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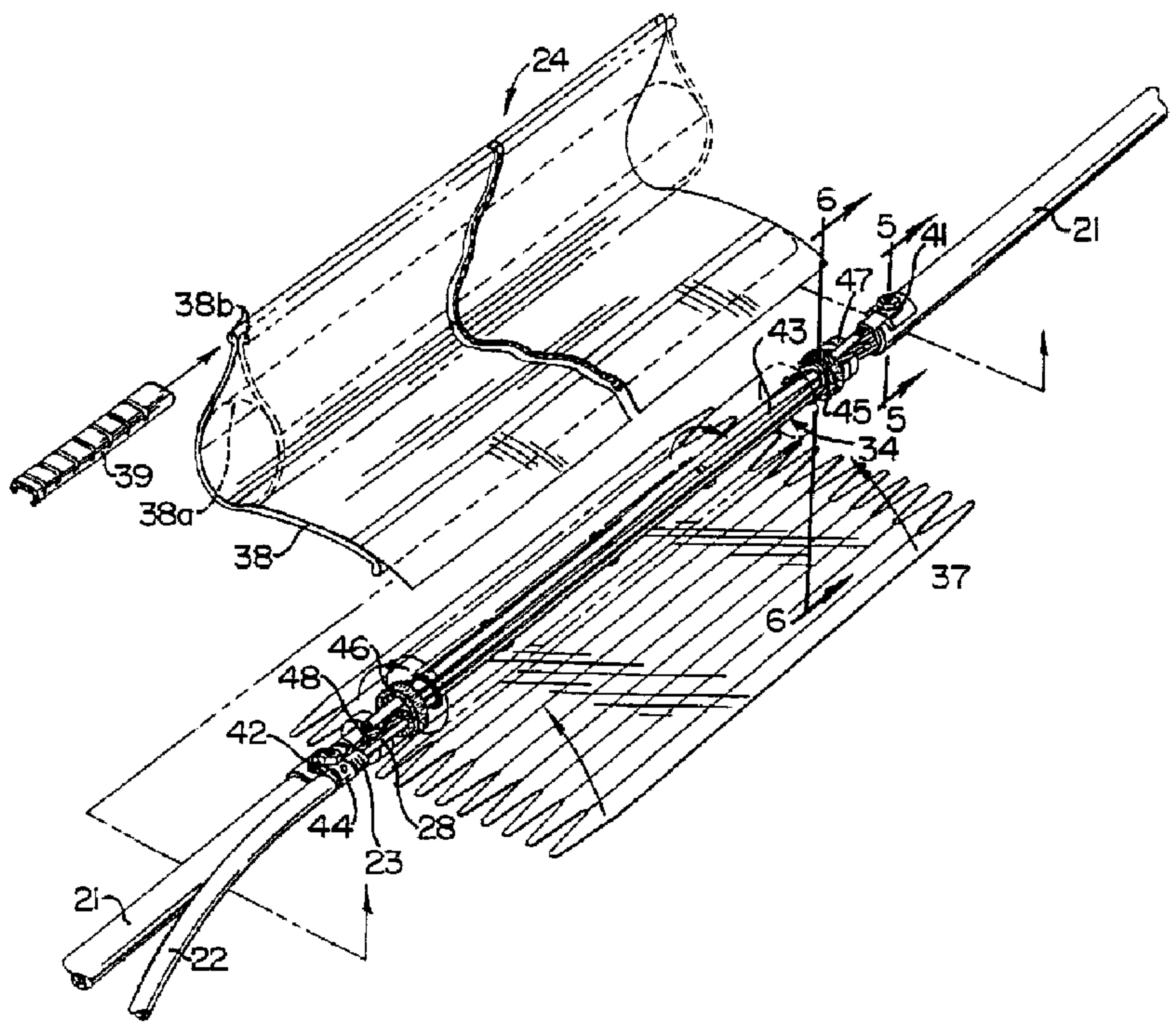

(57) Abrégé/Abstract:
A fiber optic cable system, such as a preterminated fiber cable, includes a main cable and one or more drop cables connected to the main cable at spaced apart locations along the main cable. The drop cable is spliced to the main cable using a splice closure including a fiber guide that secures spliced together end portions of the respective fibers in a longitudinally extending direction so that they are devoid of any slack coils of optical fibers. Accordingly the overall diameter of the splice closure is relatively small thereby permitting the cable system to be stored on a reel and to be readily placed within small diameter conduits. The splice closure includes a heat recoverable housing surrounding the fiber guide. Cable sheath end portions are scaled by melting C-shaped bodies of heat flowable material positioned adjacent cable sheath end portions.

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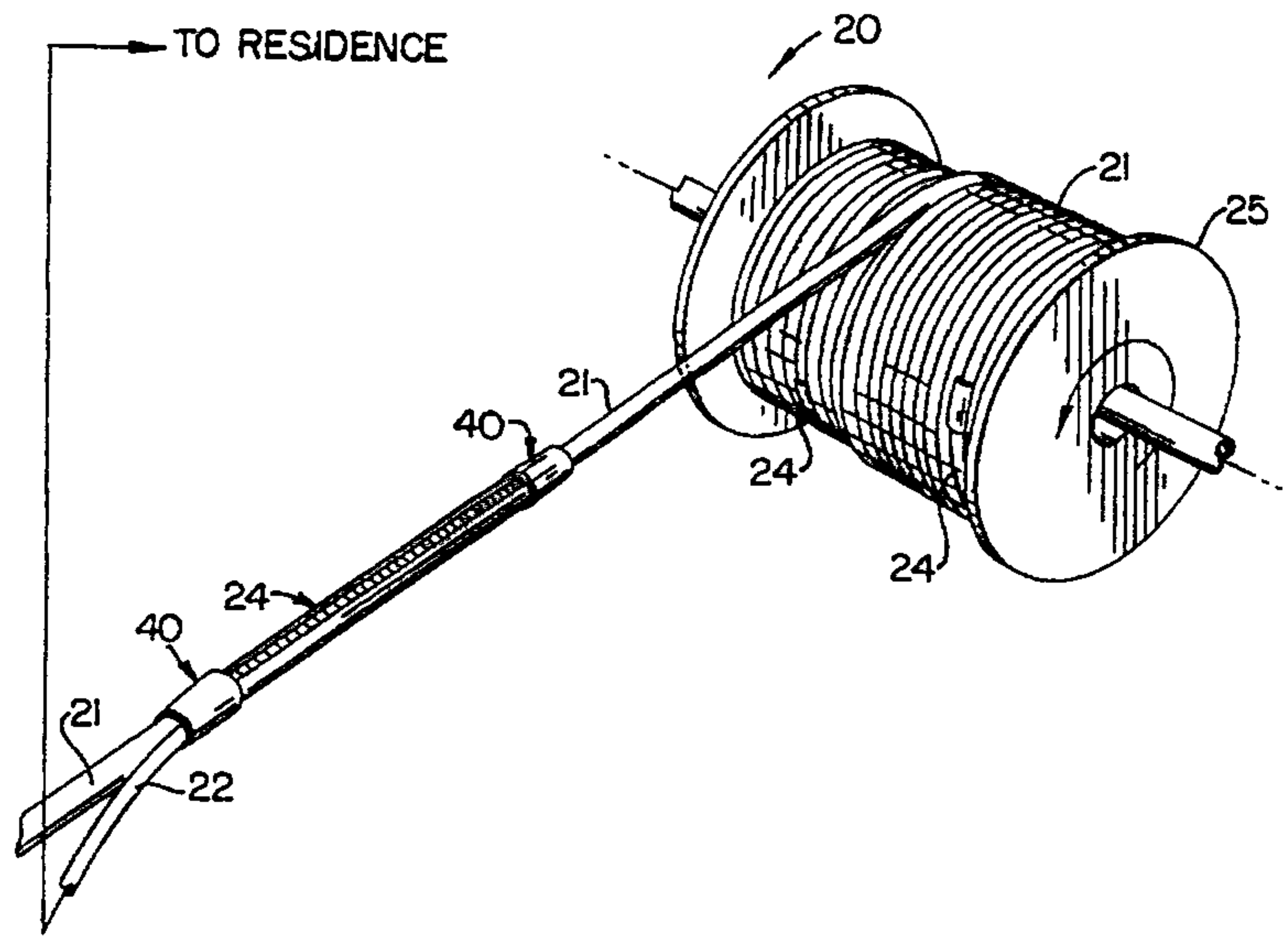

(57) Abstract

A fiber optic cable system, such as a preterminated fiber cable, includes a main cable and one or more drop cables connected to the main cable at spaced apart locations along the main cable. The drop cable is spliced to the main cable using a splice closure including a fiber guide that secures spliced together end portions of the respective fibers in a longitudinally extending direction so that they are devoid of any slack coils of optical fibers. Accordingly, the overall diameter of the splice closure is relatively small thereby permitting the cable system to be stored on a reel and to be readily placed within small diameter conduits. The splice closure includes a heat recoverable housing surrounding the fiber guide. Cable sheath end portions are sealed by melting C-shaped bodies of heat flowable material positioned adjacent cable sheath end portions.

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FIBER OPTIC CABLE SYSTEM INCLUDING MAIN AND DROP CABLES AND ASSOCIATED FABRICATION METHOD

Field of the Invention

The invention relates to the field of fiber optic communications systems, and more particularly, to a fiber optic cable system and associated methods.

Background of the Invention

Fiber optic cables are widely used for telecommunications applications where high information capacity, noise immunity and other advantages of optical fibers may be exploited. Fiber cable architectures are emerging for connecting homes and/or business establishments, via optical fibers, to a central location, for example. One such architecture includes a trunk or main cable routed through a housing subdivision, for example, while small fiber count "drop cables" are spliced to the main cable at predetermined spaced apart locations.

A typical main cable may be installed underground and have multiple drop cables connected thereto, each of a hundred feet or more. Each of the drop cables, in turn, is routed to an optical network unit (ONU) serving several homes. Accordingly, information may be transmitted optically to the ONU, and into the home via conventional copper cable technology. Thus, the drop cables may serve groups of users, although other architectures may also employ a main cable and one or more drop cables connected thereto.

Unfortunately, the fibers within the main cable must typically be accessed at the various drop points and spliced to respective drop cables after the main cable has already been installed. Accessing the main cable for splicing requires careful preparation of the main cable including removing a portion of the cable sheath, and identifying and separating out predetermined fibers from within the cable without disturbing adjacent fibers. The separated fibers may then be spliced and secured within a conventional protective splice closure. Moreover, these cable access and splicing steps must typically be accomplished in the field by a technician who is likely to experience difficulties imposed by weather or the particular location of each of the drop points. Accordingly, field splicing of drop cables to a main cable is time consuming, expensive, and may produce low quality optical splices.

In an effort to overcome the disadvantages of field splicing drop cables at each of a series of drop points, so-called preterminated fiber optic cables have been proposed. A preterminated fiber optic cable includes a relatively high fiber count main cable to which respective low fiber count drop cables are spliced at predetermined drop points. The locations of the drop points are determined based upon field survey measurements.

The splicing of the drop cables to the main cable of a preterminated cable is performed at the factory during manufacturing of the cable. The preterminated cable, including the main cable, drop cables, and associated splice closures, are desirably wound onto a cable reel and delivered to the installation site. Accordingly, conditions for making high quality splices may be maximized in the factory, thereby increasing splice quality and also reducing the expense and difficulty associated with field splicing.

Exemplary of a preterminated cable is U.S. Patent No. 5,121,458 to Nilsson et al. entitled *Preterminated Fiber Optic Cable*. The patent discloses a splice closure for splicing each of the drop cables to the main cable. The splice closure is generally cylindrical being no greater than 4 inches in diameter and 7 inches in length to facilitate winding of the preterminated cable, including the associated splice closures, onto a cable reel for shipping and installation. In particular, the patent discloses that the diameter of the splice closure is slightly less than 4 inches in diameter so that the preterminated cable may be installed through a 4 inch conduit.

The splice closure as disclosed in U.S. Patent No. 5,121,458 uses a conventional technique for storing slack fibers within the splice closure, that is, the slack is stored in slack coils or loops. The slack coils must be made without violating the minimum bend radius of the fibers. Accordingly, the splice closure still must have a relatively large outer diameter which hampers winding of the splice closures onto the cable reel, and which may also greatly complicate installation of the cable within a section of buried conduit. For example, conduits less than 4 inches are commonly used for placing a conventional fiber optic or copper cable to facilitate installation under obstructions, such as a driveway. In addition, small diameter conduits are also desirably used to reduce excavation time and expense when installing the conduit.

U.S. Patent No. 5,125,060 to Edmundson entitled *Fiber Optic Cable Having Spliceless Fiber Branch and Method of Making Same* discloses another approach in an attempt to overcome the difficulties in reducing the size of the connection or branching point of the drop cables from the main cable. The patent discloses spliceless stub cables extending from the main cable. More particularly, an opening is made in the jacket of the main cable at a disconnect point downstream from the intended branching point. The fibers to be branched for the stub cable are severed and pulled back through the branching point. The branched fibers are routed through a stub cable sheath and the disconnect point of the cable is sealed. The penetration into the main cable sheath, as well as its joint with the stub cable sheath are sealed at the branching point by a plastic housing. Thus, no splices are required and no slack optical fibers need be stored within the protective housing at the branching point.

