. The smaller tubular element 86 has a solid terminal extension 90 directly attached to a crushable core section 92. An expanded elastic tubular element 24 covers the terminal extension 90 and the crushable core section 92. The larger tubular element 88 is a conventional cold shrink structure having an expanded elastic tube 26 supported on a crushable support 94. Partial insertion of the smaller tubular element 86 into the larger tubular element 88 provides an arrangement 96 of cold shrink structures that may be collapsed to protect a cable junction that includes wires or cables of significantly different diameters. After collapse, the elastic tube of larger diameter 26 grips the surface of the large diameter wire or cable and shrinks over an end 98 of the smaller diameter tubular element 86 to provide an overlapped seam supported by the solid terminal extension 90, which, being a uniform solid section, retains its original dimensions. An "O" ring or sealant material, such as a mastic compound, may be placed between the end of the larger diameter tubular element 88 and the end 98 of the smaller diameter tubular element 86 for improved sealing between the tubes 24, 26 after collapse of their supports 92, 94. The crushable core section 92, joined directly to the terminal extension 90, collapses in the same way as crushable support 94 causing the supported elastic tubular element 24 to recover towards its original dimensions to grip a small diameter wire or cable that would form part of the covered junction.

Figure 26 provides another embodiment of a protective covering according to the present invention. A wire or cable junction 100 between a small diameter wire or cable 102 and a larger diameter wire or cable 104 provides a continuous signal path between a first signal carrier 106 and a second signal carrier 108. After formation of the junction 100, a solid adapter 110 may be placed over the junction

100 as a means to protect the junction 100. The adapter 110 includes a disc 112 having an inner tubular extension 114 on one side and a tubular projection 116 on the other. A junction-receiving channel 118 provides a continuous opening between the disc 112 and the inner tubular extension 114. The diameter of the
5 junction-receiving channel 118 is large enough to pass over the small diameter cable 102, the cable junction 100 and the signal carrier 108 of the larger cable 104. Preferably the diameter of the smaller cable 102 is only slightly less than the diameter of the junction receiving channel 118. Also, it is preferred that the tubular projection 116 has an internal diameter close to the diameter of the larger
10 cable 104. Using this arrangement, the adapter 100 fits snugly over end portions of the cables 102, 104, to provide protection to the junction 100 formed between the signal carriers 106, 108. A first cold shrink sleeve 120 having a support core 122 of suitable dimensions for mounting on the inner tubular extension 114 may be used to cover the tubular extension 114 and a portion of the smaller cable 102 after
15 shrinking around these parts 102, 114. The sleeve 120 shrinks after applying force to collapse the support 122 used to hold the cold shrink sleeve 120 in expanded condition. A second cold shrink sleeve 124, suitably sized, provides similar protection for the tubular projection 116 and a portion of the larger cable 104. To improve sealing around an adapter 110 a support core 122 may include a sealant
20 coating 126, 128 using materials such as commonly used mastic compounds.

A solid adapter 110 may be fabricated from a material such as a plastic resin that has sufficient impact strength to withstand damage during normal operation. Solid adapters 110 provide the benefit of protecting cable junctions 100 without requiring formation of an overlapped seam between cold shrink sleeves
25 120, 124.

Figure 27, shows a protective structure similar to that of Figure 26 except for the use of a two part adapter 130 using a inner tubular extension 114 that is separable from a tubular projection 116. A screw portion 132 provides means to connect the tubular extension 114 to the tubular projection 116 in Figure 27. A
30 seal, such as an "O" ring, may be included between the male and female threaded portions of the tubular extension 114 and tubular projection 116 respectively, to provide an internally sealed two-part adapter 130. Although a screw connection

132 is indicated in Figure 27, other means of attachment may be used to produce adapters 110, 130 of the general structure shown in Figures 26 and 27 without departing from the essence of the present invention. The use of a solid or two part adapter includes several benefits including the advantage of protecting a cable junction with a solid, crush resistant structure and, in the case of the two part adapter, offering the flexibility of varying combinations of inner tubular extensions 114 and tubular projections 116 that use connecting means of common dimensions, e.g. screw size. Apart from the use of a special adapter 110, 130, as described previously, a pre-mounted cover, or covered cable junction, may be produced using conventional cold shrink tubes held on a variety of collapsible supports including crushable and helically wound ribbon types. As a further option, using a two-part adapter 130, it is conceivable to integrally form a support 122 with either a inner tubular extension 114 or a tubular projection 116. This reduces from four to two the number of parts required to form a pre-mounted structure similar to that shown in Figure 27.

Protective covers, for cable junctions, connections and splices and terminations and components thereof, have been described herein. These and other variations, which will be appreciated by those skilled in the art, are within the intended scope of this invention as claimed below. As previously stated, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various forms.

CLAIMS

What is claimed is:

1. A cold shrink cover for a cable junction including a first cable (18) having a first outer diameter joined to a second cable (16) having a second outer diameter greater than the first outer diameter, the cold shrink cover comprising:
5 a first elastic tubular member (24) held in expanded condition over a first hollow collapsible support (32) sized to receive a portion of the first cable (18) and a first portion of the cable junction; and
a second elastic tubular member (26) held in expanded condition
10 over a second hollow collapsible support (34) sized to receive a portion of the second cable (16), a second portion of the cable junction and an end portion of the first elastic tubular member (24), the first support (32) adapted to collapse during application of force to allow the first elastic tubular member (24) to shrink for covering the portion of the first cable (18) and the first portion of the cable
15 junction, the second support (34) adapted to collapse during application of force to allow the second elastic tubular member (26) to shrink for covering the portion of the second cable (16), the second portion of the cable junction and the end portion of the first elastic tubular member (24).
2. The cold shrink cover of claim 1, including a multi-zone support
20 core (70) having the first hollow collapsible support (72) integrally formed with the second hollow collapsible support (74).
3. The cold shrink cover of claim 2, wherein the multi-zone support core (70) includes a crush resistant transition zone (76) separating the first hollow collapsible support (72) from the second hollow collapsible support (74).
- 25 4. The cold shrink cover of claim 1, wherein the cable junction includes a cable connector (20).

5. The cold shrink cover of claim 1, wherein the first hollow collapsible support (32) includes a solid terminal extension (90) directly attached to a crushable core section (92).

6. The cold shrink cover of claim 1, further including a sealing material to seal at least opposing ends of each of the first elastic tubular member (24) and the second elastic tubular member (26).

7. The cold shrink cover of claim 1, wherein both of the first (18) and second cables (16) are coaxial cables.

8. A cold shrink cover for a cable junction including a first cable (102) having a first outer diameter joined to a second cable (104) having a second outer diameter greater than the first outer diameter, the cold shrink cover comprising:

an adapter (110) including an inner tubular extension (114) opposite a tubular projection (116) and further including a junction receiving channel (118) sized to surround at least a portion of the cable junction;

a first elastic tubular member (120) held in expanded condition over a first hollow collapsible support (122) sized to receive a portion of the first cable (102) and a portion of the inner tubular extension (114); and

a second elastic tubular member (124) held in expanded condition over a second hollow collapsible support (122) sized to receive a portion of the second cable (104), and a portion of the tubular projection (116), the first hollow collapsible support (122) adapted to collapse during application of force to allow the first elastic tubular member (120) to shrink for covering the portion of the first cable (102) and the portion of the inner tubular extension (114), the second support (122) adapted to collapse during application of force to allow the second elastic tubular member (124) to shrink for covering the portion of the second cable (104), and the portion of the tubular projection (116), thereby holding the adapter (110) between the first elastic tubular member (120) and the second elastic tubular member (124) for covering the cable junction.

9. The cold shrink cover of claim 8, wherein the cable junction includes a cable connector.

10. The cold shrink cover of claim 8, wherein the adapter (130) includes means for forming a connection (132) between the inner tubular extension (114) and the tubular projection (116).

11. The cold shrink cover of claim 10, wherein the connection (132)
5 includes an "O-ring" seal.

12. The cold shrink cover of claim 8, wherein the adapter (110) is crush resistant.

13. The cold shrink cover of claim 8, further including a sealing material to seal at least opposing ends of each of the first elastic tubular member
10 (120) and the second elastic tubular member (124).

14. The cold shrink cover of claim 8, wherein both of the first (102) and second (104) cables are coaxial cables.

15. A cold shrink cover for a cable junction including a first cable (18) having a first outer diameter joined to a second cable (16) having a second outer
15 diameter greater than the first outer diameter, the cold shrink cover comprising:
a first elastic tubular member (24) held in expanded condition over a first hollow collapsible support (72) sized to receive a portion of the first cable (18) and a first portion of the cable junction; and
a second elastic tubular member (26) held in expanded condition
20 over a second hollow collapsible support (74) integrally formed with the first hollow collapsible support (72) to provide a multi-zone support core (70) having the second hollow collapsible support (74) sized to receive a portion of the second cable (16) and a second portion of the cable junction, the first support (72) adapted to collapse under pressure to allow the first elastic tubular member (24) to shrink
25 for covering the portion of the first cable (18) and the first portion of the cable junction, the second support (74) adapted to collapse under pressure to allow the second elastic tubular member (26) to shrink for covering the portion of the second cable (16) and the second portion of the cable junction.

16. The cold shrink cover of claim 15, wherein the multi-zone support core (70) includes a solid transition zone (76) separating the first hollow collapsible support (72) from the second hollow collapsible support (74).

17. The cold shrink protective cover of claim 15, wherein the cable
5 junction includes a cable connector.

18. The cold shrink cover of claim 15, further including a sealing material to seal at least opposing ends of each of the first elastic tubular member (24) and the second elastic tubular member (26).

19. The cold shrink cover of claim 15, wherein both the first (18) and
10 second (16) cables are coaxial cables.

20. A pre-mounted pre-stretched cover for a cable junction including a first cable (18) having a first outer diameter and a second cable (16) having a connection to the first cable (18), the second cable (16) having a second outer diameter that differs from the first outer diameter, the pre-mounted pre-stretched
15 cover comprising:

a support (70) including a first crushable portion (72) separated by a non-crushable transition zone (76) from a second crushable portion (74);

a first shrinkable tubular member (24) substantially covering the first crushable portion (72) and extending into a first portion of the non-crushable
20 transition zone (76); and

a second shrinkable tubular member (26) substantially covering the second crushable portion (74), a second portion of the non-crushable transition zone (76) and adapted to overlap the first shrinkable tubular member (24) to form an overlapped seam (78) therewith.