Unfortunately, the approach disclosed in U.S. Patent No. 5,125,060 suffers from a significant drawback in that the stub cable extending from the main cable is limited to only about 12 feet in length. Accordingly, for a typical fiber optic cable system route, a conventional splice is still needed to add an additional length of cable to the stub cable, and the splice must still be made in the field by a technician. Another drawback of the approach disclosed in U.S. Patent No. 5,125,060 is that considerable care must be taken when pulling the 12 foot lengths of fibers back through the branching point during preparation of the stub cables. A corresponding difficulty is encountered when stuffing the 12 foot lengths of fibers into the stub cable sheath. The main cable sheath is also penetrated 12 feet downstream from the branching point at the disconnect point, and this cable penetration must also be sealed to protect the cable from water entry.

Because the fiber optic cable systems described above include penetrations of the cable sheath, it is important to seal such penetrations to prevent water from entering the cable and damaging the optical fibers particularly at a splice location. One approach to sealing a splice point is disclosed in U.S. Patent No. 5,125,060 which describes a heat recoverable housing surrounding the branch point from which the short stub cables extend. Similarly, U.S. Patent No. 5,121,458 discloses a heat recoverable housing surrounding the splice closure which, in turn, stores the coils of slack cable in a conventional fashion.

U.S. Patent No. 5,185,844 to Bensel, III et al. entitled *Closure for Optical Fiber Connective Arrangements and Method for Making Same* discloses a splice closure for joining together only two small fiber count cables in an in-line configuration with very little slack in the optical fibers. Thus, the closure is not suitable for splicing a drop cable to a main cable as in a preterminated fiber optic cable.

Summary of the Invention

In view of the foregoing background, it is therefore an object of the present invention to provide a fiber optic cable system and associated fabrication method including a relatively compact splice closure for joining one or more drop cables to a main cable so that the entire cable system may be readily wound upon a cable reel and readily installed within a typical conduit system.

It is another object of the present invention to provide a fiber optic cable system which is effectively sealed where the cables enter the interior of the splice closure to protect the splices from water damage, such as caused by water migration from the cable end.

These and other objects, advantages, and features of the present invention are provided by a fiber optic cable system including a main cable and a drop cable joined together at a splice closure, wherein at least one spliced together fiber portion is guided in a generally longitudinal path adjacent the main cable, and wherein the spliced together fiber portion is devoid of a slack coil of optical fibers. Accordingly, the outer diameter of the splice closure may be made very small so as to be readily accommodated within typical conduits and to be readily wound onto a conventional cable reel. For example, the splice closure according to the present invention may be fabricated having an outer diameter of less than about 1.8 inches.

The fiber optic cable system as described herein includes a preterminated cable system as may preferably be manufactured in a factory setting. As would be readily understood by those skilled in the art, the fiber optic cable system according to the present invention may also include a system wherein the drop cable and associated splice are made to the main cable in the field.

More particularly, the fiber optic main cable includes a longitudinally extending buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening. As would be readily understood by those skilled in the art, the main cable may be of the type having a plurality of stranded buffer tubes or a single centrally located buffer tube. The main cable is typically a high fiber count cable of greater than about 48 fibers.

The fiber optic drop cable has an end secured to the main cable at a second location downstream from the first location. The drop cable includes at least one fiber and is typically a low fiber count cable having two or four fibers. An end portion of at least one optical fiber extends outwardly from the end of the drop cable. The at least one fiber end portion of the drop cable is spliced together with the at least one end portion of the fiber of the main cable by a conventional splicing technique, such as fusion splicing, and thereby define at least one spliced together fiber portion. Accordingly, the splice closure surrounds and protects the at least one spliced together fiber portion. Since it is typical that the drop cable and main cable would include two or more fibers spliced together, the plural term "fibers" is sometimes used herein, it being understood that a splice between even single fibers is contemplated by the invention.

The fiber guide means preferably includes an elongate tube having a longitudinally extending slot therein which receives the spliced together fiber portions. In addition, the drop cable preferably includes a central buffer tube having an end portion of its buffer tube positioned within an adjacent end portion of the elongate tube of the fiber guide means. The fiber guide means also preferably includes a pair of longitudinally extending arcuately shaped walls connected to the elongate tube and gripping adjacent portions of the main cable. The elongate tube and arcuately shaped walls may be integrally molded plastic, for example.

A foam cushion layer is preferably provided underlying the arcuately shaped walls of fiber guide means to serve as a cushioning layer. A plurality of longitudinally spaced apart fasteners, such as tie wraps, may surround the main cable and the pair of arcuately shaped walls to secure the fiber guide means to the main cable.

As would be readily be understood by those skilled in the art, the fiber optic main cable may preferably include a metallic shield surrounding the one or more buffer tubes. Accordingly, to permit access to a predetermined buffer tube for removing the end portions of the optical fibers, a longitudinally extending portion of the metallic shield is preferably removed from the main cable. The discontinuous metallic shield defines first and second cable shield end portions adjacent respective ones of the first and second locations along the main cable. Accordingly, the splice closure of the present invention preferably includes electrical connection means extending between the first and second metallic shield end portions and connected thereto for maintaining electrical continuity of the metallic shield.

The electrical connection means preferably includes a length of wire, and first and second bonding clamps securing opposing ends of the wire to respective first and second metallic shield end portions. The electrical connection means may thus be provided without adversely impacting the overall outer diameter of the splice closure. Yet another feature of the invention is that the second bonding clamp preferably includes a strap encompassing the end of the drop cable for securing the drop cable to the main cable. In an embodiment of the invention including a single buffer tube, such as in an LXE® cable by AT&T, longitudinal strength members may be cut and tucked under an adjacent portion of the shield. Alternately, a bonding clamp may be used of the type described in copending application entitled *FIBER OPTIC BONDING ASSEMBLY AND ASSOCIATED METHOD*, assigned to the assignee of the present invention.

A longitudinally extending portion of the cable sheath is also preferably removed from the main cable and defines first and second cable sheath end portions adjacent respective ones of the first and second locations along the main cable. Moreover, the splice closure also preferably includes a heat recoverable housing surrounding the main cable and extending between the first and second cable sheath end portions to prevent water entry into the closure. The splice closure also preferably includes a heat shield layer underlying the heat recoverable housing for providing mechanical protection and for protecting the fiber guide means and other underlying components when heating the housing to cause the housing to shrink to its final dimensions.

Another aspect of the present invention is that the splice closure preferably includes sealing means contained within the heat recoverable housing adjacent respective first and second cable sheath end portions. The sealing means serves to prevent water migration into the splice closure from the cable sheath end portions. The sealing means also preferably includes first and second masses of heat flowable material surrounding the cable and filling any voids adjacent respective first and second cable sheath end portions.

To prevent flow of heat flowable material into the fiber guide when melting the heat flowable material, the sealing means also preferably includes respective blocking dams adjacent opposing ends of the fiber guide means. The blocking dams preferably include a layer of compressible material, such as a wound strip of foam material, surrounding the main cable. The blocking dams permit less heat flowable material to be used to protect the splices and help to reduce the need for a larger diameter splice closure.

To further facilitate sealing of the cable sheath end portions for a stranded buffer tube cable, concentric spacers surround respective predetermined ones of the buffer tubes for maintaining the buffer tubes in spaced apart relation. The spacers are preferably positioned on alternating tubes in a staggered relation. The thus spaced apart relation of the buffer tubes facilitates flow of the heat flowable material into voids between the buffer tubes.

According to another aspect of the invention, the sealing means and a heat recoverable tube define a sealing arrangement that may be used in other applications for sealing an end of a fiber optic cable, such as for a cable entry into a conventional splice closure. The protective sealing arrangement preferably includes a blocking dam surrounding one or more buffer tubes longitudinally spaced apart from the cable sheath end portion, a heat recoverable tube surrounding the fiber optic cable between the cable sheath end portion and the blocking dam, and at least one C-shaped body of heat flowable material which is melted and flows to fill voids underlying the heat recoverable tube.

A plurality of concentric spacers, as discussed above, preferably surround predetermined ones of the buffer tubes for a stranded cable design. The spacers position the buffer tubes in spaced apart relation to facilitate flow of said heat flowable material into voids between the spaced apart buffer tubes. The heat recoverable tube may also be a transparent material to permit viewing into the interior of the tube to assure proper flow of the heat flowable material upon heating. A bonding clamp may also be secured to a metallic shield portion of the cable for bonding or grounding of the cable shield.

Another aspect of the present invention is a combined strain relief and guide means preferably positioned on each end of the housing of a splice closure to provide both strain relief and to assist in guiding the enclosure through a conduit, for example. While the strain relief may preferably be used in combination with the splice closure for the main and drop fiber optic cables as described above, those of skill in the art will readily understand that the strain relief may be used in other splicing arrangements as well, such as in conventional copper cable splices.

More particularly, the cable has a first degree of flexibility, while a heat recoverable housing surrounding the cable splice will have a second degree of flexibility higher than the first degree of flexibility of the cable. The housing also includes an end opening through which a portion of the cable emerges. The strain relief is secured to the emerging portion of the cable immediately downstream from the end opening of the housing to provide strain relief to the emerging cable portion. The strain relief means includes an elongate body and means for securing the elongate body to the emerging cable portion. The elongate body preferably has a predetermined degree of flexibility, for producing in combination with the emerging cable portion, a third degree of flexibility between the first and second degrees of flexibility to thereby provide strain relief to the emerging cable portion.

The housing is preferably provided by a sheet of heat recoverable material having a pair of abutting longitudinally extending edge portions, and a clamp member for securing the edge portions together thereby defining an enlarged circumferential portion for the housing. Accordingly, the elongate body preferably further includes a longitudinally extending tapered portion aligned with the enlarged circumferential portion for facilitating passage of said splice closure through a conduit. In one embodiment of the invention, the elongate body preferably includes a second or tapered distal end portion for further facilitating passage of the splice closure through a conduit. The elongate body also preferably includes a proximal end portion extending longitudinally into the end opening of the heat recoverable housing and between the cable and the housing, thus, providing even greater strain relief capability.

In another embodiment of the invention, the clamp member has an end portion extending longitudinally outwardly a predetermined distance beyond adjacent edge portions of the sheet of heat recoverable material. Accordingly, a portion of the elongate body adjacent the tapered portion has a recess therein receiving therein the end portion of the clamp member. A tape wrapping or another fastener may be used to secure the elongate body to the cable.

A method for making the fiber optic cable system as described above includes the steps of withdrawing end portions of the optical fibers of the main cable outwardly from a buffer tube at a first location along the main cable. The end portions of optical fibers of the drop cable are spliced with respective end portions of the predetermined optical fibers of the main cable to form spliced together fiber portions. The spliced together fiber portions are secured adjacent the main cable in a generally longitudinally extending direction so that the spliced together fiber portions are devoid of a slack coil of optical fiber.

The method also preferably further includes the step of securing the end of the fiber optic drop cable to the main cable at a second location downstream from the first location. Accordingly, the step of securing the spliced together fiber portions preferably includes positioning a fiber guide extending in a generally longitudinal direction adjacent the main cable between the first and second locations thereof.

The fiber guide preferably is provided by an elongate tube having a longitudinally extending slot therein, and the step of securing the spliced together fiber portions includes positioning the spliced together fiber portions through the longitudinal slot of the elongate tube. The splicing step preferably includes preparing the respective fiber end portions so that the spliced together fiber portions have a substantially corresponding length to the elongate tube.

The drop cable also preferably includes a longitudinally extending buffer tube. Accordingly, the step of securing the drop cable to the main cable preferably includes inserting a portion of the drop cable buffer tube into an adjacent end of the elongate tube.

As discussed above, the cable is preferably of the type including a metallic shield and outer sheath that are removed substantially between the first and second locations along the main cable. Accordingly, the electrical continuity of the metallic shield is preferably maintained by connecting the shield end portions. The method also preferably includes the step of positioning a heat recoverable housing surrounding the main cable between the first and second cable sheath end portions.

As would be readily understood by those skilled in the art, the step of withdrawing end portions of the optical fibers of the main cable preferably includes severing same adjacent the second location along the main cable downstream from the first location along the main cable. For a typical splice, the separation between the first and second locations may be about a foot which provides sufficient fiber length to perform several splices if a remake is necessary.

Another method aspect according to the invention is for making the protective sealing arrangement for a fiber optic cable as described in greater detail above. The method may be used for sealing a cable end as in the splice closure for the main and drop cables, or the method may be used for a cable end entering a conventional splice closure. The method preferably includes the steps of positioning a blocking dam surrounding the one or more buffer tubes longitudinally spaced apart from a cable sheath end portion; positioning at least one body of heat flowable material surrounding the buffer tubes between the blocking dam and the cable sheath end portion; positioning a heat recoverable housing surrounding the fiber optic cable between the cable sheath end portion and the blocking dam; and heating the heat recoverable housing to shrink the housing and melting the heat flowable material to cause the heat flowable material to fill voids underlying the housing.

The body of heat flowable material is preferably C-shaped so that the step of positioning the body surrounding the fiber optic cable preferably includes inserting the fiber optic cable into an opening of the C-shaped body. The heat recoverable housing also serves to compress the C-shaped body upon melting to thereby force the material to flow to fill underlying voids.

Brief Description of the Drawings

FIG. 1 is a perspective schematic view of a fiber optic cable system according to the present invention being payed out from a cable reel and illustrating a drop cable connected to a main cable at a splice closure.

FIG. 2 is an enlarged exploded perspective view of the splice closure according to the present invention.

FIG. 3 is a greatly enlarged exploded perspective view of a cable sheath end portion and metallic shield end portion as shown in FIG. 1 and illustrates positioning of a portion of a metallic shield bonding clamp member thereto.

FIG. 4 is a greatly enlarged exploded perspective view of a cable sheath end portion and metallic shield end portion as shown in FIG. 3 and illustrates installation of other metallic shield bonding clamp portions.

FIG. 5 is a greatly enlarged cross-sectional view taken along lines 5-5 of FIG. 2.

FIG. 6 is a greatly enlarged cross-sectional view taken along lines 6-6 of FIG. 2.

FIG. 7 is a greatly enlarged perspective fragmentary view of a portion of the fiber guide means and underlying main cable portion according to the invention with the heat shield and outer heat recoverable housing removed for clarity.

Thus, in one broad aspect, the invention provides a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having opening at a first location, and at least one optical fiber having an end portion mending through the opening at the first location; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the Erst location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; and a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction such that said spliced together fiber portion must be devoid of a slack coil of optical fiber, and said splice closure having dimensions smaller than sufficient to accommodate the minimum bend radius of a slack coil of optical fiber.

The invention provides, in a further aspect, a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one

one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; and a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction and devoid of a slack coil of optical fiber, said fiber guide means comprising an elongate tube having a longitudinally extending slot therein for receiving therein said at least one spliced together fiber portion, and tube securing means for securing said elongate tube to said main cable.

The invention also provides a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction and devoid of a slack coil of optical fiber, and said splice closure comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and said splice closure further comprising a heat shield layer underlying said heat recoverable housing for protecting said fiber guide means when heating said housing.

In accordance with a still further aspect of the invention, there is provided a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction and devoid of a slack coil of optical fiber, and said splice closure comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and said splice closure further comprising sealing means contained within said heat recoverable housing adjacent respective first and second cable sheath end portions for sealing same, and wherein said sealing means comprises first and second masses of heat flowable material adjacent respective first and second cable sheath end portions.

According to another aspect of the invention, there is provided a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion least one spliced together fiber portion; and a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means, comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion such that it must be devoid of a slack coil of optical fiber, and said splice closure having dimensions smaller than sufficient to accommodate the minimum bend radius of a slack coil of optical fiber.

The invention provides, in a further aspect, a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; and a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion devoid of a slack coil of optical fiber, said elongate tube having a longitudinally extending slot therein for receiving therein said at least one spliced together fiber portion, and wherein said fiber guide means further comprises tube securing means for securing said elongate tube to said main cable.

The invention also provides a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion devoid of a slack coil of optical fiber, and said splice closure further comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and said splice closure further comprising a heat shield layer underlying said heat recoverable housing for protecting said fiber guide means when heating said housing.

In accordance with a still further aspect of the invention, there is provided a fiber optic cable system comprising: a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable; a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion devoid of a slack coil of optical fiber, and said splice closure further comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and said splice closure further comprising sealing means contained within said heat recoverable housing adjacent respective first and second cable sheath end portions for sealing same, and wherein said sealing means comprises first and second masses of heat flowable material adjacent respective first and second cable sheath end portions.

According to another aspect of the invention, there is provided a method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic drop cable connected thereto, the fiber optic main cable comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of: withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable; splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion; and securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion must be devoid of a slack coil of optical fiber and has dimensions smaller than sufficient to accommodate the minimum bend radius of a slack coil thereof.

The invention provides, in a further aspect, a method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic drop cable connected thereto, the fiber optic main cable comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of: withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable; splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion; and securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion is devoid of a slack coil of optical fiber, said securing step including positioning a fiber guide extending in a generally longitudinal direction adjacent the main cable between the first and second locations thereof, the fiber guide comprising an elongate tube having a longitudinally extending slot therein, and positioning the at least one spliced together end portion through the longitudinal slot of the elongate tube.

The invention also provides a method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic drop cable connected thereto, the fiber optic main cable comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of: withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable, the fiber optic main cable having an outer sheath, and further comprising the step of removing a longitudinally extending portion of the sheath defining first and second cable sheath end portions adjacent respective first and second locations along the main cable; splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion; securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion is devoid of a slack coil of optical fiber; positioning a heat recoverable housing extending along and surrounding the main cable between the first and second cable sheath end portions; and positioning a heat shield layer underlying the heat recoverable housing.

In accordance with a still further aspect of the invention, there is provided a method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic drop cable connected thereto, the fiber optic main cable comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of: withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable, the fiber optic main cable having an outer sheath, and further comprising the step of removing a longitudinally extending portion of the sheath defining first and second cable sheath end portions adjacent respective first and second locations along the main cable; splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion; securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion is devoid of a slack coil of optical fiber; positioning a heat recoverable housing extending along and surrounding the main cable between the first and second cable sheath end portions; and sealing the first and second cable sheath end portions by positioning respective bodies of heat flowable material surrounding the main cable adjacent the first and second cable sheath end portions, and heating the heat recoverable housing to shrink the housing and cause the bodies of heat flowable material to melt and flow thereby filling voids underlying the heat recoverable housing adjacent respective first and second cable sheath end portions.

FIG. 8 is a greatly enlarged perspective view of spaced apart first and second locations along the main cable illustrating separation of optical fibers from a buffer tube according to the invention.

FIG. 9 is a greatly enlarged exploded perspective view of a portion of the fiber guide means adjacent the first location along the main cable according to the invention and illustrating routing of the separated optical fibers in the fiber guide means.

FIG. 10 is a greatly enlarged perspective view of a portion of the fiber guide means illustrating portions of the spliced together fiber portions according to the invention.

FIG. 11 is a greatly enlarged perspective view of an end portion of the splice guide at a second location along the main cable and illustrating connection to a buffer tube of the drop cable according to the invention.

FIGS. 12-14 are a greatly enlarged cross-sectional views of a portion of the main cable illustrating sealing thereof and the sealing arrangement according to the present invention.

FIG. 15 is a flowchart block diagram of a method of fabricating the fiber optic cable system of the present invention.

FIG. 16 is an enlarged cross-sectional view of an alternate embodiment of the fiber guide means according to the invention.

FIG. 17 is a perspective view of a portion of a single buffer tube cable including longitudinal strength members and illustrating how the strength members may be captured according to one aspect of the invention.

FIGS. 18-20 are perspective views of an end portion of the housing according to the invention illustrating a first embodiment of a strain relief or cable guide means being secured to an end of the splice closure housing.

FIGS. 21 and 22 are perspective views of an end portion of the housing according to the invention illustrating a second embodiment of a strain relief or cable guide means secured to an end of the splice closure housing.

Description of the Preferred Embodiments

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which a preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, applicants provides these embodiments so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Referring first to FIG. 1, the fiber optic cable system **20** according to the present invention includes a fiber optic main cable **21** and a fiber optic drop cable **22** connected thereto at a splice closure **24**. As would readily be understood by those skilled in the art, the main cable **21** preferably has a relatively high fiber count, such as 48 fibers, while the drop cable **22** is typically a low fiber count cable, such as 2 or 4 fibers. As illustrated, the cable system **20** may be installed so that one or more drop cables extend to desired locations, such as a residence or an ONU, along the route of the main cable **21**.

As also illustrated in FIG. 1, the fiber optic cable system **20** may be readily wound onto a conventional cable reel **25** during manufacturing, and delivered and installed in the field from the cable reel, because of the relatively compact outer diameter of the splice closure **24**, that is, less than about 1.8 inches. The fiber splice closure **24** is also somewhat flexible and permits the splice closure to bend slightly to conform to the curvature of the cable reel **25**.

Although the cable system **20** according to the present may advantageously be assembled in the factory as a preterminated optical fiber cable, those of skill in the art will readily appreciate that the splice closure **24** and techniques described herein may also be readily used for connecting drop cables along a main cable already installed in the field.

Referring now to FIGS. 2 through 5, several components of the splice closure **24** are described. The main cable **21** may be either of the stranded loose buffer tube type, as shown, or the single central buffer tube type, as would be readily understood by those skilled in the art. The stranded loose buffer tube cable includes a plurality of buffer tubes **26** stranded around a plastic coated central supporting member **27**. A longitudinally extending portion of the cable sheath **31** and the underlying metallic shield **32** are removed from the main cable **21** to expose the underlying buffer tubes **26**. As shown best in FIG. 3, the main cable **21** may also be of the type having an aramid yarn covering **29** surrounding the buffer tubes **26** for strength, and a polyethylene covering **30** positioned between the aramid yarn covering **29** and the metallic shield **32**. Fiber guide means **34**, as described in greater detail below, is secured adjacent the buffer tubes **26** exposed along the opened portion of the main cable **21**. The fiber guide means **34** carries the spliced together fiber portions of the main and drop cables.

A heat shield **37**, and heat recoverable housing **38** along with its associated clamp member **39** are positioned to surround the main cable **21** to protect the exposed open sheath portion thereof and the fiber guide means **34**. As would be readily understood by those having skill in the art, the heat shield **37**, housing **38** and clamp **39** may preferably be of the conventional type as used in copper cable repair and splicing. For example, the heat recoverable material may be a woven sleeve product sold by the assignee of the present invention under the designation XAGA® 550, or an extruded sleeve product sold under the designation XAGA® 500. Strain relief or guide means **40** may be positioned on the opposing ends of the splice closure **24** to facilitate pulling the splice closure through a conduit, as described more fully below.

The heat recoverable housing **38** in the illustrated embodiment preferably includes an interior sealing flap **38a** for sealing the upper portion of the housing adjacent the joint between the opposing edges of the housing. A tape wrapping, not shown, may also be used to secure the heat shield **37** in position until the heat recoverable housing is properly positioned around the main cable **21**.

A first bonding clamp **41** and a second bonding clamp **42** are secured to respective first and second metallic shield end portions, and a wire **43** is connected between the clamps to maintain the electrical continuity of the metallic cable shield **32**. As shown in greater detail in FIGS. 3 through 5, the first clamp **41** includes a shoe **41a** and an upstanding threaded stud **41b** connected thereto. The shoe **41a** is positioned under the metallic cable shield **32** and a top plate **41c** is positioned overlying the metallic shield. A suitable crimp connector **43a** secured to the end of the wire **43** may also be positioned onto the threaded stud **41b** and secured by a suitable locking nut **41d** as illustrated.

Referring now briefly to FIG. 17, a cable **21'** having a single central buffer tube **26'** is illustrated having a pair of lengthwise extending metallic strength members **27'**. These strength members **27'** are desirably captured or positioned so that the ends do not move and puncture or damage any adjacent components. In the illustrated embodiment, the ends of the strength members **27'** are tucked back into the cable underlying the shield **32'** or adjacent covering **30'**. The strength members **27'** may be further secured by a tape wrapping, not shown. Alternatively, the strength members **27'** may be secured to a bonding clamp of the type described in copending application entitled *FIBER OPTIC BONDING ASSEMBLY AND ASSOCIATED METHOD*, assigned to the assignee of the present invention.

For certain cable types (for example, Siecor EST), the distribution and drop cable strength members are secured by the sleeve, sleeve adhesive, and Tye-Wraps in order to allow field deployment via the recommended procedure of strength member axial pull. The strength members, which are folded back, are protected from shield laceration by a Tye-Wrap. The strength members are folded back across the shield approximately 1 inch. The strength members are initially secured with a Tye-Wrap. Subsequently, the XAGA sleeve is shrunk and adds additional axial pull strength.

Referring briefly again to FIG. 2, the second bonding clamp **42** additionally includes a strap member **44** cooperating therewith to secure the end of the fiber optic drop cable **22** to the main cable **21**. Thus, the strap member **44** electrically connects the drop cable metallic shield **23** to the metallic shield **32** of the main cable **21** and, moreover, permits adjustment of the position of the end of the drop cable to ensure proper positioning of spliced together fiber portions as described in greater detail below.

Referring now to FIGS. 2, 3 and 6, and 12-14 another aspect of the present invention is illustrated. Water may enter an unintended penetration in the cable sheath **32** remote from the splice closure **24** and migrate through the cable and into the splice closure. Accordingly, the cable sheath end portions of the main cable **21** are desirably sealed by sealing means to prevent water entry into the splice closure **24** at the respective first and second cable sheath end portions. The sealing means is preferably provided by respective blocking dams **45, 46** formed of a wrapped compressible foam strip, and respective C-shaped bodies **47, 48** of heat flowable material, which when heated flow to fill the voids underlying the heat recoverable housing **38** adjacent the respective blocking dams **45, 46**.

As would be readily understood by those skilled in the art, the heat flowable material is preferably a conventional type of heat flowable material, for example, as supplied in small pellet form contained within a mesh pouch in copper cable technology for sealing splices. More particularly, the heat flowable material preferably has a relatively abrupt melt flow point at about 90-95_C. The C-shaped bodies **47, 48** of the heat flowable material are also positioned to surround the underlying components and thus be adjacent the housing **38** to facilitate the transfer of heat through the housing and to the C-shaped bodies.

For a main cable **21** of the stranded buffer tube design as illustrated, the sealing means also preferably includes concentric C-shaped spacers **48** positioned onto respective buffer tubes **26** (FIG. 3) in an alternating or staggered arrangement as illustrated. The spacers **48** serve to spread the buffer tubes **26** out into spaced apart relation at the cable sheath end portions, to thereby facilitate the flow of the heat flowable material to fully seal the cable sheath end portions.

As illustrated best in FIGS. 12 through 14, as heat is applied to cause the heat recoverable tube or housing **38** to shrink down onto the underlying components, the C-shaped body of heat flowable material is also melted and flows to fill the voids adjacent the buffer tubes **26**. In one embodiment, the heat recoverable housing **38** may be transparent to permit viewing of the interior of the housing to assure proper flow of material. In addition, a visible bump or protrusion would also indicate that secondary heating may be required to melt the C-shaped bodies.