21. A covered cable junction including a first cable (18) having a first
25 outer diameter and a second cable (16) having a connection to the first cable (18), the second cable (16) having a second outer diameter that differs from the first outer diameter, the covered cable junction having a pre-mounted, pre-stretched

cover shrunk into gripping contact with the cable junction, the pre-mounted, pre-stretched cover before shrinking comprising:

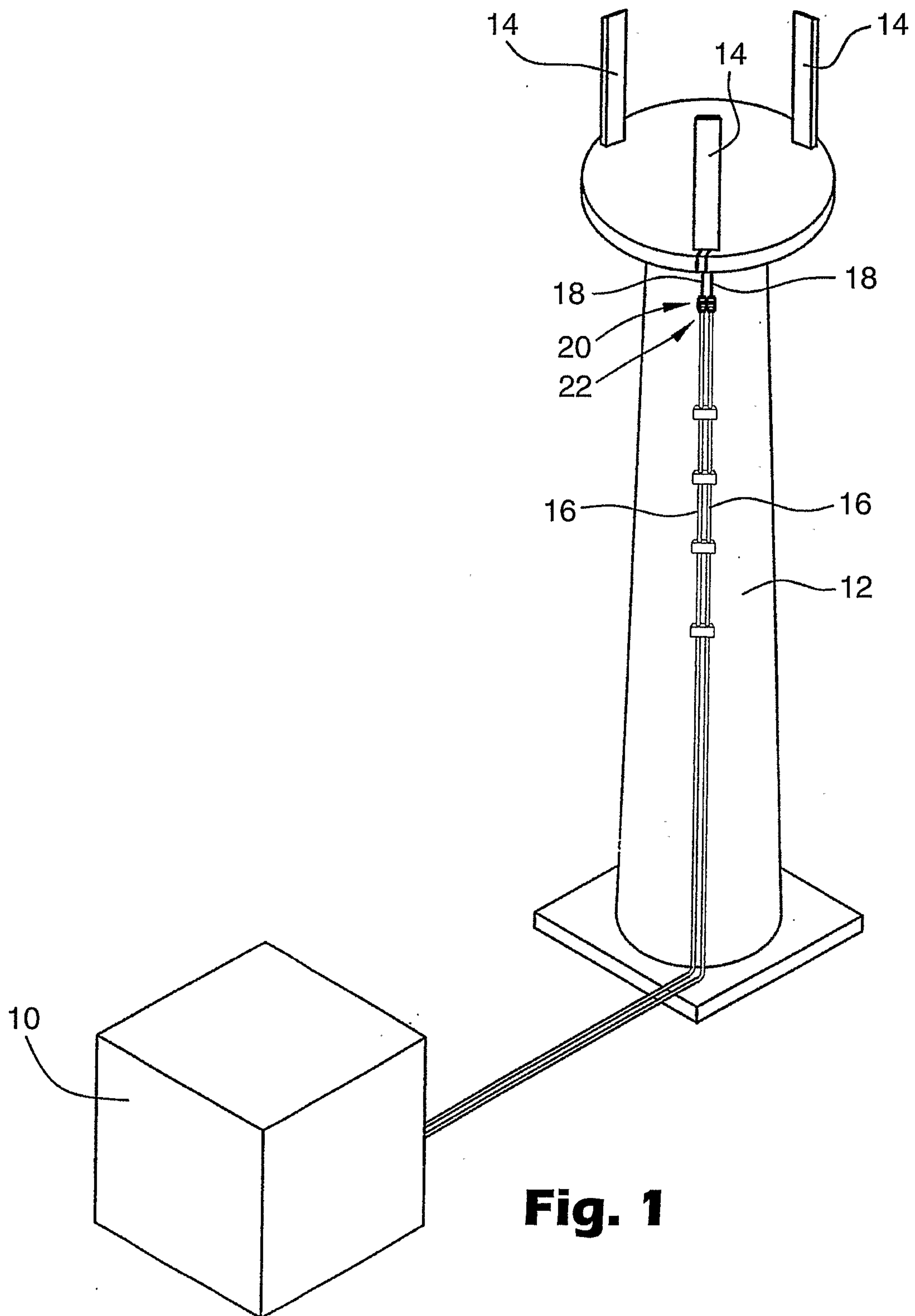
a support (70) including a first crushable portion (72) separated by a non-crushable transition zone (76) from a second crushable portion (74);

5 a first shrinkable tubular member (24) substantially covering the first crushable portion (72) and extending into a first portion of the non-crushable transition zone (76); and

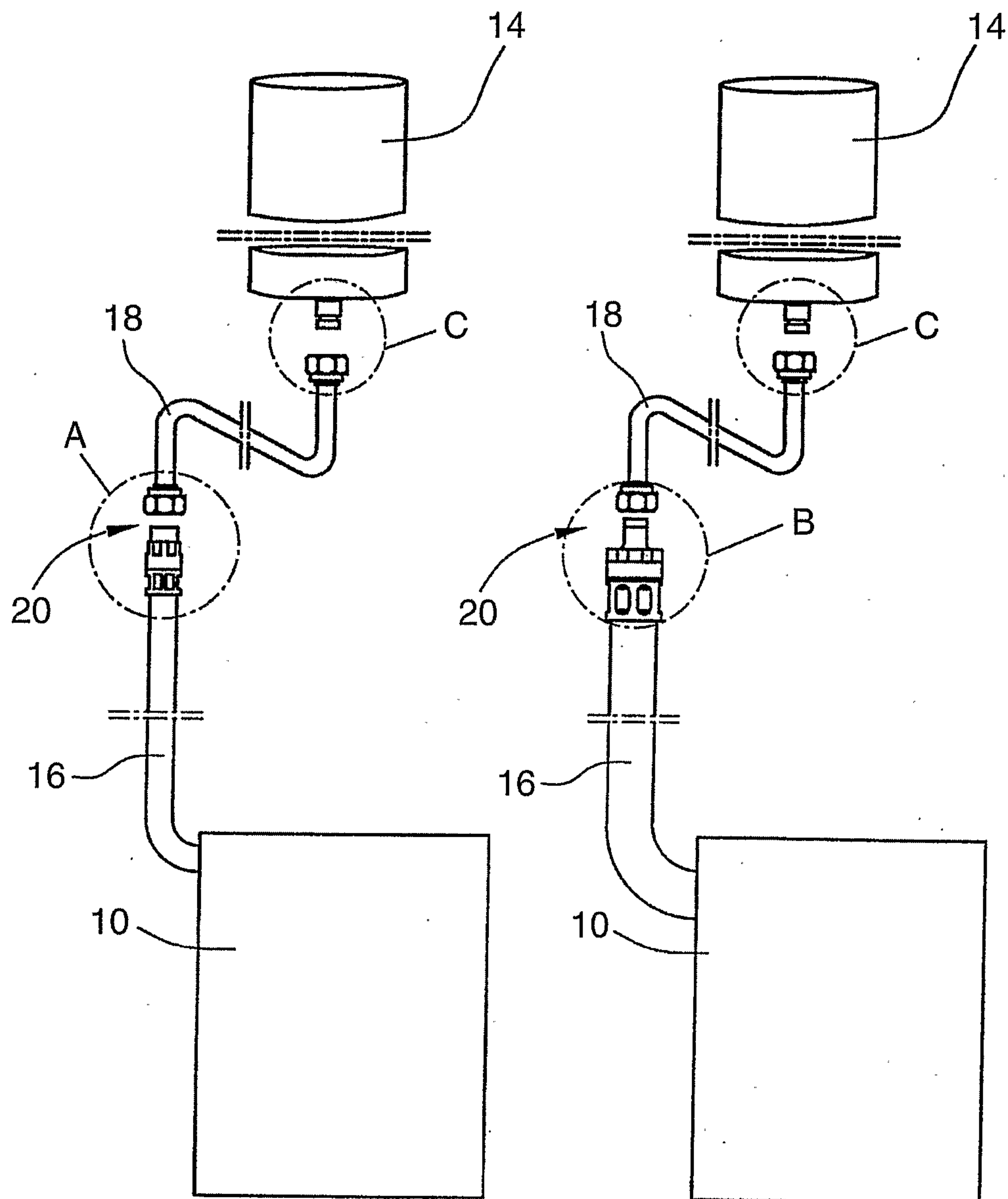
a second shrinkable tubular member (26) substantially covering the second crushable portion (74), a second portion of the non-crushable transition zone (76) and adapted to overlap the first shrinkable tubular member (24) to form an overlapped seam (78) therewith, the pre-mounted, pre-stretched tube shrinking into gripping contact with the cable junction by application of pressure to cause collapse of the first crushable portion (72) and the second crushable portion (74) of the support (70).