The concentric spacers **48** further serve to separate the buffer tubes **26** so that the cable sheath end may be completely sealed. As would be readily understood by those skilled in the art, the C-shaped body of heat flowable material **47**, blocking dam **45** (FIG. 6) and heat recoverable housing **38** may be used to seal cable sheath end portions of cables for other applications, such as involving conventional in-line or butt splice closures for aerial or buried installation. In addition, this aspect of the invention may be applied to a single central buffer tube cable, and a single spacer may optionally be used to ensure flow to seal the area between the cable shield and the underlying central buffer tube. To facilitate sealing of stranded buffer tube cables, the concentric spacers **48** are also desirably used.

Referring now to FIGS. 7 through 10, the fiber guide means **34** and its installation and functions are explained. As shown in FIG. 8, respective end portions of a pair of predetermined optical fibers **50** are extended outwardly from a first opening **51** in a respective buffer tube **26**, by first making a second opening **52** in the same buffer tube **26** at a location downstream from the first location and adjacent a second location whereat the drop cable **22** is secured to the main cable **21**. The openings **51, 52** in the buffer tube **26** may be readily made using a conventional procedure as outlined, for example, in Siecor Operator Manual SOM-004-026 Issue 2 (9/88) entitled SIECOR® No-Slack Optical Fiber Access Tool.

The predetermined optical fibers are severed at the second opening **52** and pulled back to extend outwardly from the first opening **51**. The spacing between the first and second openings **51, 52** is preferably about a foot to thereby provide sufficient slack for several splice attempts using a conventional fusion splicer, as would be readily understood by those skilled in the art. This relatively short length of fiber may be readily withdrawn from the buffer tube **26** without a substantial likelihood of damaging the fibers.

As would also be readily understood by those skilled in the art, a main cable **21** of the type having a single central buffer tube may also be accessed by cutting a longitudinally extending slit in the buffer tube from a first location to a second location. The optical fibers may be severed at the first location, thereby creating a predetermined length of slack optical fiber for subsequent splicing.

The fiber guide means **34** preferably includes an elongate tube **55** having a longitudinally extending slot **56** therein for receiving therein spliced together fiber portions **50, 57** of the main cable **21** and drop cable **22**, respectively. The spliced together fiber portions **50, 57** are positioned within the fiber guide means **34** extending in a substantially longitudinal direction adjacent the main cable **21**. Moreover, the length of the elongate tube **55** substantially corresponds to the length of the spliced together fiber portions.

In other words, the spliced together fiber portions **50, 57** are positioned within the elongate tube **55** devoid of a slack coil of optical fiber. Accordingly, the outer diameter of the splice closure **24** may be greatly reduced over prior art designs which required that the closure be sufficiently large to accommodate the minimum bend radius of an optical fiber.

As shown in FIGS. 2 and 11, another feature of the invention is that the drop cable **22** preferably includes a central buffer tube **28** having an end portion positioned within an adjacent end portion of the elongate tube **55** of the fiber guide means **34**. The fiber guide means **34** also preferably includes a pair of longitudinally extending arcuately shaped walls **58, 59** connected to the elongate tube **55** and gripping adjacent portions of the buffer tubes **26** of the main cable **21**. The elongate tube **55** and arcuately shaped walls **58, 59** may be integrally molded plastic, for example, to reduce the number of component parts.

A foam cushion layer **61** (FIGS. 7 and 9) is preferably provided between the buffer tubes **26** of the main cable **21** and the arcuately shaped walls **58, 59** of the fiber guide means **34**. A plurality of longitudinally spaced apart fasteners, such as tie wraps **63**, preferably surround the main cable **21**, pass through suitable openings in the fiber guide means **34**, and surround the pair of arcuately shaped walls **58, 59** to thereby secure the fiber guide means **34** to the main cable. The foam cushion layer **61** resists twist of the guide means **34** independently of the tubes, which might otherwise result in pinched fibers.

As shown best in the exploded view of FIG. 9, the elongate tube **55** includes a slotted opening **64** extending inwardly from a first end thereof. This slotted opening **64** permits the fiber guide means **34** to be positioned over the underlying first opening **51** of the buffer tube **26** to protect the opening and permit routing of fiber end portions **50** into the elongate tube. The fiber guide means **34** also preferably extends longitudinally to cover the second opening **52** in the buffer tube **26** and thereby protect this opening as well. As shown in FIGS. 2 and 7, the wire **43** for maintaining electrical continuity of the metallic shield **32** is preferably positioned in side-by-side relation with the elongate tube **55** of the fiber guide means **34** to thereby further reduce the required exterior diameter of the splice closure **24**.

The end portions of the drop cable optical fibers **57** may be spliced together with respective end portions of the predetermined optical fibers **50** of the main cable **21** by conventional means, such as fusion splicing or mechanical splicing as would be readily understood by those skilled in the art. For example, for conventional fusion splicing, protective sleeves **50a, 50b** may be secured surrounding the fusion splices (FIG. 10). In addition, the respective lengths of the fibers **50, 57** may be selected to provided the longitudinally staggered relationship of the protective sleeves **50a, 50b** as in the illustrated embodiment.

Referring now to FIG. 16, another embodiment of fiber guide means **34'** according to the invention is illustrated. The fiber guide means **34'** includes an elongate tube **55'** having an elongate opening **56'** and a somewhat square cross-sectional shape, although other configurations are contemplated by the present invention. The embodiment includes a cover **68** integrally molded with the elongate tube **55'** and the depending sidewalls **58', 59'**. The interior of the sidewalls **58', 59'** also include longitudinal ribs **69** for gripping adjacent portions of the main cable **21**. The interior of the elongate tube **55'** may be filled with a gel, not shown, to prevent movement of the spliced together fiber portions **50** therein.

Referring now to FIGS. 18-20 a first embodiment of a strain relief or guide means **40** in combination with a heat recoverable housing **38** and cable **21** according to another aspect of the present invention are illustrated being assembled. The strain relief or guide means **40** is preferably positioned on each end of the splice closure housing **38** (FIG. 1) to provide both strain relief and to assist in guiding the closure through a conduit, for example. While the strain relief or guide means **40** may preferably be used in combination with the splice closure **24** for the main cable **21** and drop cable **22** as shown in FIG. 1, those of skill in the art will readily understand that the strain relief or guide means may be used in other splicing arrangements as well, such as in conventional copper cable splices.

More particularly, the cable **21** has a first degree of flexibility, while the heat recoverable housing **38** surrounding the cable splice will have a second degree of flexibility higher than the first degree of flexibility of the cable. The housing **38** also includes an end opening through which a portion of the cable emerges. As shown in the illustrated embodiment, a portion of heat flowable material **104** is shown adjacent the end opening of the housing **38**.

The strain relief or guide means **40** is secured to the emerging portion of the cable **21** immediately downstream from the end opening of the housing **38** to provide strain relief to the emerging cable portion. The strain relief or guide means **40** includes an elongate body **100** and means for securing the elongate body to the emerging cable portion. The elongate body **100** preferably has a predetermined degree of flexibility, for producing in combination with the emerging cable portion, a third degree of flexibility between the first and second degrees of flexibility to thereby provide strain relief to the emerging cable portion.

The housing **38** is preferably provided by a sheet of heat recoverable material having a pair of abutting longitudinally extending edge portions **38b** (FIG. 1), and a clamp member **39** for securing the edge portions together thereby defining an enlarged circumferential portion for the housing. Accordingly, the elongate body **100** preferably further includes a longitudinally extending tapered portion **103** aligned with the enlarged circumferential portion for facilitating passage of said splice closure through a conduit.

In the illustrated embodiment of the invention, the clamp member **39** has an end portion extending longitudinally outwardly a predetermined distance beyond adjacent edge portions **38b** of the sheet of heat recoverable material. Accordingly, a portion of the elongate body **100** adjacent the tapered portion **103** has a recess **105** therein receiving therein the end portion of the clamp member **39**. A tape wrapping **105** is preferably used to secure the elongate body **100** to the cable **21** and the clamp member **39**. The extending end of the clamp member **39** serves to maintain the elongate body **100** in proper rotational alignment with the enlarged circumferential portion of the housing **38**.

A second embodiment of the strain relief or guide means **40'** is shown in FIGS. 21 and 22. Like elements are indicated by prime notation and thus need not be described further. In the illustrated embodiment, the elongate body **100'** surrounds the cable **21** and thus is preferably formed of mating halves to facilitate installation. In addition, the elongate body **100'** preferably includes a second or tapered distal end portion **108** immediately adjacent the cable **21** for further facilitating passage of the splice closure through a conduit. The elongate body **108** also preferably includes a proximal end portion **109** (FIG. 22) extending longitudinally into the end opening of the heat recoverable housing **38** and between the cable **21** and the housing, thus, providing even greater strain relief capability. A fastener, such as a tie wrap **110** may be used to secure halves of the elongate body **100'** to the cable **21**.

Referring now to additionally to the flowchart of FIG. 15, method steps according to the present invention are described. If a preterminated fiber optic system is being made, the following steps explained would desirably be performed in a factory environment; however, the steps may also be performed in the field, for example, to add a drop cable **22** to an existing main cable **21**. Upon starting (Block **70**), a technician cuts back the cable sheath **31** of the main cable **21** at Block **72**. Other cable components may also be removed, such as an aramid yarn layer **29** and surrounding covering **30**. The predetermined fiber end portions **50** from the main cable **21** are then separated from other fibers and extended outwardly from the respective buffer tube **26** (Block **74**).

The fiber guide means **34** extensively described above is then positioned on the exposed portion of the buffer tubes of the main cable **21** (Block **76**). At Block **79**, if the cable has a metallic shield **32**, at Block **78** the bonding clamps **41, 42** and the interconnecting wire **43** are installed onto the respective metallic shield end portions to maintain the electrical continuity of the shield **32**.

The respective end portions of the optical fibers of the main and drop cables are spliced together at Block **80** and positioned through the longitudinal opening **56** of the elongate tube **55** so that the spliced together fiber portions **50, 57** are secured within the elongate tube **55** and are devoid of slack coils of optical fiber to thereby provide a compact splice closure **24** (Block **82**).

The end of the drop cable **22**, and more particularly, the exposed portion of the metallic shield **23** may be positioned within the strap **44** of the second bonding clamp **42** and its position adjusted to maintain a desired nontaut condition in the spliced together fiber portions

50, 57 (Block **84**). A cover **68** (FIG. 16) may be positioned over the elongate tube **55'** to cover its longitudinal opening **56'**.

At Block **86**, the blocking dams **45, 46** are positioned adjacent the ends of the fiber guide means **34**, and the respective C-shaped heat flowable material bodies or rings **47, 48** are positioned surrounding the buffer tubes **26** (Block **88**). The concentric spacers **48** may also be positioned around the buffer tubes **26** to spread the buffer tubes into spaced apart relation.

At Block **90**, the heat shield **37** and heat recoverable housing **38** are positioned surrounding the main cable **21** and underlying fiber guide means **34**. Accordingly, at Block **90** the housing **38** is heated to its heat recovery temperature, such as using a conventional oven or torch as used for similar heat recoverable housings for copper cables. During heating of the housing **38**, the C-shaped bodies **45, 46** of heat flowable material may melt and flow to completely seal the cable sheath end portions. At Block **91** if heat flowable material bodies have not been sufficiently heated to melt and flow, bumps in the housing may be visible, and if so, a secondary heating step (Block **92**) will melt the bodies and cause the material to flow and fill the voids at the cable sheath end.

For a single field-installed drop cable and its associated splice closure, the splice closure and drop cable may then be installed into their desired positions. For a preterminated fiber optic system, at Block **92** the splice closure **24** and the respective portions of the main cable **21** and the drop cable **22** may be wound onto a takeup reel **25** and the process repeated for a desired number and position of a series of drop cables (Block **94**). The preterminated cable may then be shipped and placed along its desired route in the field.

Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed, and that modifications and embodiments are intended to be included within the scope of the appended claims.

CLAIMS:

1. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having opening at a first location, and at least one optical fiber having an end portion mending through the opening at the first location;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the Erst location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; and

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction such that said spliced together fiber portion must be devoid of a slack coil of optical fiber, and said splice closure having dimensions smaller than sufficient to accommodate the minimum bend radius of a slack coil of optical fiber.

2. A fiber optic cable system according to claim 1 wherein said fiber guide means and said at least one spliced together fiber portion have substantially corresponding lengths.

3. A fiber optic cable system according to claim 1 wherein said fiber optic main cable further comprises a metallic shield, and wherein a longitudinally extending portion of said metallic shield is removed from said main cable and defines first and second metallic shield end portions adjacent respective ones of the first and second locations along said main cable.

4. A fiber optic cable system according to claim 3 further comprising electrical connection means extending between said first and second metallic shield end portions and connected thereto for maintaining electrical continuity of said metallic shield.

5. A fiber optic cable system according to claim 4 wherein said electrical connection means comprises a predetermined length of wire, and first and second bonding clamps securing opposing ends of the wire to respective first and second metallic shield end portions.

6. A fiber optic cable system according to claim 5 wherein said second bonding clamp includes strap means for securing the end of said fiber optic drop cable to said main cable at the second location.

7. A fiber optic cable system according to claim 6 wherein said drop cable includes a metallic shield, and wherein said strap means surrounds an end portion of the shield of the drop cable for electrically connecting thereto.

8. A fiber optic cable system according to claim 1 wherein said fiber optic main cable further comprises an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines

first and second cable sheath end portions adjacent respective first and second locations along said main cable.

9. A fiber optic cable system according to claim 8 wherein said splice closure further comprises a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions.

10. A fiber optic cable system according to claim 1 further comprising a cable reel upon which said main cable, said drop cable and said splice closure are wound.

11. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; and

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction and devoid of a slack coil of optical fiber, said fiber guide means comprising an elongate tube having a longitudinally extending slot therein for receiving therein said at least one spliced together fiber portion, and tube securing means for securing said elongate tube to said main cable.

12. A fiber optic cable system according to claim 11 wherein said drop cable comprises a buffer tube, and wherein said buffer tube of said drop cable has an end portion positioned within an adjacent end portion of said elongate tube.

13. A fiber optic cable system according to claim 11 wherein said tube securing means comprises a pair of longitudinally extending arcuately shaped walls connected to said elongate tube and gripping adjacent portions of said main cable.

14. A fiber optic cable system according to claim 13 wherein said fiber guide means further comprises a foam cushion layer underlying said arcuately shaped walls of said tube securing means.

15. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion;

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction and devoid of a slack coil of optical fiber, and said splice closure comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and

said splice closure further comprising a heat shield layer underlying said heat recoverable housing for protecting said fiber guide means when heating said housing.

16. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion;

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means extending adjacent said main cable between the first and second locations for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction and devoid of a slack coil of optical fiber, and said splice closure comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and

said splice closure further comprising sealing means contained within said heat recoverable housing adjacent respective first and second cable sheath end portions for sealing same, and wherein said sealing means comprises first and second masses of heat flowable material adjacent respective first and second cable sheath end portions.

17. A fiber optic cable system according to claim 16 wherein said sealing means further comprises first and second blocking dams adjacent respective first and second ends of said fiber guide means for preventing flow of said heat flowable material into said guide means, and wherein

each of said blocking dams comprises a compressible material.

18. A fiber optic cable system according to claim 16 wherein said main cable includes a plurality of buffer tubes, and wherein said sealing means further comprises first and second pluralities of concentric spacers surrounding predetermined ones of said plurality of buffer tubes adjacent respective first and second cable sheath end portions for maintaining said buffer tubes in spaced apart relation to facilitate flow of said heat flowable material into voids between said spaced apart buffer tubes.

19. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; and

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means, comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion such that it must be devoid of a slack coil of optical fiber, and said splice closure having dimensions smaller than sufficient to accommodate the minimum bend radius of a slack coil of optical fiber.

20. A fiber optic cable system according to claim 19 wherein said drop cable comprises a buffer tube, and wherein said buffer tube of said drop cable has an end portion positioned within an adjacent end portion of said elongate tube.

21. A fiber optic cable system according to claim 19 wherein said fiber optic main cable further comprises a metallic shield, and wherein a longitudinally extending portion of said metallic shield is removed from said main cable and defines first and second metallic shield end portions adjacent respective ones of the first and second locations along said main cable.

22. A fiber optic cable system according to claim 21 further comprising electrical connection means extending between said first and second metallic shield end portions and connected thereto for maintaining electrical continuity of said metallic shield.

23. A fiber optic cable system according to claim 22 wherein said electrical connection means comprises a predetermined length of wire, and first and second bonding clamps securing opposing ends of the wire to respective first and second metallic shield end portions.

24. A fiber optic cable system according to claim 23 wherein said second bonding clamp includes strap means for securing the end of said fiber optic drop cable to said main cable at the second location.

25. A fiber optic cable system according to claim 24 wherein said drop cable includes a metallic shield, and wherein said strap means surrounds an end portion of the shield of the drop cable for electrically connecting thereto.

26. A fiber optic cable system according to claim 19 wherein said fiber optic main cable further comprises an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable.

27. A fiber optic cable system according to claim 26 wherein said splice closure further comprises a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions.

28. A fiber optic cable system according to claim 19 further comprising a cable reel upon which said main cable, said drop cable and said splice closure are wound.

29. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion; and

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion devoid of a slack coil of optical fiber, said elongate tube having a longitudinally extending slot therein for receiving therein said at least one spliced together fiber portion, and wherein said fiber guide means further comprises tube securing means for securing said elongate tube to said main cable.

30. A fiber optic cable system according to claim 29 wherein said tube securing means comprises a pair of longitudinally extending arcuately shaped walls connected to said elongate tube and gripping adjacent portions of said main cable.

31. A fiber optic cable system according to claim 30 wherein said fiber guide means further comprises a foam

cushion layer underlying said arcuately shaped walls of said tube securing means.

32. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion;

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion devoid of a slack coil of optical fiber, and said splice closure further comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and

said splice closure further comprising a heat shield layer underlying said heat recoverable housing for protecting said fiber guide means when heating said housing.

33. A fiber optic cable system comprising:

a fiber optic main cable comprising a buffer tube having an opening at a first location, and at least one optical fiber having an end portion extending through the opening at the first location, said fiber optic main cable having an outer sheath, and wherein a longitudinally extending portion of said sheath is removed from said main cable and defines first and second cable sheath end portions adjacent respective first and second locations along said main cable;

a fiber optic drop cable having an end secured to said main cable at a second location downstream from the first location, said fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from the end of said drop cable, the end portion of the at least one optical fiber of said drop cable being spliced together with an end portion of the at least one optical fiber of said main cable thereby defining at least one spliced together fiber portion;

a splice closure extending between the first and second locations and surrounding the at least one spliced together fiber portion and said main cable, said splice closure comprising fiber guide means for guiding the at least one spliced together fiber portion adjacent said main cable in a generally longitudinal direction extending adjacent said main cable between the first and second locations, said fiber guide means comprising an elongate tube having a length substantially corresponding to a length of said at least one spliced together fiber portion and a width to guide the at least one spliced together fiber portion devoid of a slack coil of optical fiber, and said splice closure further comprising a heat recoverable housing surrounding said main cable substantially between said first and second cable sheath end portions; and

said splice closure further comprising sealing means contained within said heat recoverable housing adjacent respective first and second cable sheath end portions for sealing same, and wherein said sealing means comprises first and second masses of heat flowable material adjacent respective first and second cable sheath end portions.

34. A fiber optic cable system according to claim 33 wherein said sealing means further comprises first and second blocking dams adjacent respective first and second ends of said fiber guide means for preventing flow of said heat flowable material into said guide means, and wherein each of said blocking dams comprises a compressible material.

35. A fiber optic cable system according to claim 34 wherein said main cable includes a plurality of buffer tubes, and wherein said sealing means further comprises first and second pluralities of concentric spacers surrounding predetermined ones of said plurality of buffer tubes adjacent respective first and second cable sheath end portions for maintaining said buffer tubes in spaced apart relation to facilitate flow of said heat flowable material into voids between said spaced apart buffer tubes.

36. A method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic

drop cable connected thereto, the fiber optic main cable comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of:

withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable;

splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion; and

securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion must be devoid of a slack coil of optical fiber and has dimensions smaller than sufficient to accommodate the minimum bend radius of a slack coil thereof.

37. A method according to claim 36 further comprising the step of securing the end of the fiber optic drop cable to the main cable at a second location downstream from the first location.

38. A method according to claim 36 further comprising the steps of positioning a heat recoverable housing surrounding the main cable between the first and second locations along the main cable, and heating the heat recoverable housing.

39. A method according to claim 36 wherein the fiber optic main cable further comprises a metallic shield, and

further comprising the step of removing a longitudinally extending portion of the metallic shield from the main cable defining first and second metallic shield end portions adjacent respective first and second locations along the main cable.

40. A method according to claim 39 further comprising the step of electrically connecting the first and second metallic shield end portions for maintaining electrical continuity of the metallic shield.

41. A method according to claim 36 wherein the fiber optic main cable further comprises an outer sheath, and further comprising the step of removing a longitudinally extending portion of the sheath defining first and second cable sheath end portions adjacent respective first and second locations along the main cable.

42. A method according to claim 41 further comprising the step of positioning a heat recoverable housing extending along and surrounding the main cable between the first and second cable sheath end portions.

43. A method according to claim 36 wherein the step of withdrawing end portions of the at least one optical fiber of the main cable includes severing same adjacent the second location along the main cable downstream from the first location.

44. A method according to claim 36 further comprising the step of winding the connected main cable and drop cable onto a cable reel.

45. A method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic drop cable connected thereto, the fiber optic main cable

comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of:

withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable;

splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion; and

securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion is devoid of a slack coil of optical fiber, said securing step including positioning a fiber guide extending in a generally longitudinal direction adjacent the main cable between the first and second locations thereof, the fiber guide comprising an elongate tube having a longitudinally extending slot therein, and positioning the at least one spliced together end portion through the longitudinal slot of the elongate tube.

46. A method according to claim 45 wherein the drop cable includes a longitudinally extending buffer tube, and wherein the step of securing the drop cable to the main cable comprises inserting an end portion of the drop cable buffer tube into an adjacent end of the elongate tube.

47. A method according to claim 45 wherein the splicing step includes preparing each of the at least one fiber end portions so that the at least one spliced together

fiber portion has a length corresponding substantially to the elongate tube.

48. A method according to claim 45 wherein the fiber guide includes a pair of longitudinally extending arcuately shaped walls connected to the elongate tube, and wherein the step of positioning the fiber guide adjacent the main cable comprises positioning the arcuately shaped walls on adjacent portions of the main cable.

49. A method according to claim 48 wherein the step of positioning the fiber guide adjacent the main cable comprises positioning a foam cushion layer underlying the arcuately shaped walls of the fiber guide.

50. A method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic drop cable connected thereto, the fiber optic main cable comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of:

withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable, the fiber optic main cable having an outer sheath, and further comprising the step of removing a longitudinally extending portion of the sheath defining first and second cable sheath end portions adjacent respective first and second locations along the main cable;

splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion;

securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion is devoid of a slack coil of optical fiber;

positioning a heat recoverable housing extending along and surrounding the main cable between the first and second cable sheath end portions; and

positioning a heat shield layer underlying the heat recoverable housing.

51. A method for making a fiber optic cable system of the type having a fiber optic main cable and a fiber optic drop cable connected thereto, the fiber optic main cable comprising a buffer tube and at least one optical fiber contained therein, the fiber optic drop cable comprising at least one optical fiber having an end portion extending outwardly from an end of the drop cable, said method comprising the steps of:

withdrawing an end portion of the at least one optical fiber outwardly from the buffer tube at a first location along the main cable, the fiber optic main cable having an outer sheath, and further comprising the step of removing a longitudinally extending portion of the sheath defining first and second cable sheath end portions adjacent respective first and second locations along the main cable;

splicing together the end portion of the at least one optical fiber of the drop cable with an end portion of the at least one optical fiber of the main cable to form at least one spliced together fiber portion;

securing the at least one spliced together fiber portion adjacent the main cable in a generally longitudinally extending direction so that the at least one spliced together fiber portion is devoid of a slack coil of optical fiber;

positioning a heat recoverable housing extending along and surrounding the main cable between the first and second cable sheath end portions; and

sealing the first and second cable sheath end portions by positioning respective bodies of heat flowable material surrounding the main cable adjacent the first and second cable sheath end portions, and heating the heat recoverable housing to shrink the housing and cause the bodies of heat flowable material to melt and flow thereby filling voids underlying the heat recoverable housing adjacent respective first and second cable sheath end portions.

52. A method according to claim 51 wherein the step of sealing the first and second cable sheath end portions further comprises positioning a respective blocking dam comprising a compressible material surrounding the main cable adjacent respective ends of the housing for preventing flow of the heat flowable material into an interior portion of the housing.

53. A method according to claim 51 wherein the main cable includes a plurality of buffer tubes, and wherein the step of sealing the first and second cable sheath end portions further comprises the step of arranging the plurality of buffer tubes adjacent respective first and second cable sheath end portions in spaced apart relation by positioning a plurality of concentric spacers surrounding predetermined ones of the plurality of buffer tubes to facilitate the flow of the heat flowable material into voids between the spaced apart buffer tubes.

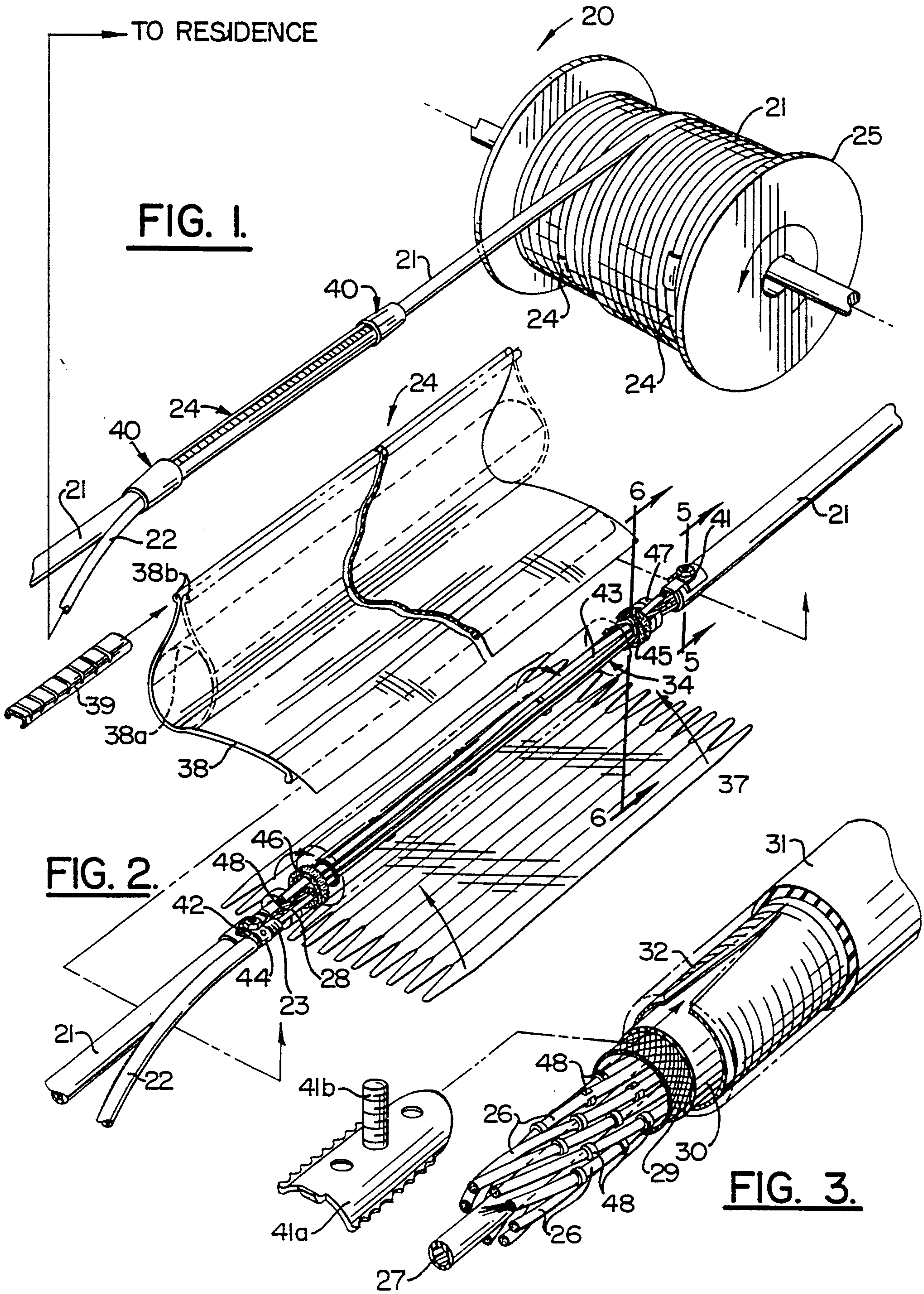


FIG. 1.