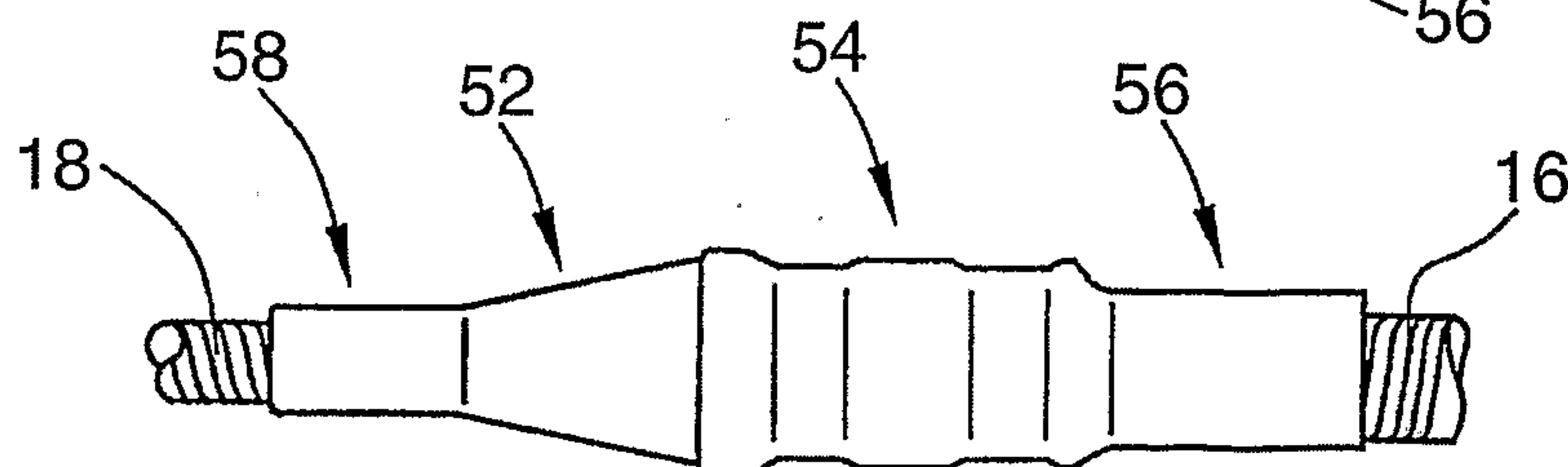
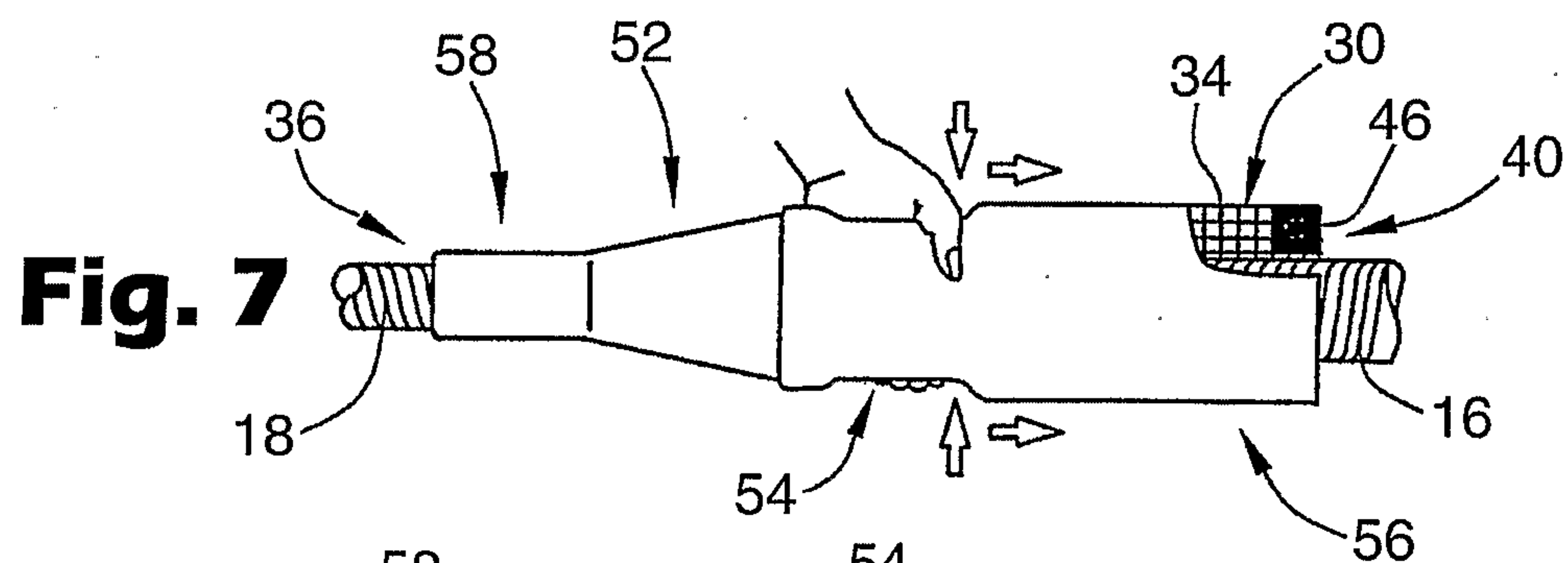
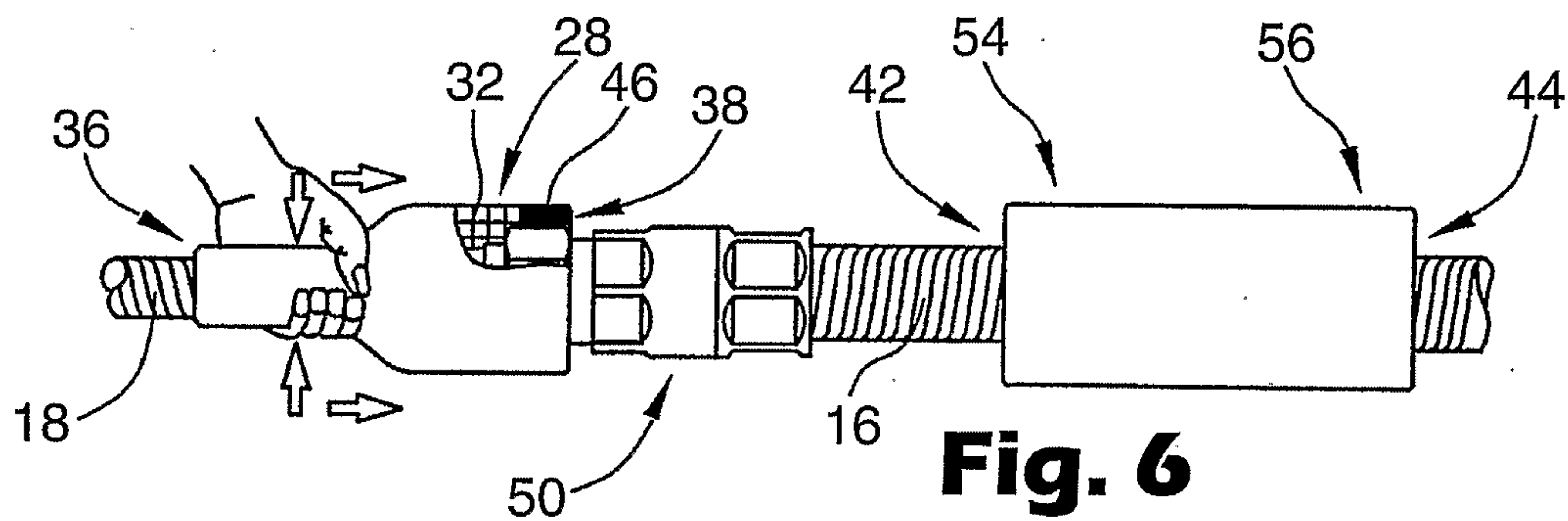
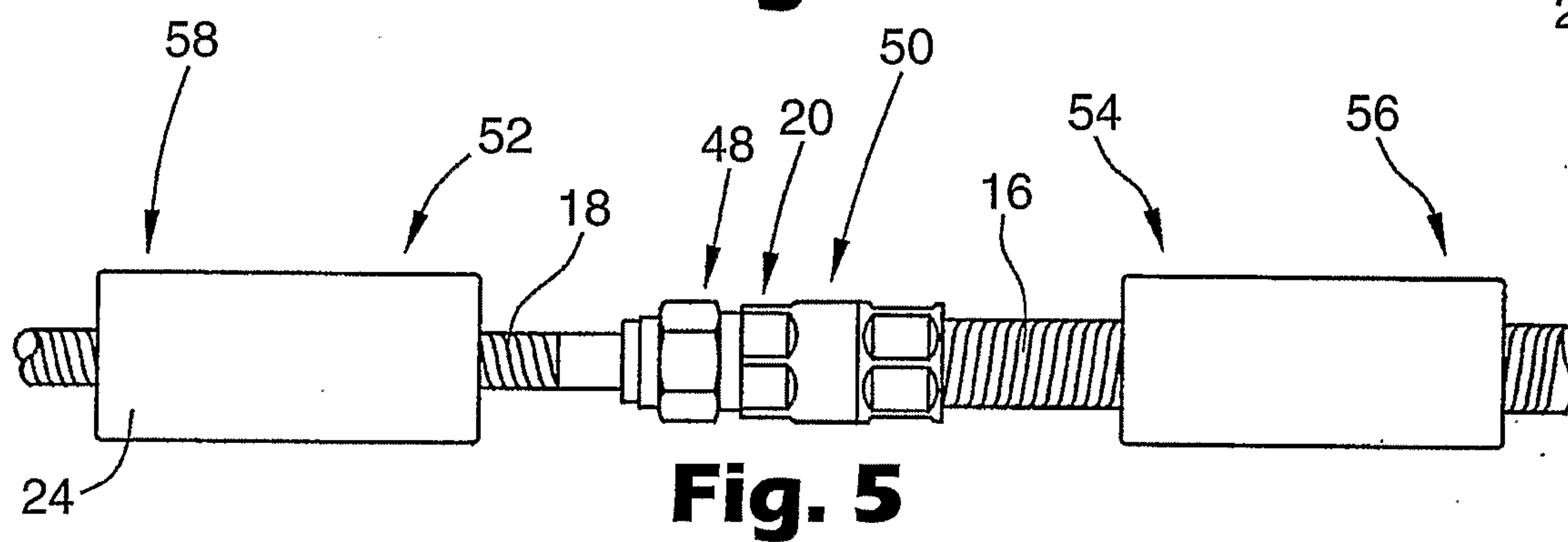
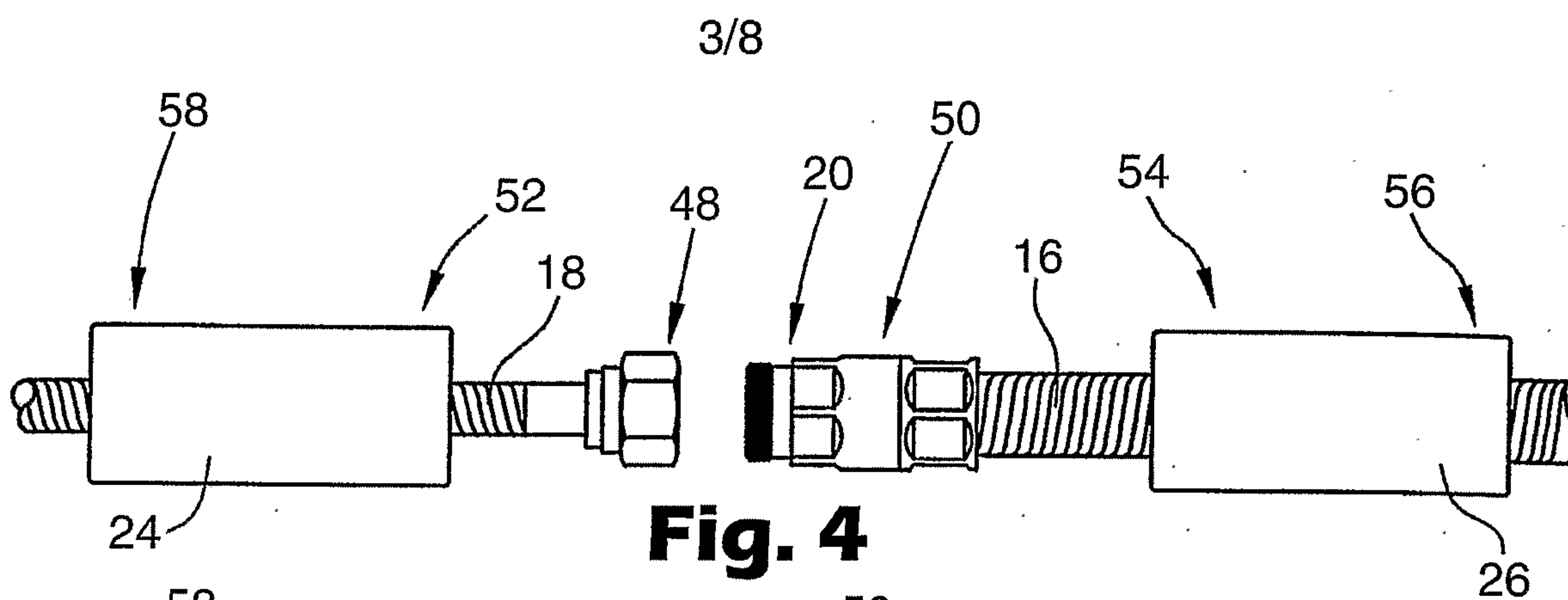
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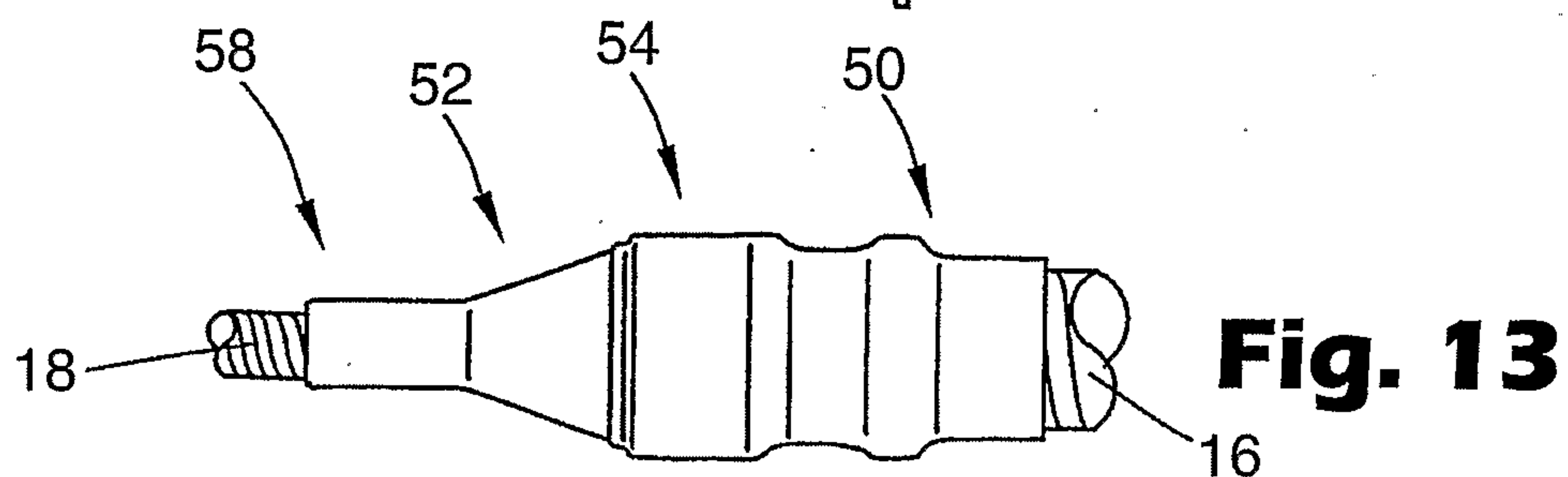