FIG. 2.

FIG. 3.

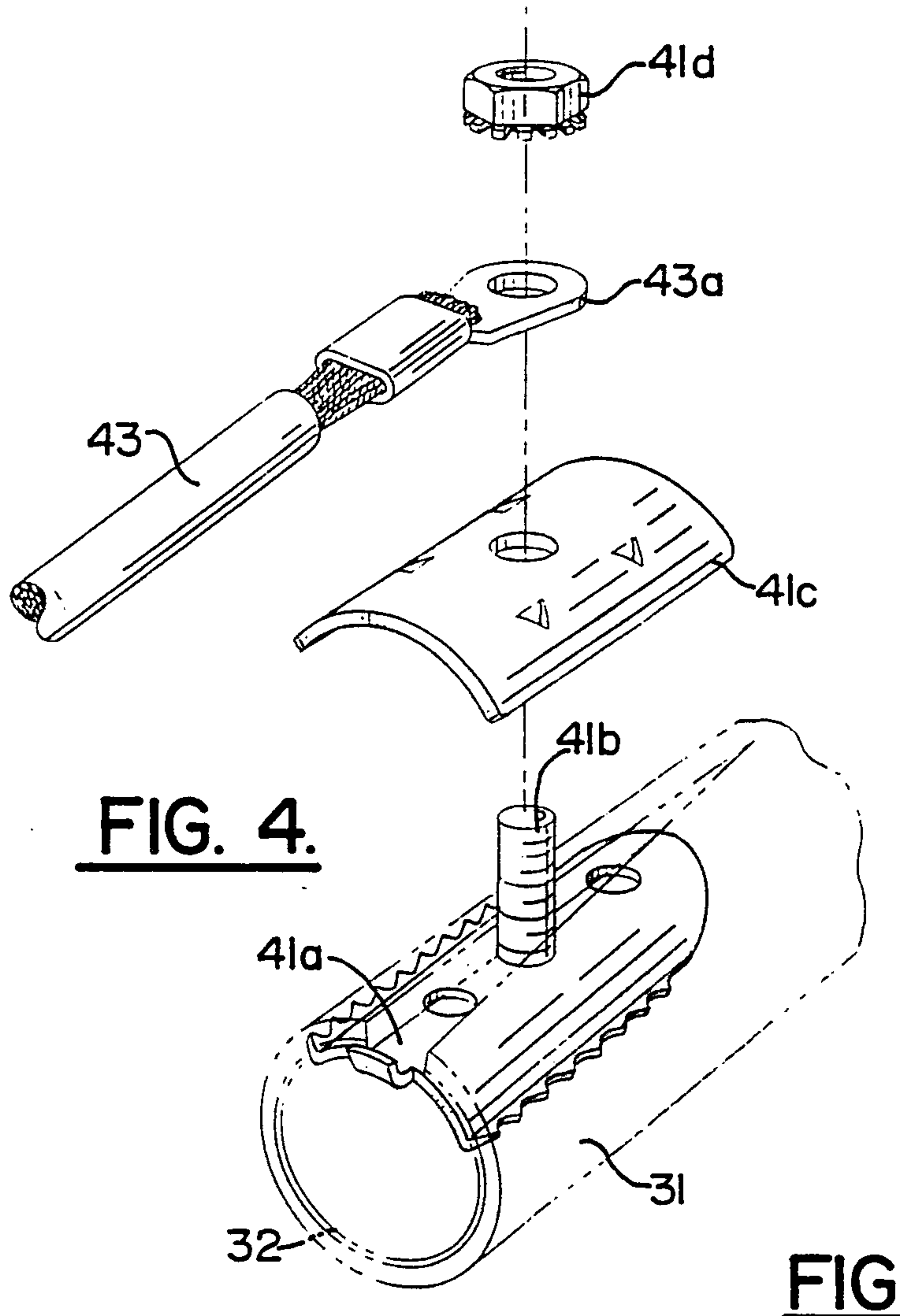


FIG. 4.

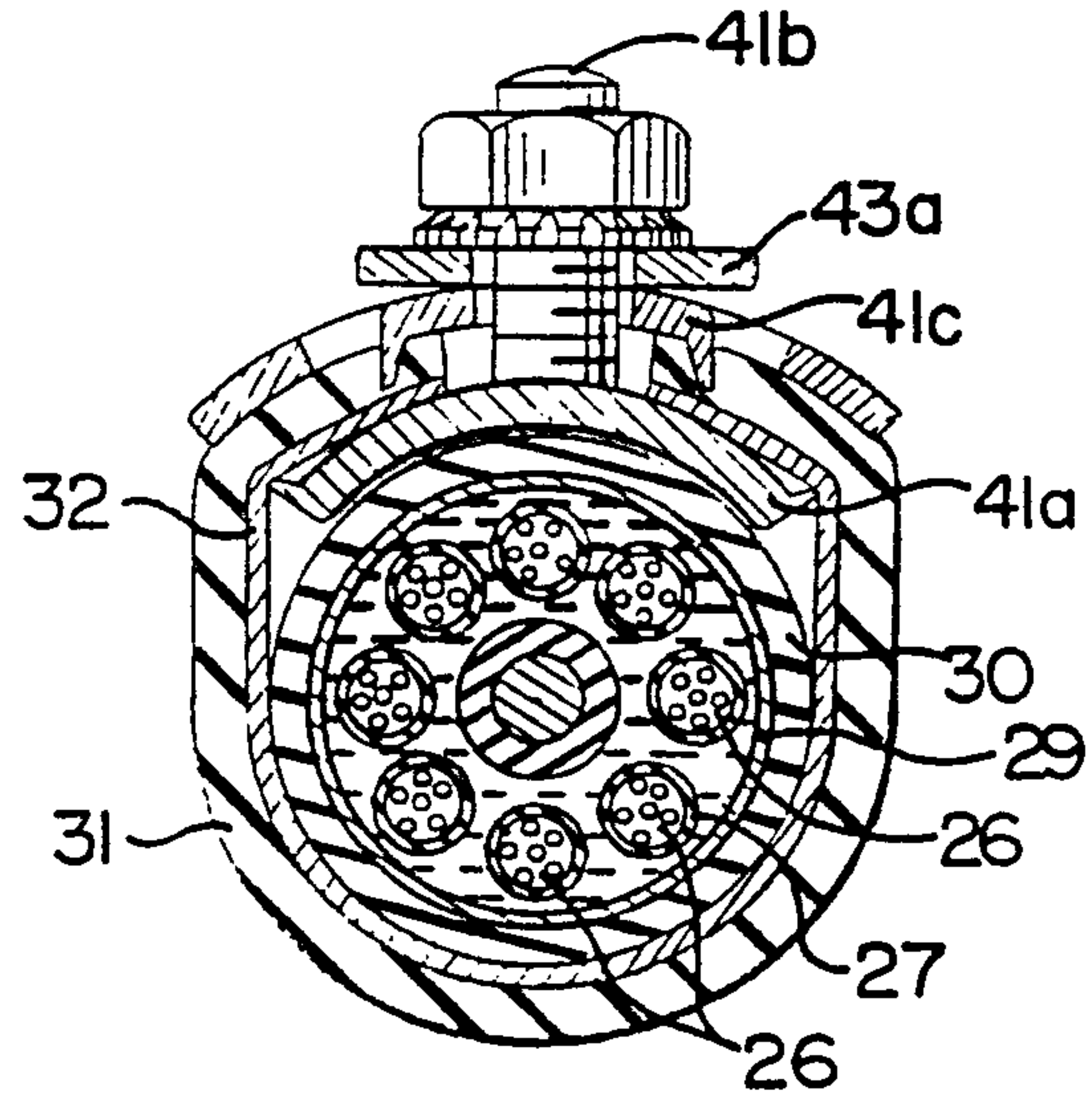


FIG. 5.

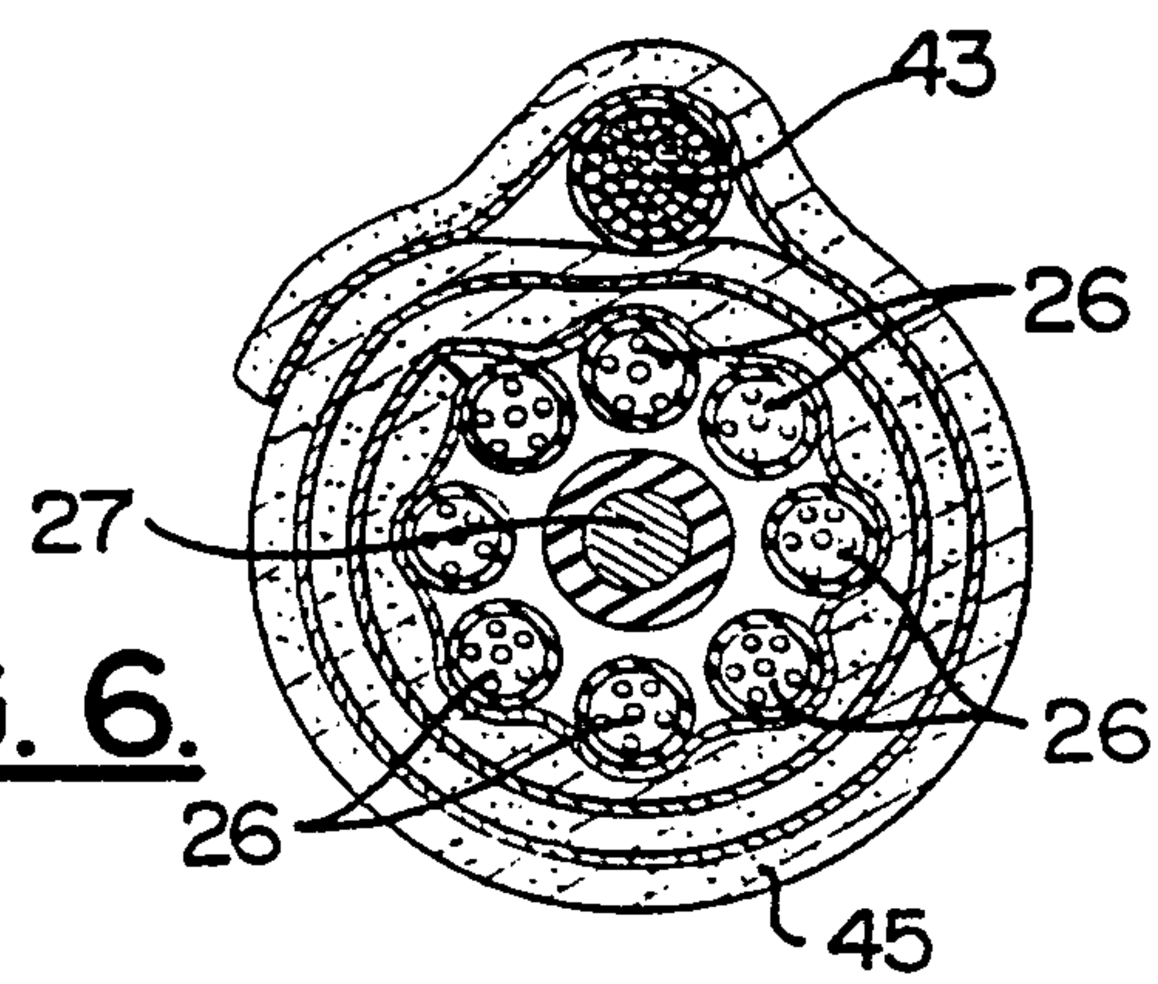


FIG. 6.

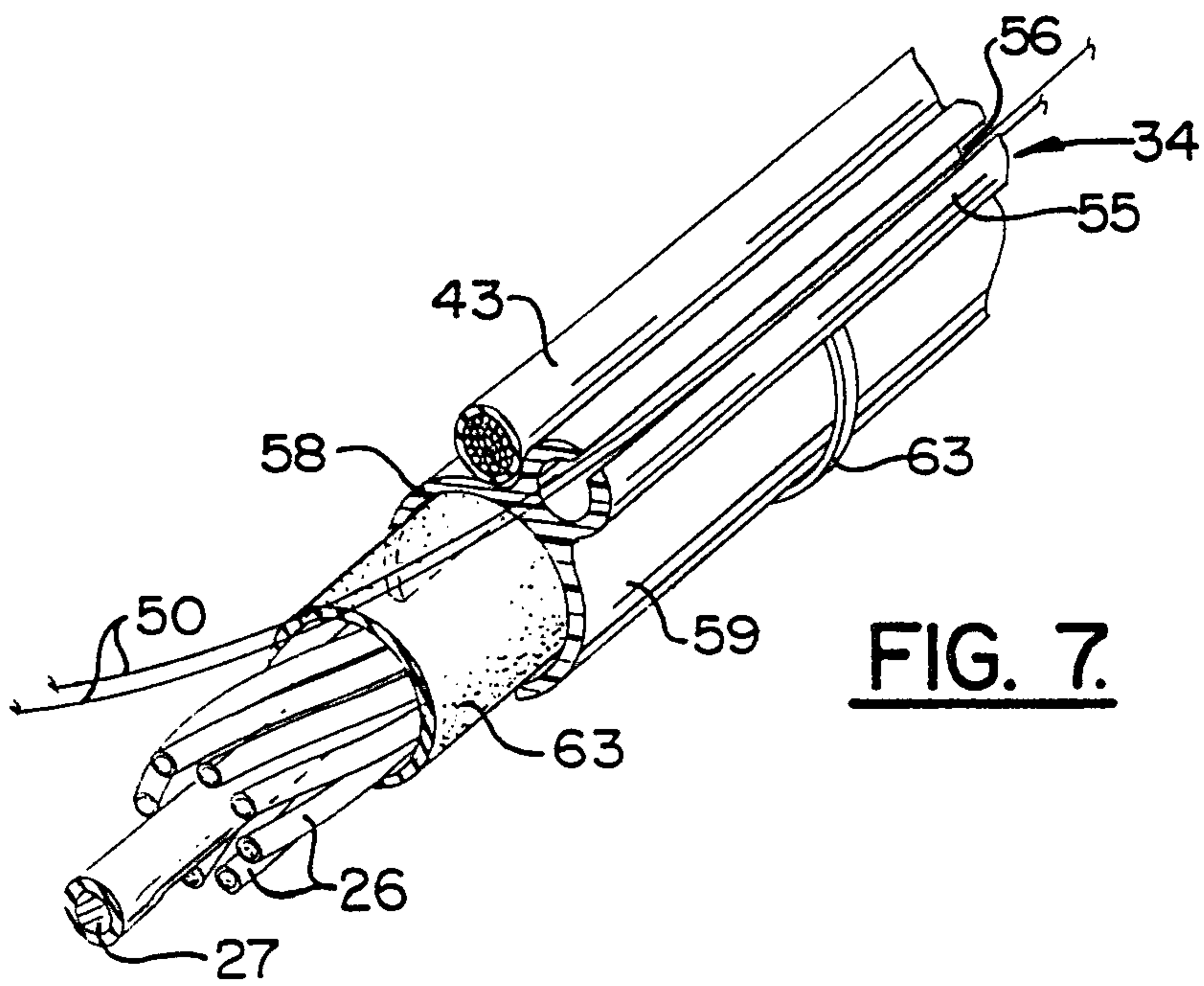


FIG. 7.

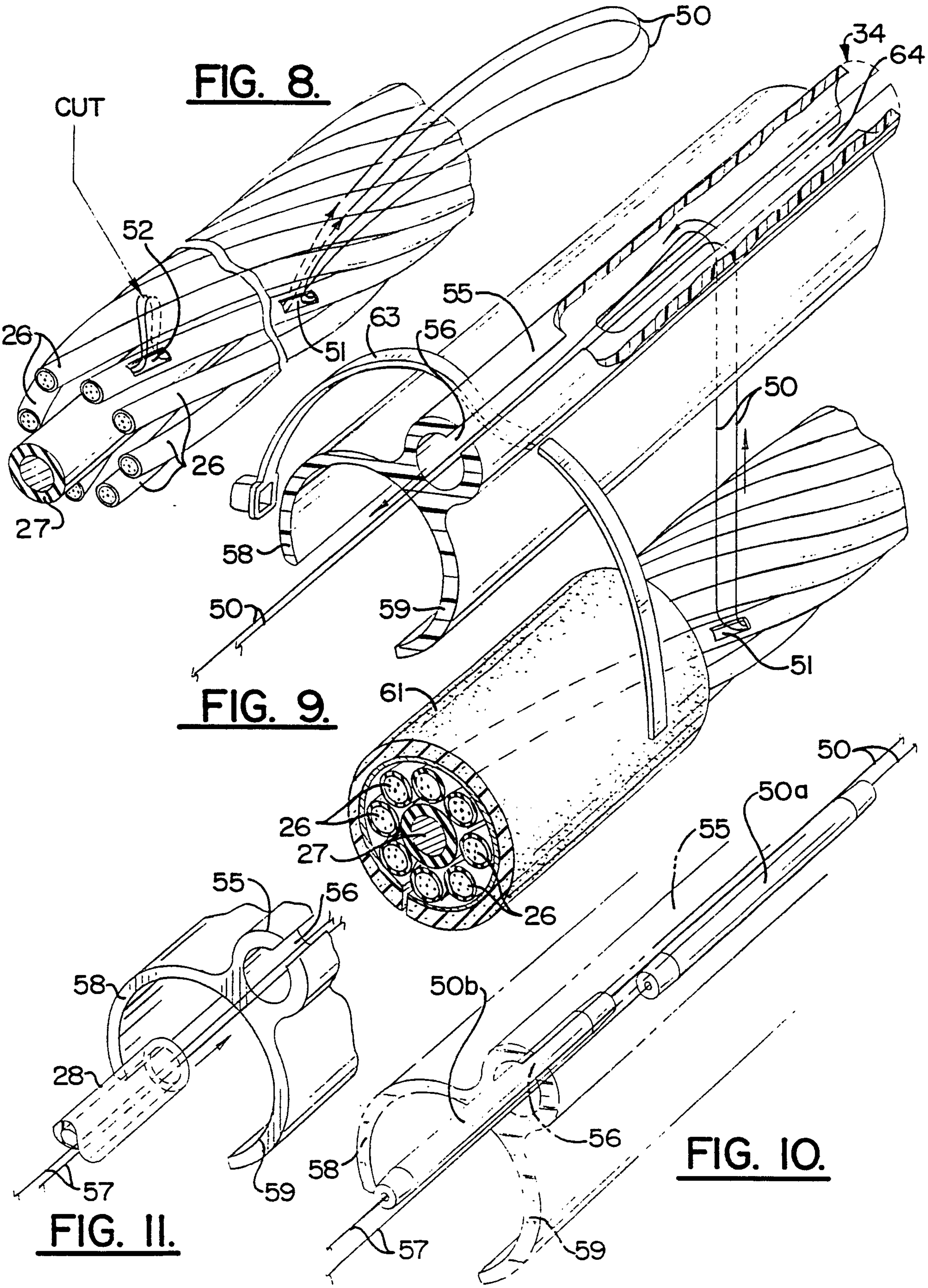


FIG. 8.

FIG. 9.

FIG. 10.

FIG. 11.

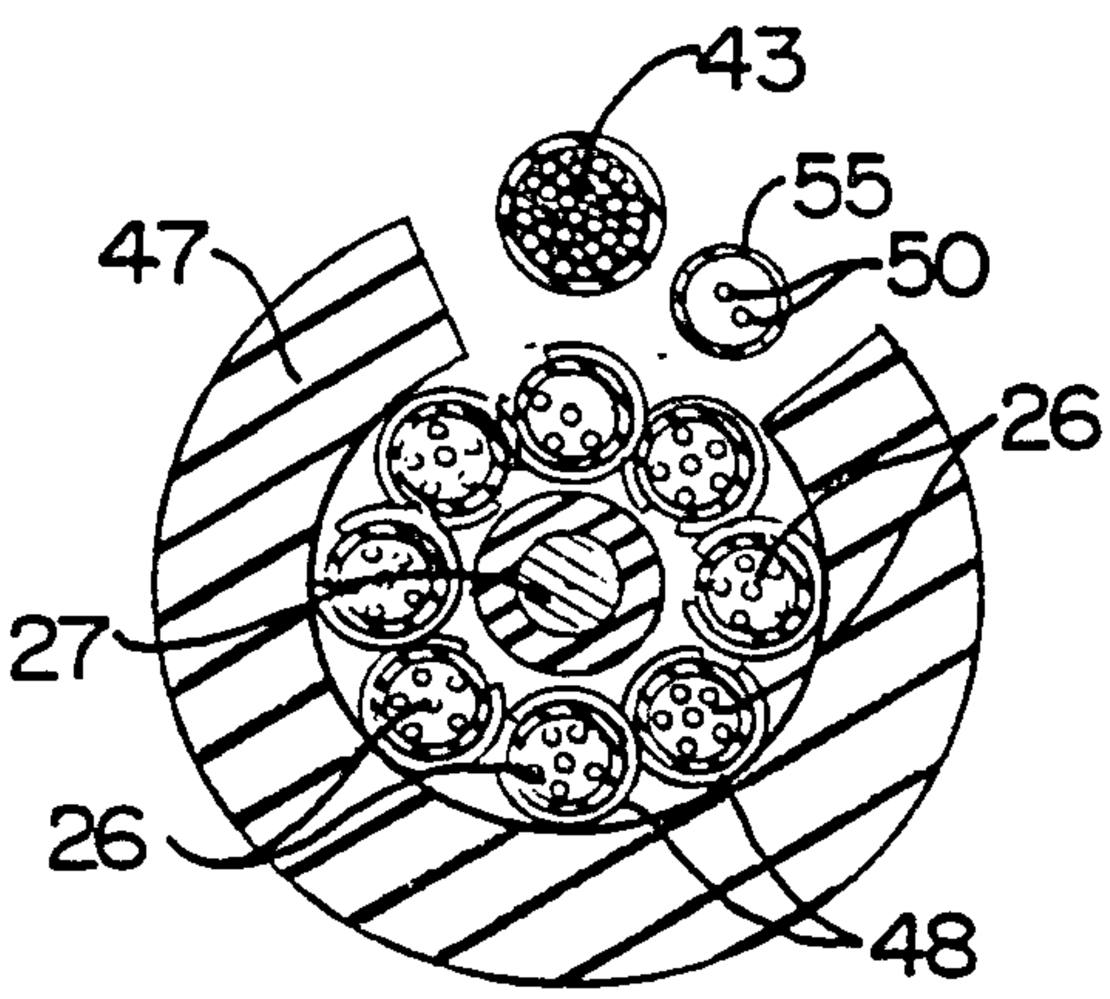


FIG. 12.

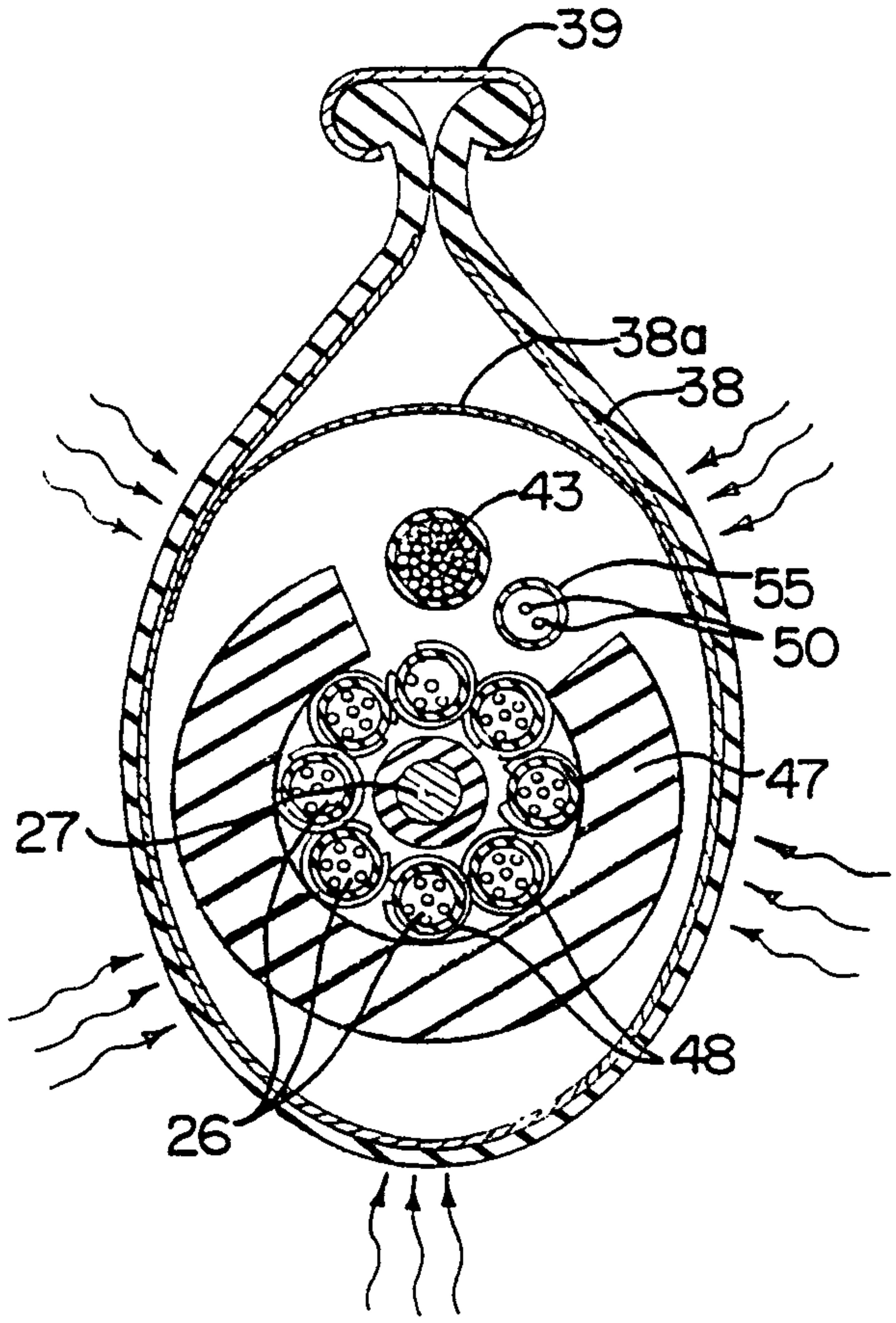


FIG. 13.