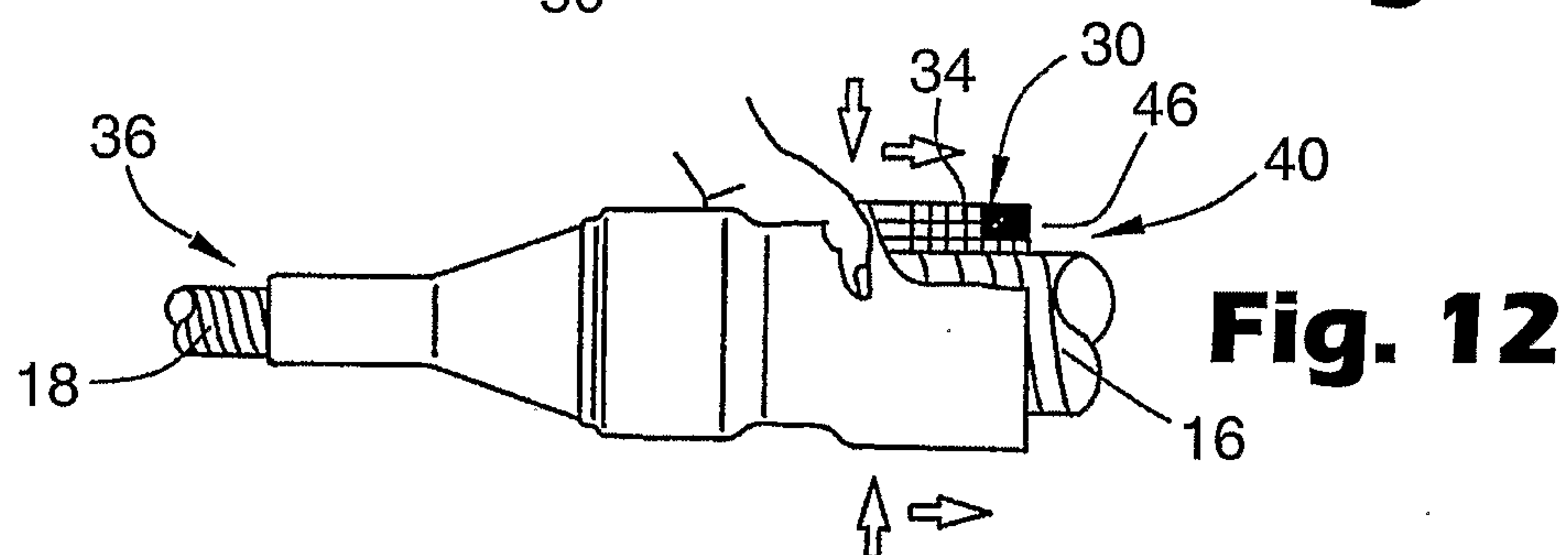
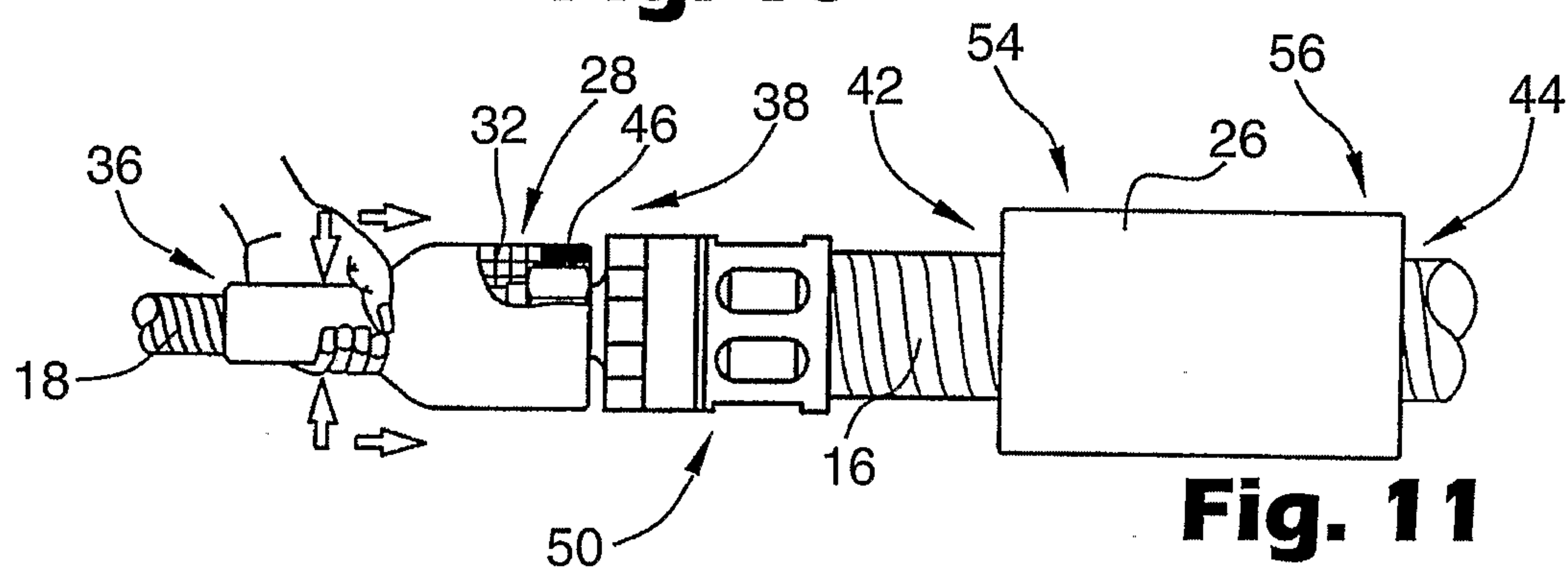
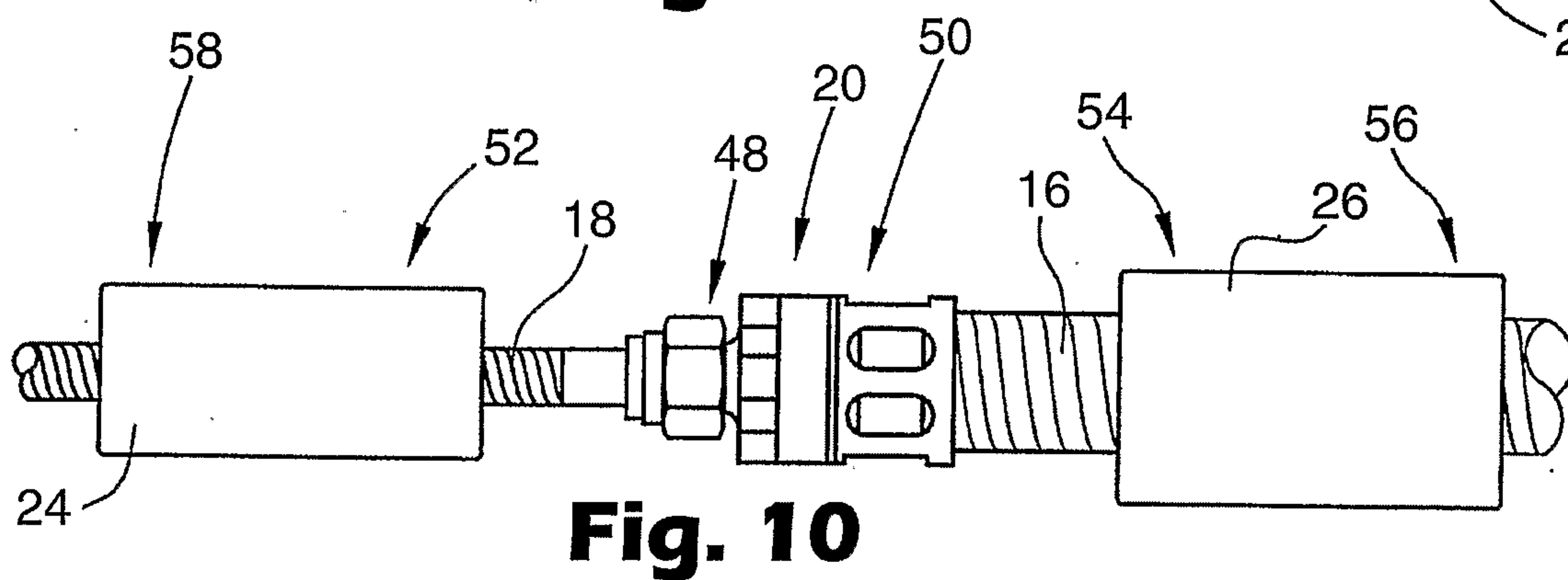
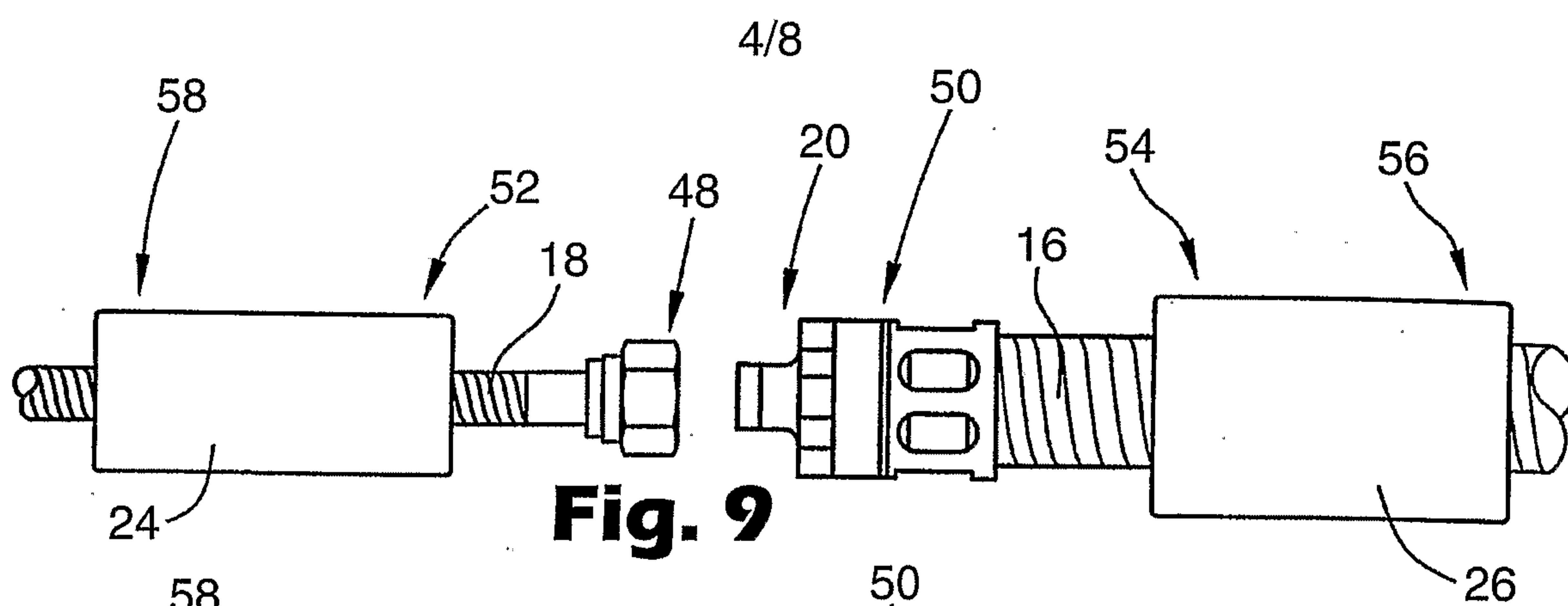
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**Fig. 1**

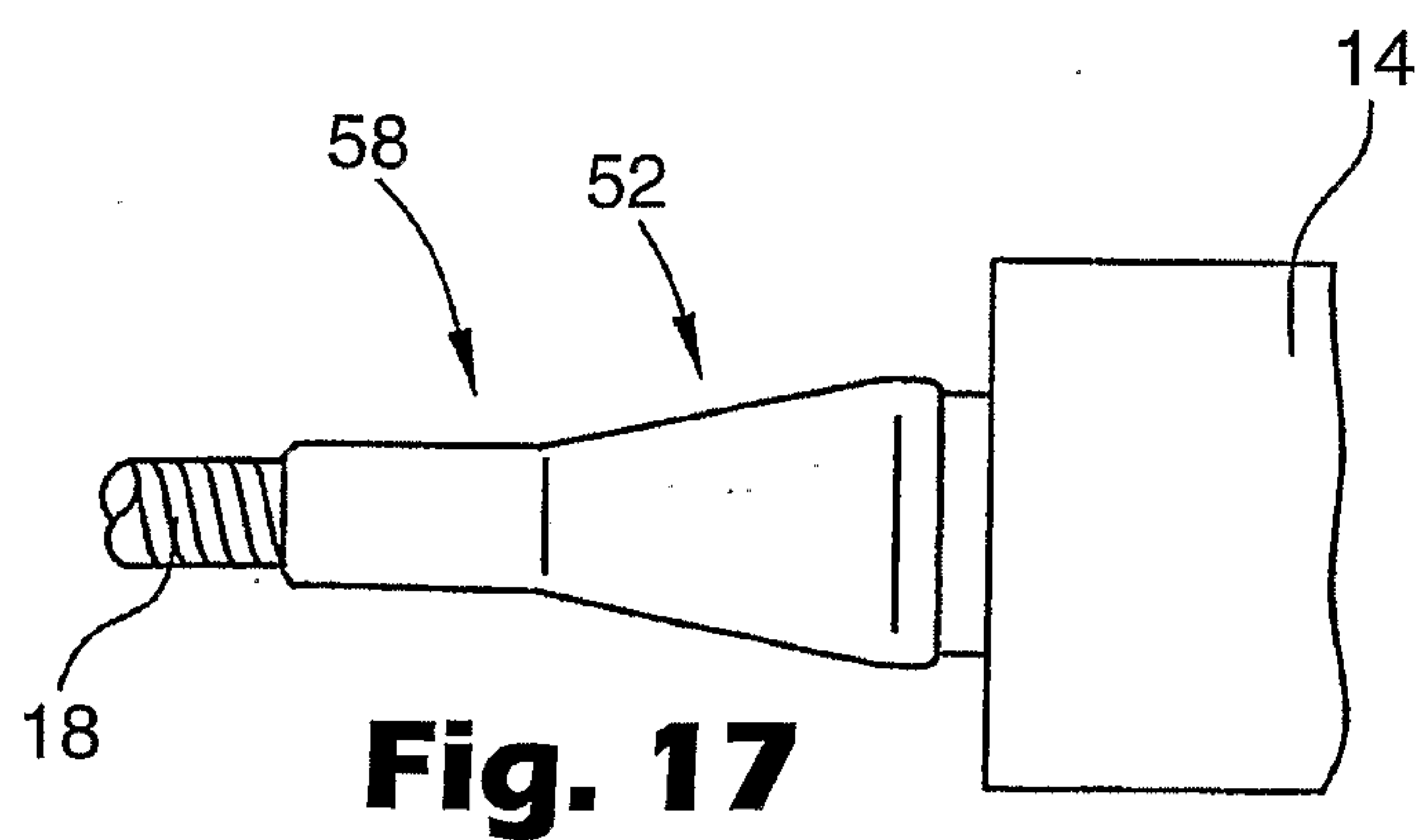
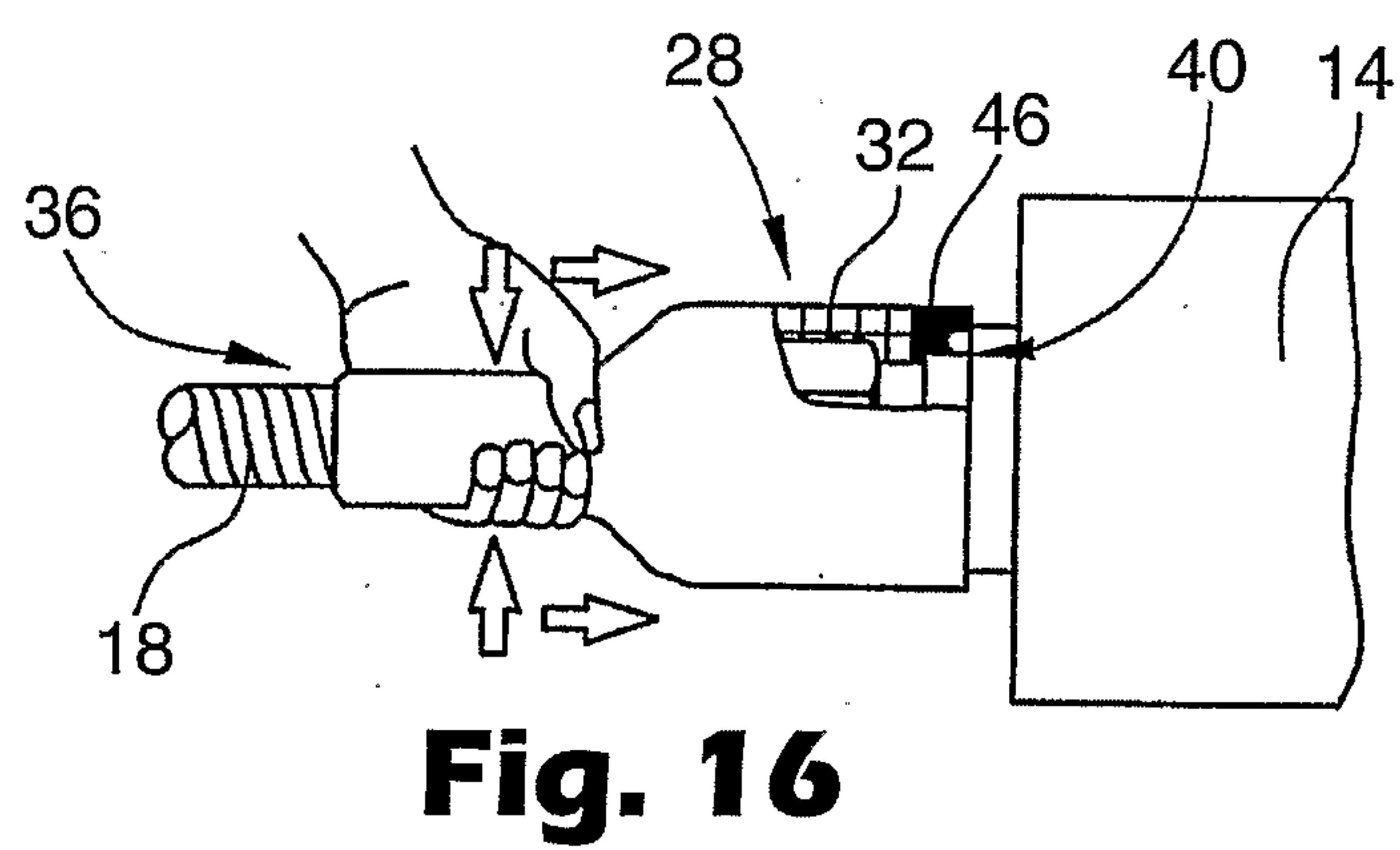
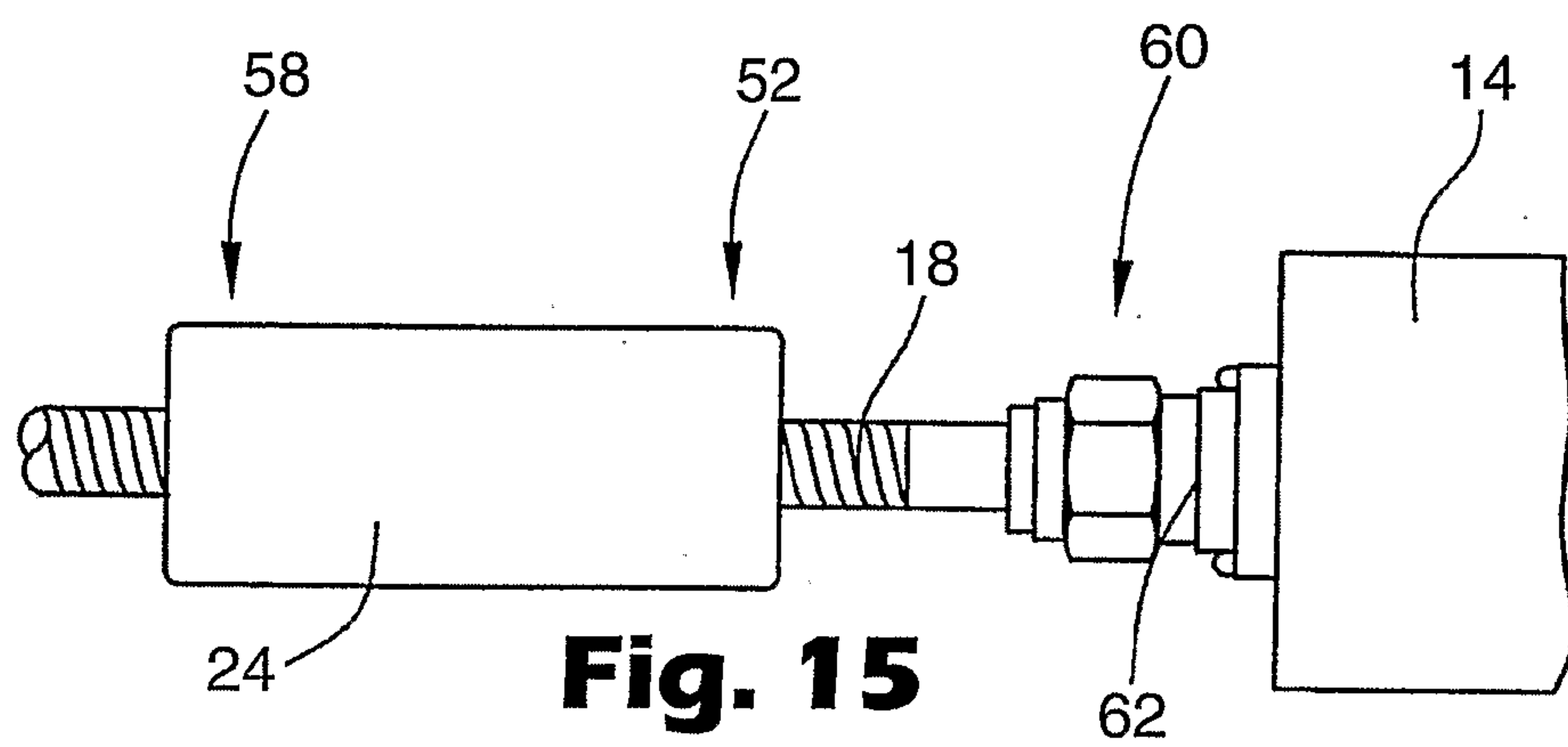
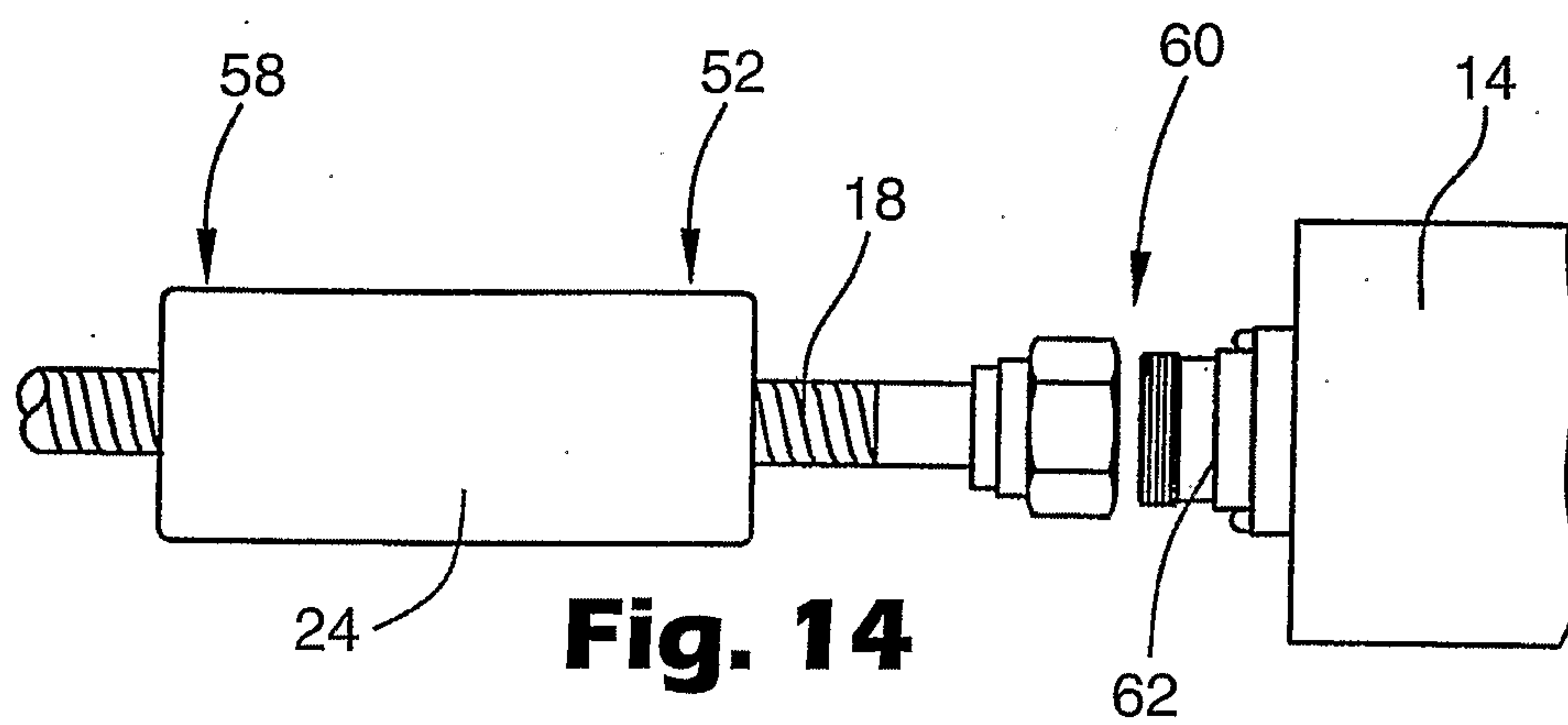
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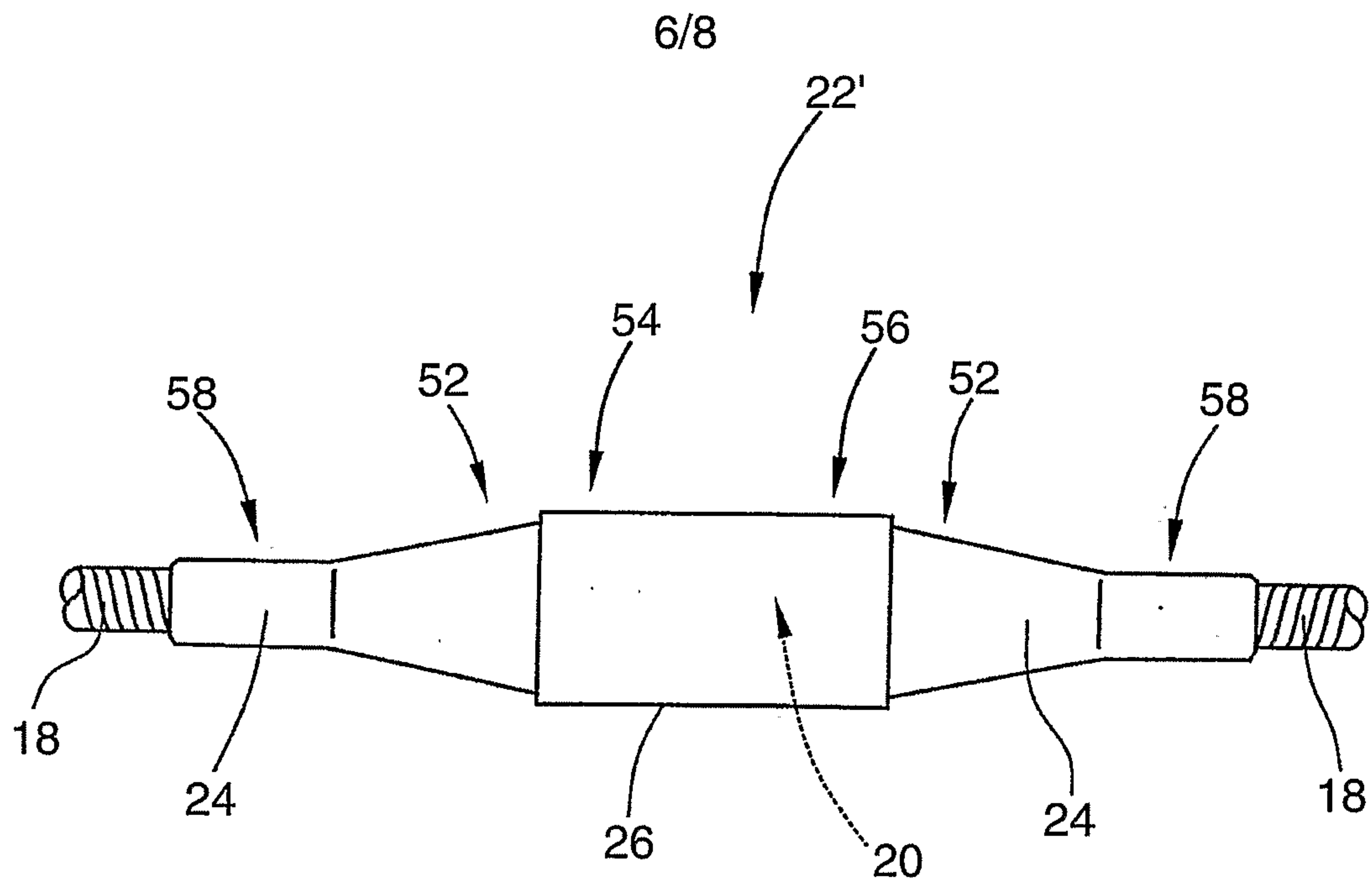
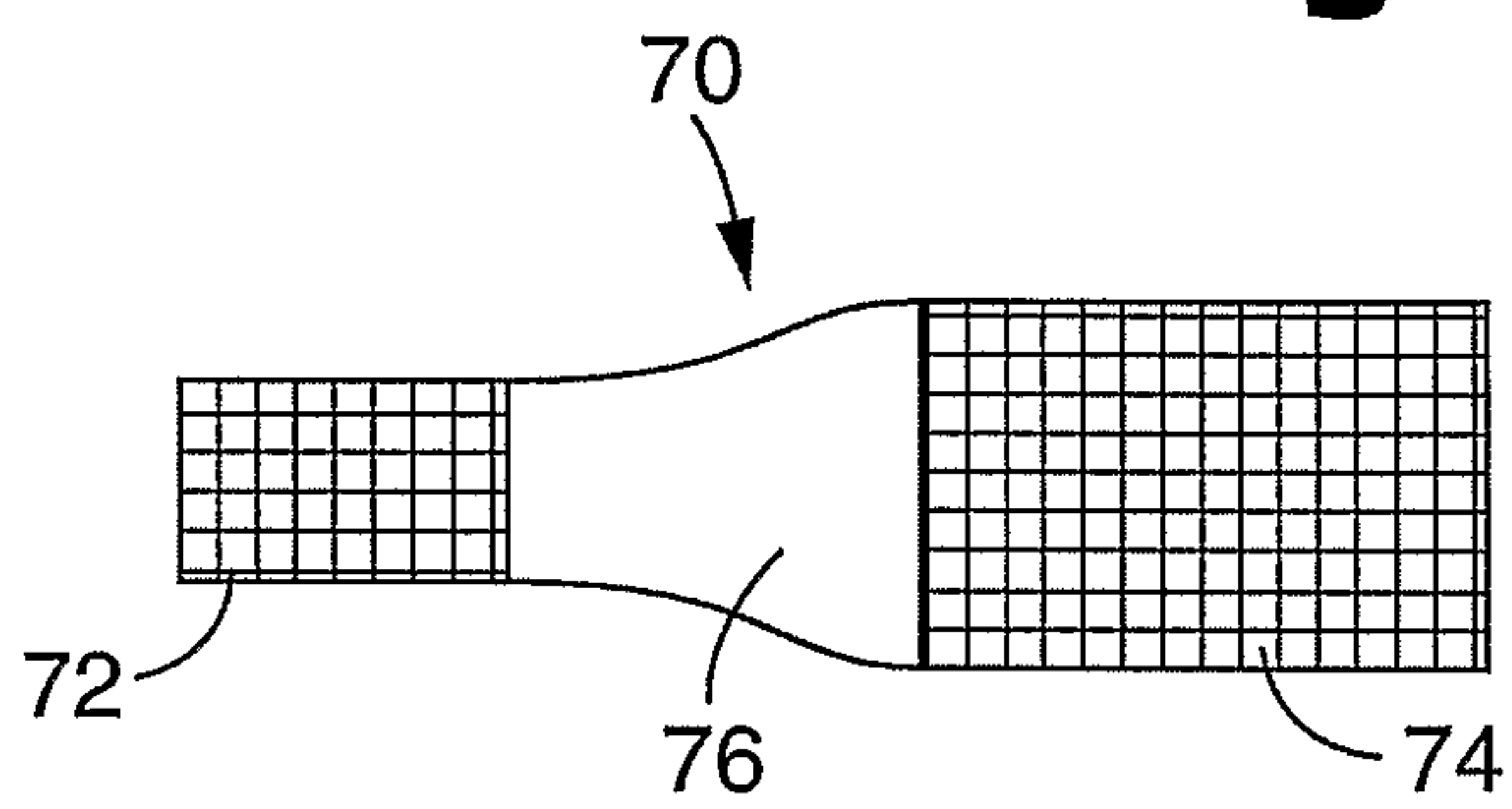
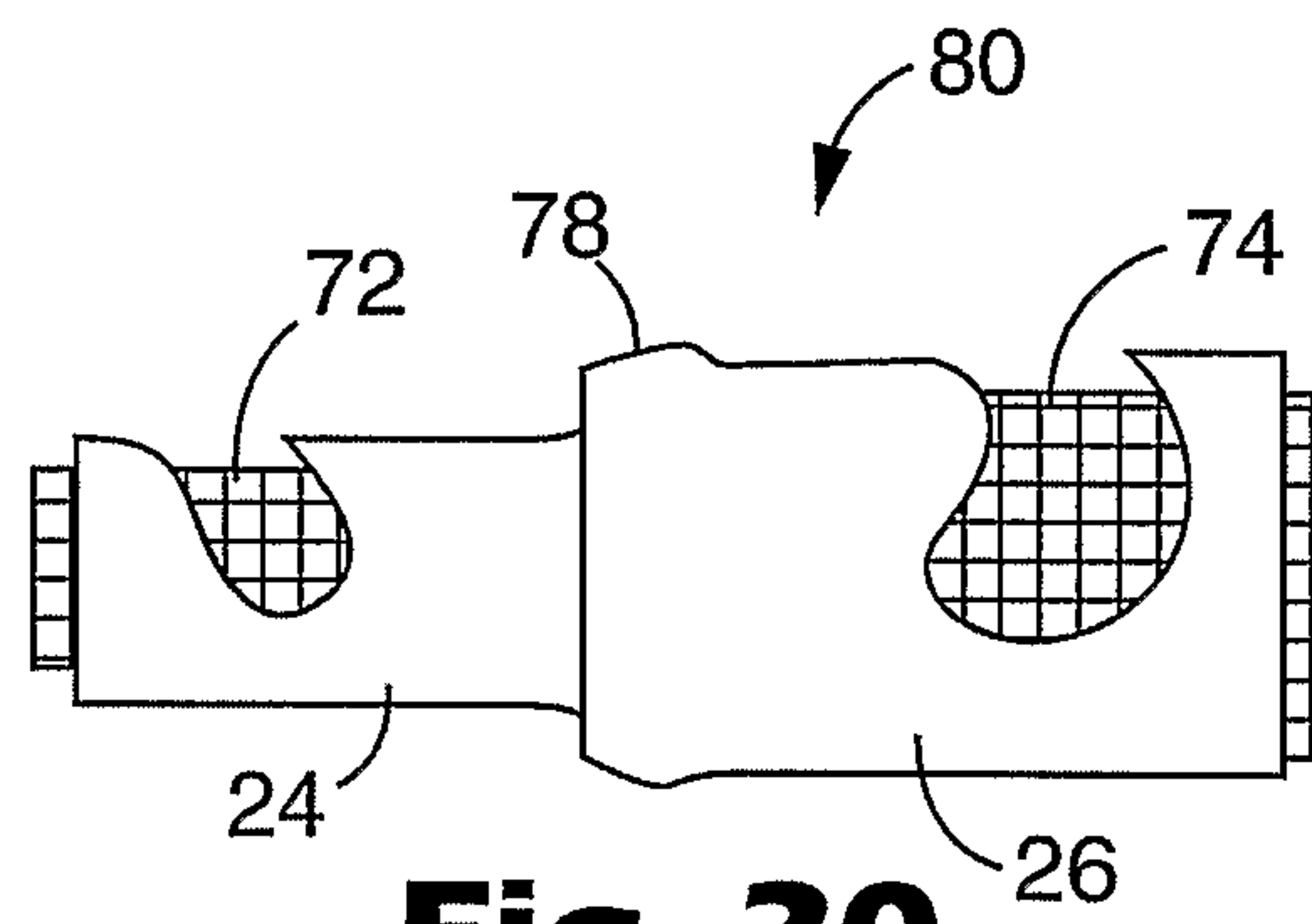
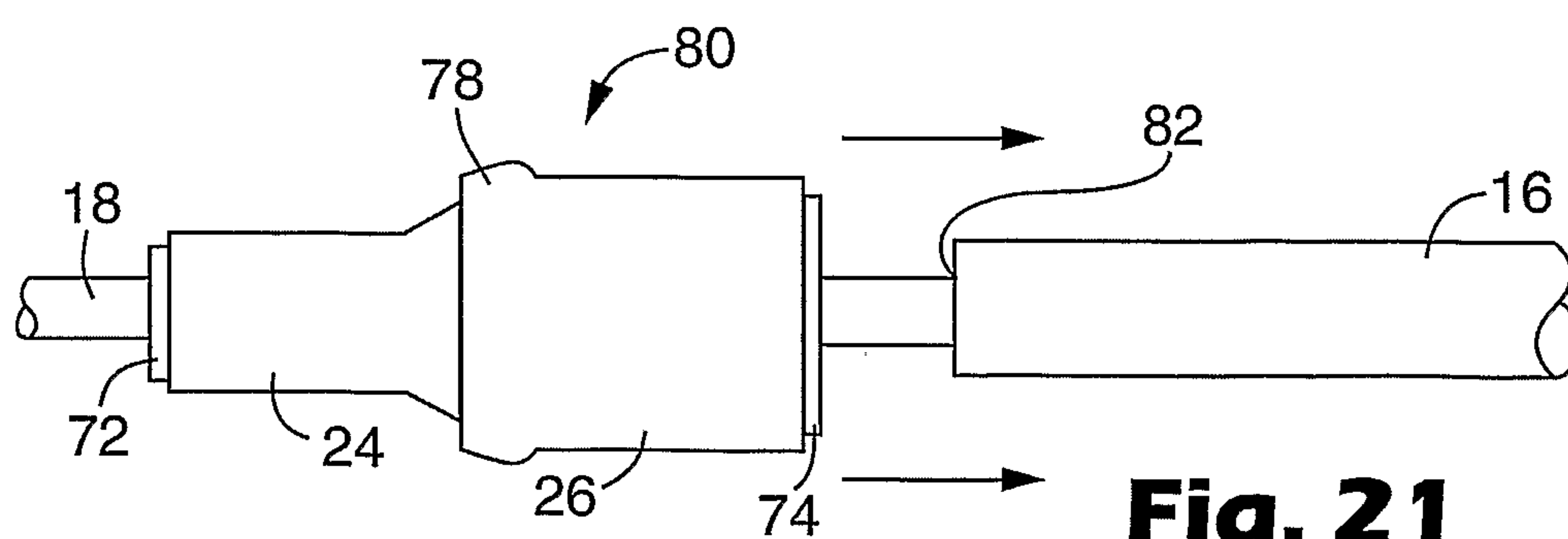
**Fig. 2****Fig. 3**

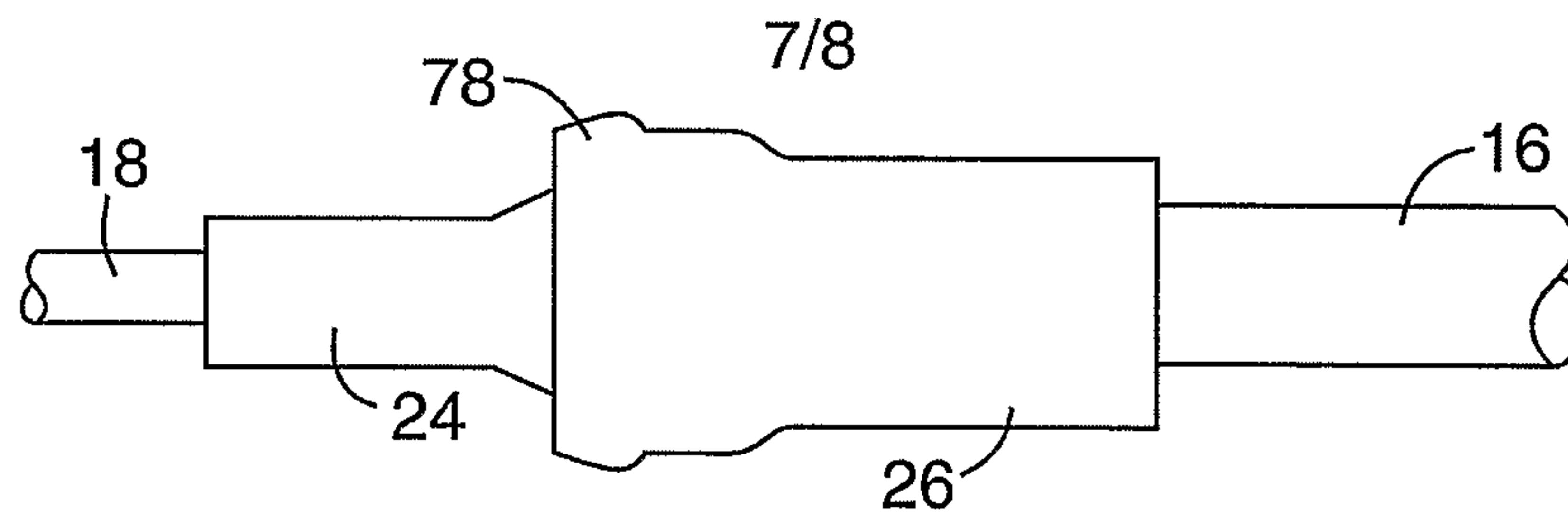
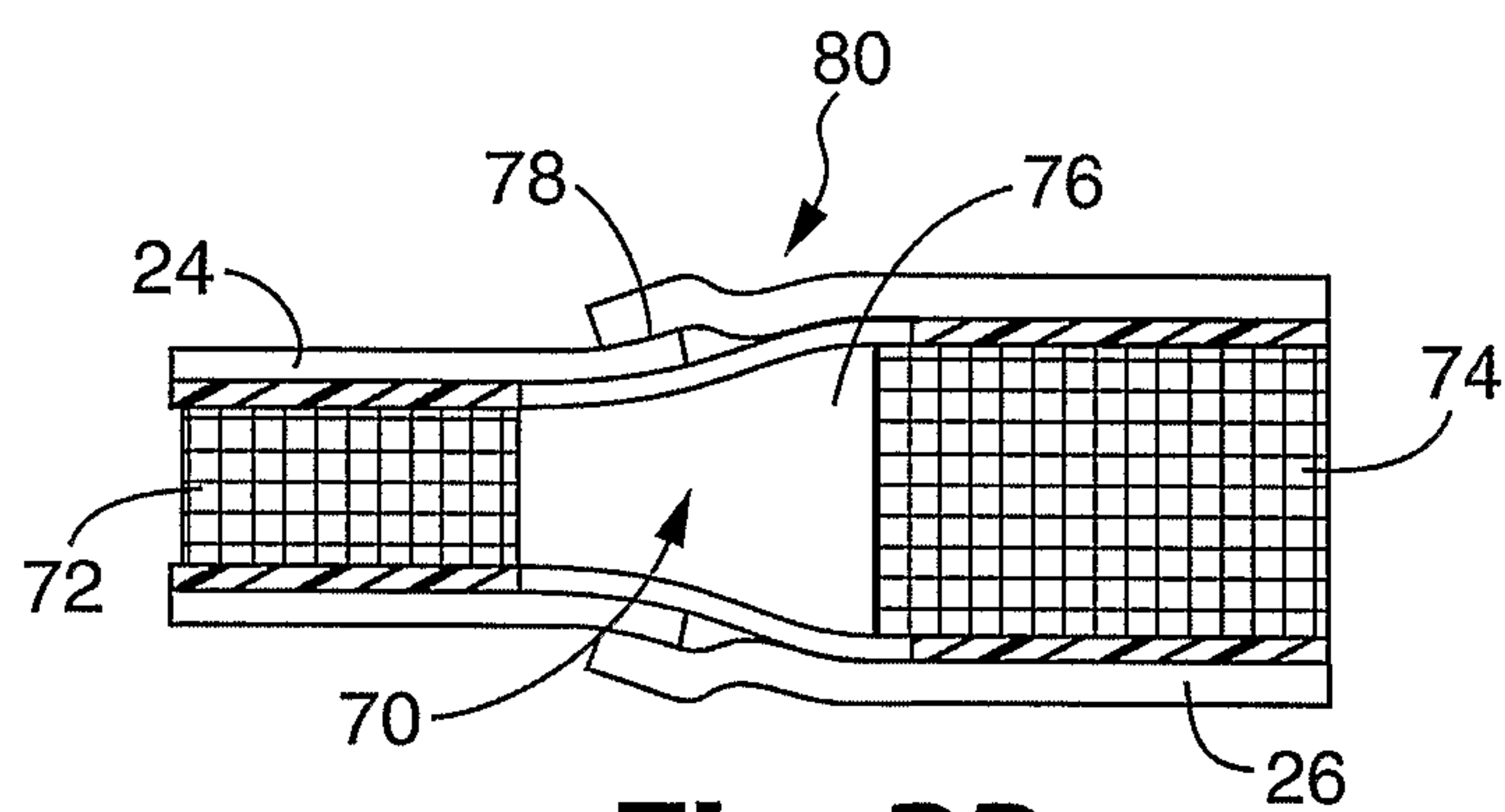
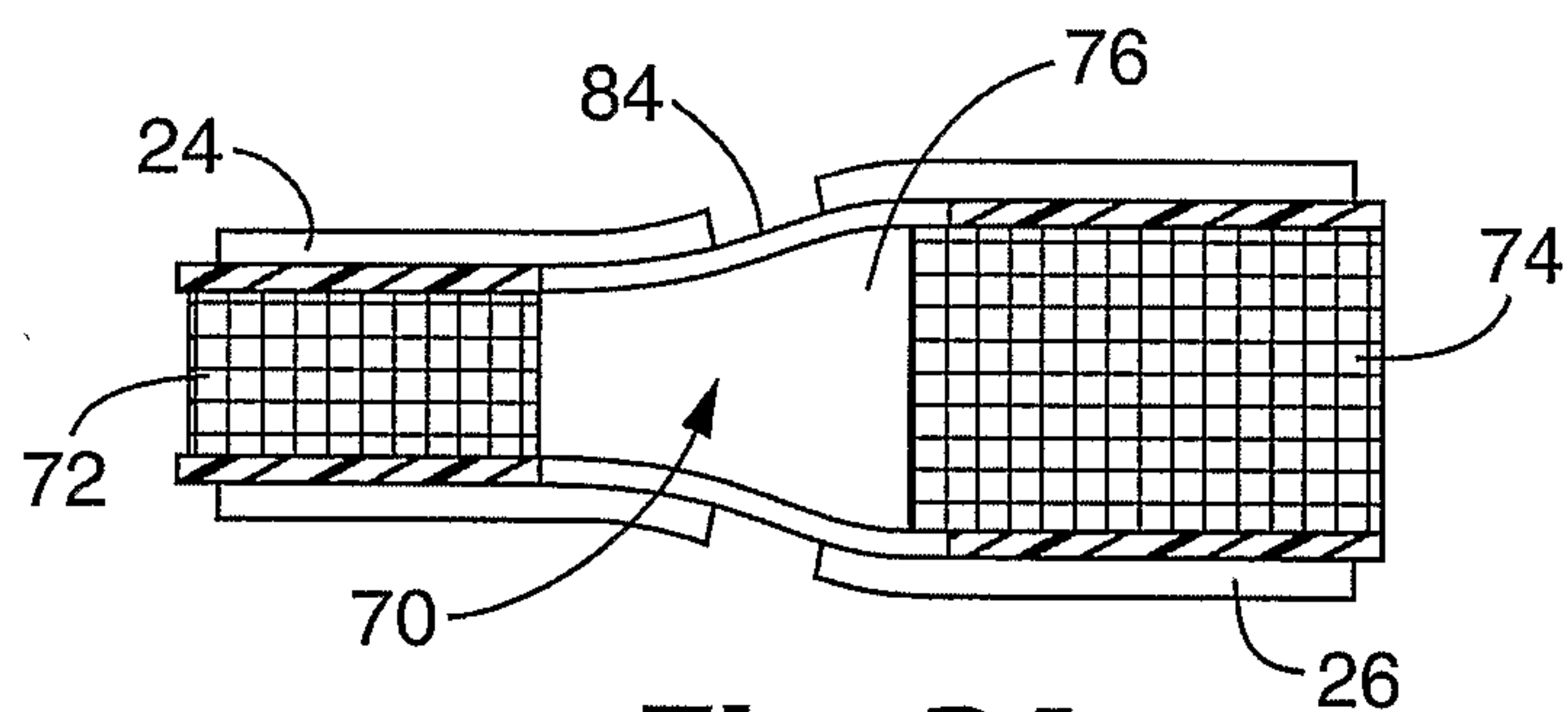
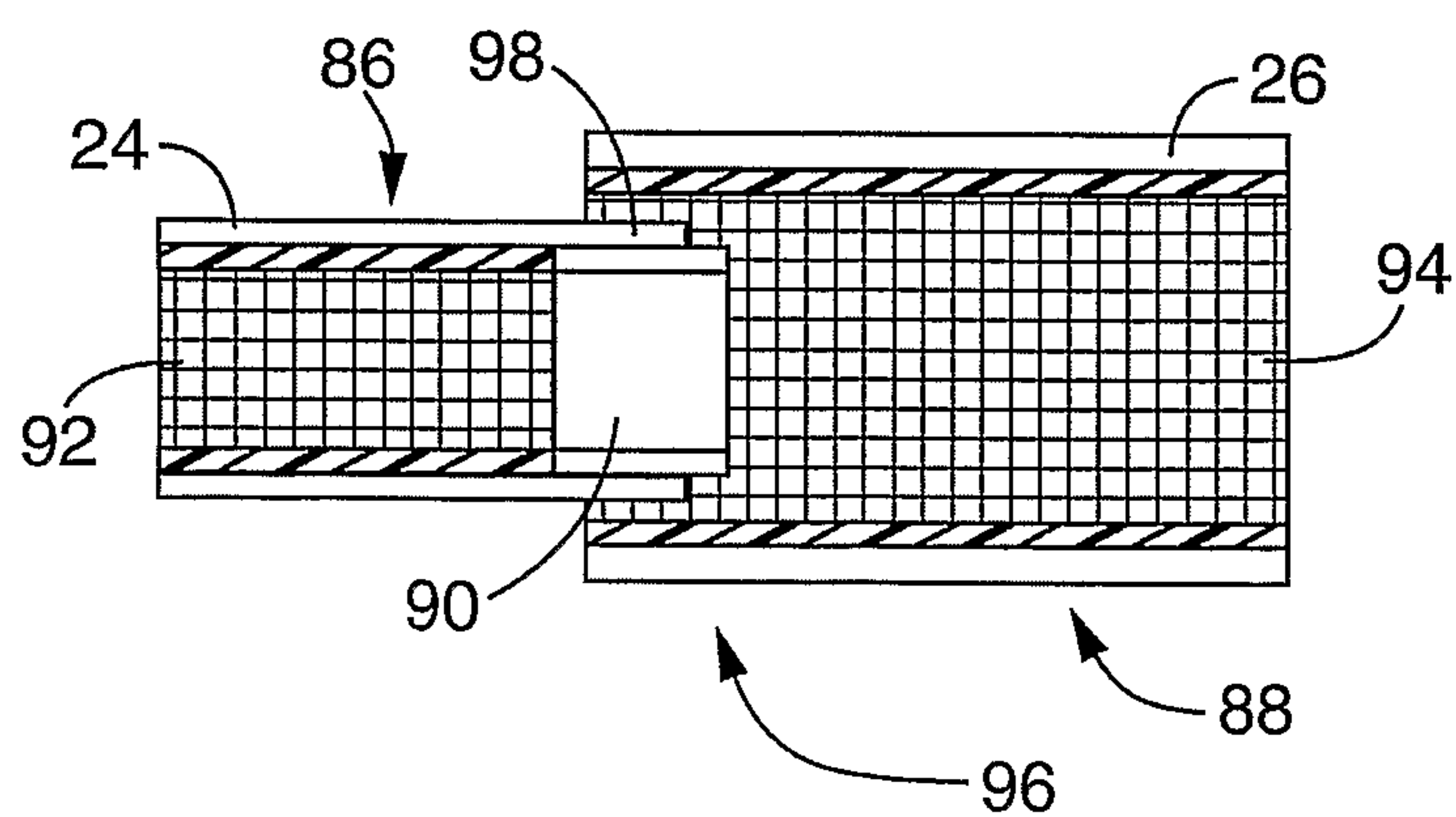




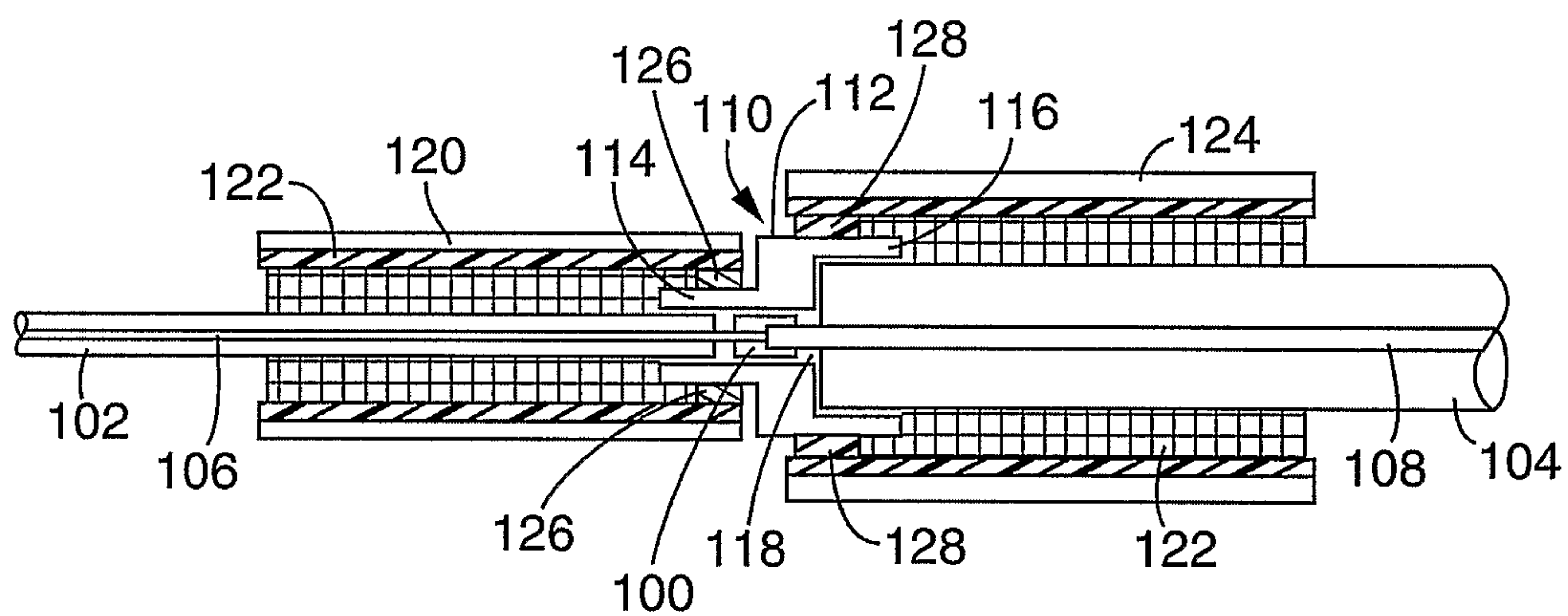
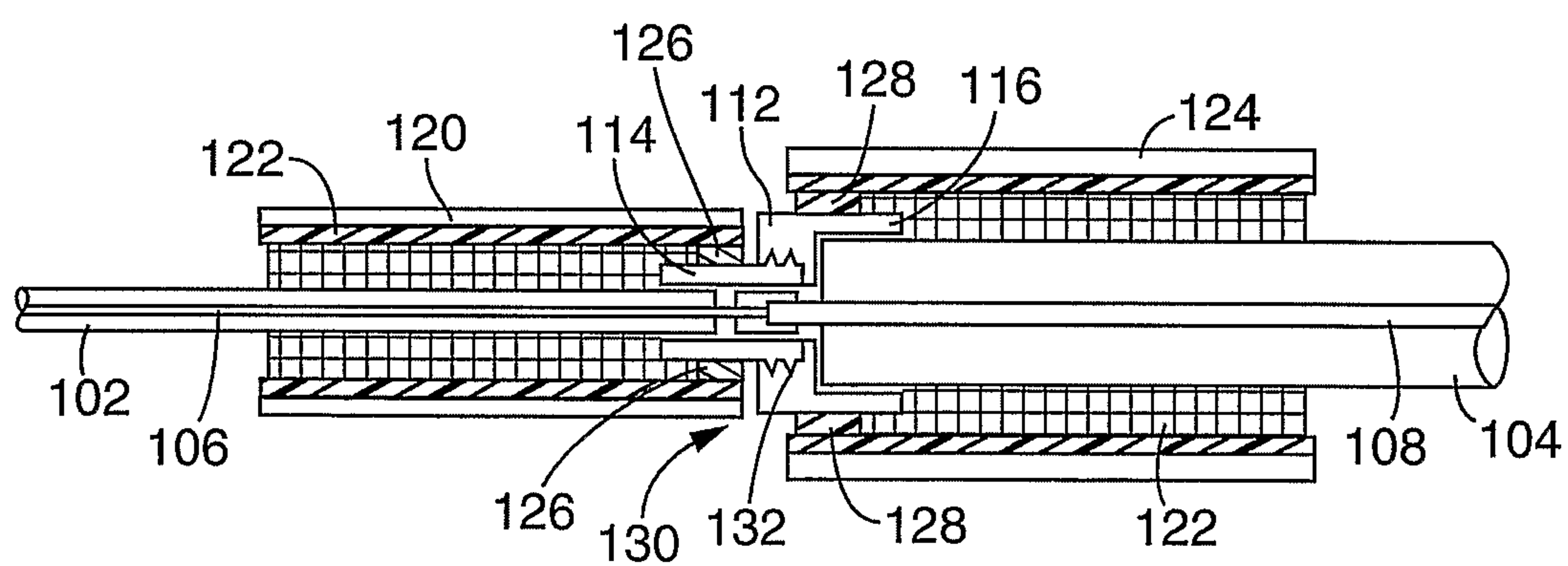
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**Fig. 18****Fig. 19****Fig. 20****Fig. 21**

**Fig. 22****Fig. 23****Fig. 24****Fig. 25**

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**Fig. 26****Fig. 27**