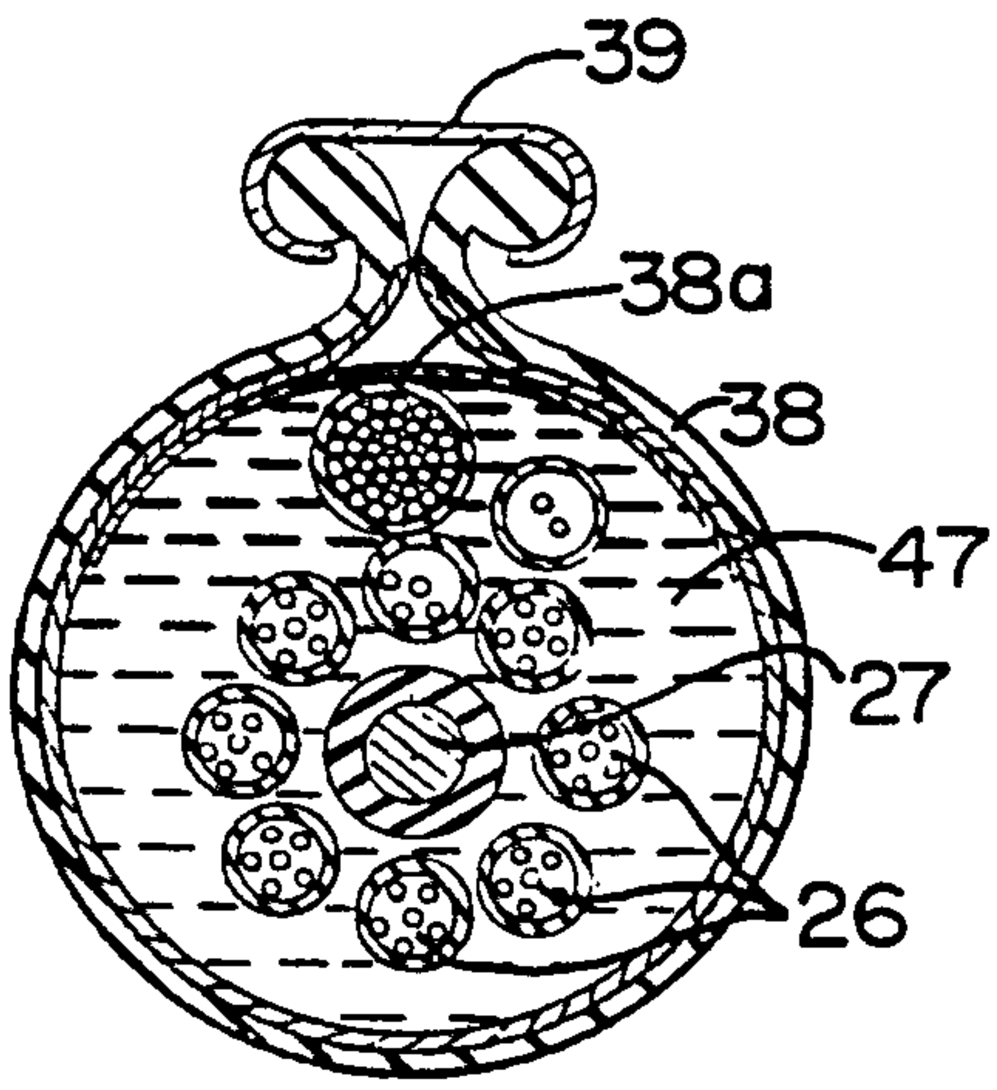


FIG. 14.

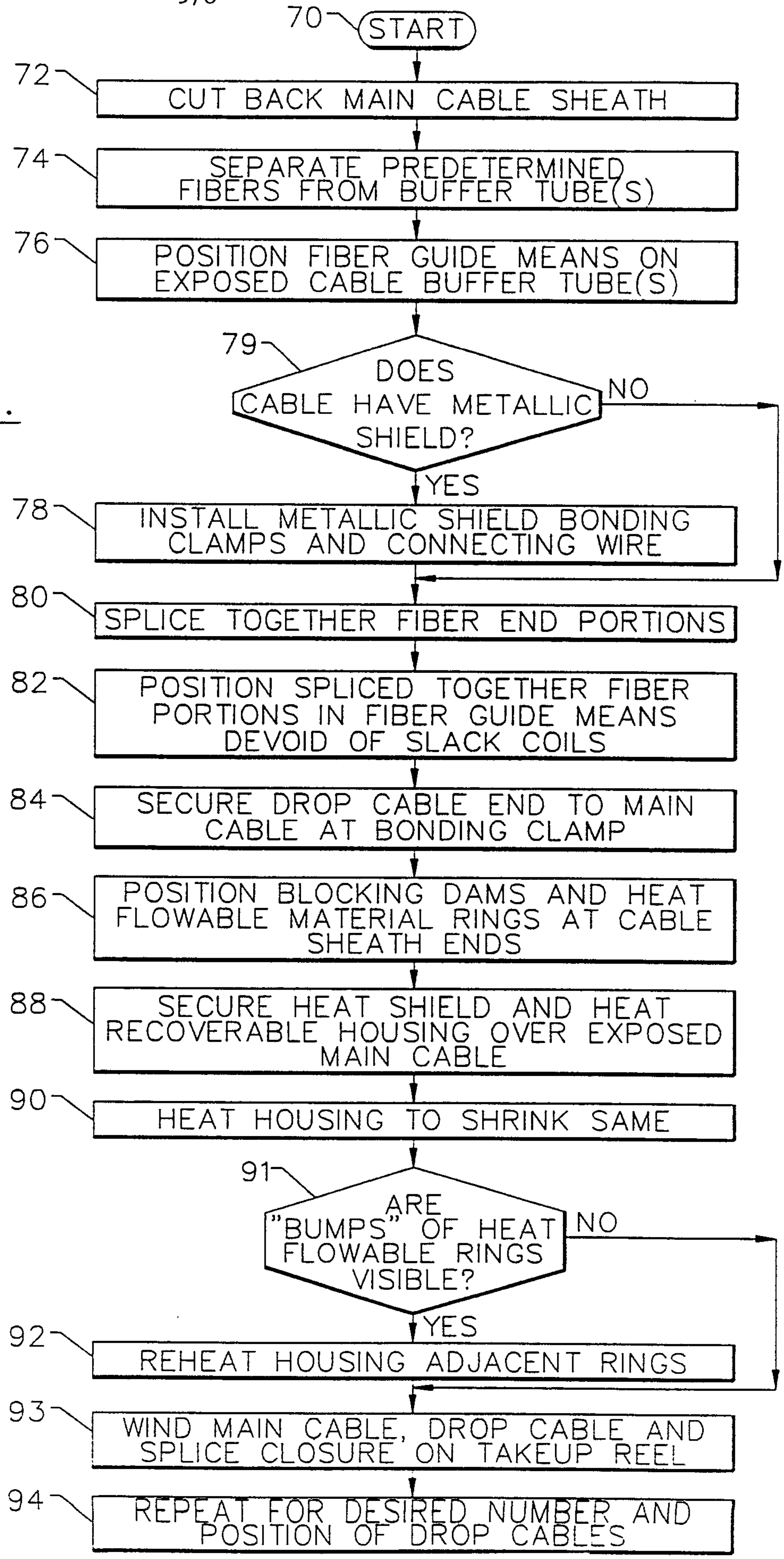

70 START
72 CUT BACK MAIN CABLE SHEATH
74 SEPARATE PREDETERMINED FIBERS FROM BUFFER TUBE(S)
76 POSITION FIBER GUIDE MEANS ON EXPOSED CABLE BUFFER TUBE(S)
79 DOES CABLE HAVE METALLIC SHIELD?
NO
YES
78 INSTALL METALLIC SHIELD BONDING CLAMPS AND CONNECTING WIRE
80 SPLICE TOGETHER FIBER END PORTIONS
82 POSITION SPLICED TOGETHER FIBER PORTIONS IN FIBER GUIDE MEANS DEVOID OF SLACK COILS
84 SECURE DROP CABLE END TO MAIN CABLE AT BONDING CLAMP
86 POSITION BLOCKING DAMS AND HEAT FLOWABLE MATERIAL RINGS AT CABLE SHEATH ENDS
88 SECURE HEAT SHIELD AND HEAT RECOVERABLE HOUSING OVER EXPOSED MAIN CABLE
90 HEAT HOUSING TO SHRINK SAME
91 ARE "BUMPS" OF HEAT FLOWABLE RINGS VISIBLE?
NO
YES
92 REHEAT HOUSING ADJACENT RINGS
93 WIND MAIN CABLE, DROP CABLE AND SPLICE CLOSURE ON TAKEUP REEL
94 REPEAT FOR DESIRED NUMBER AND POSITION OF DROP CABLES

FIG. 15.

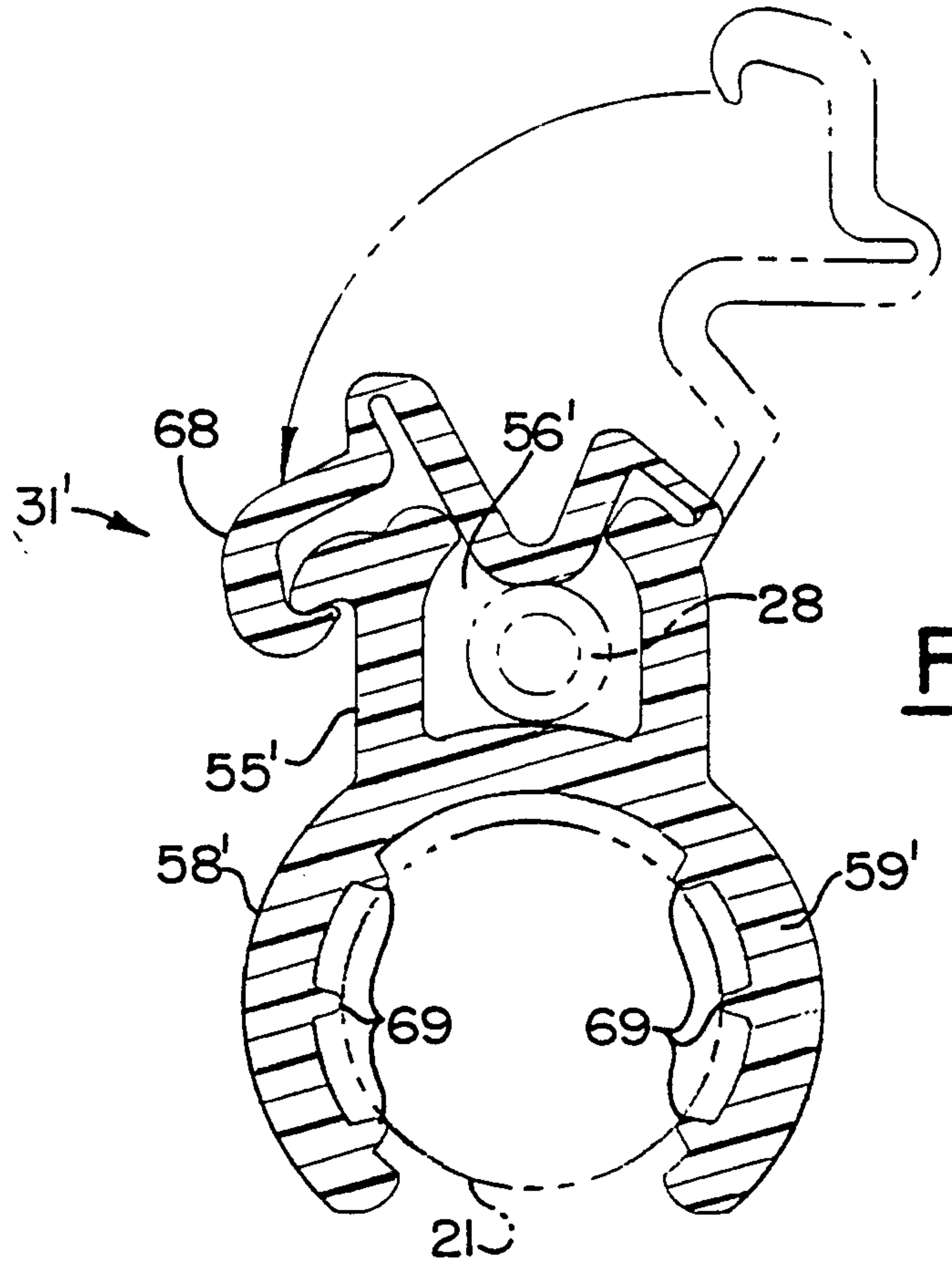


FIG. 16.

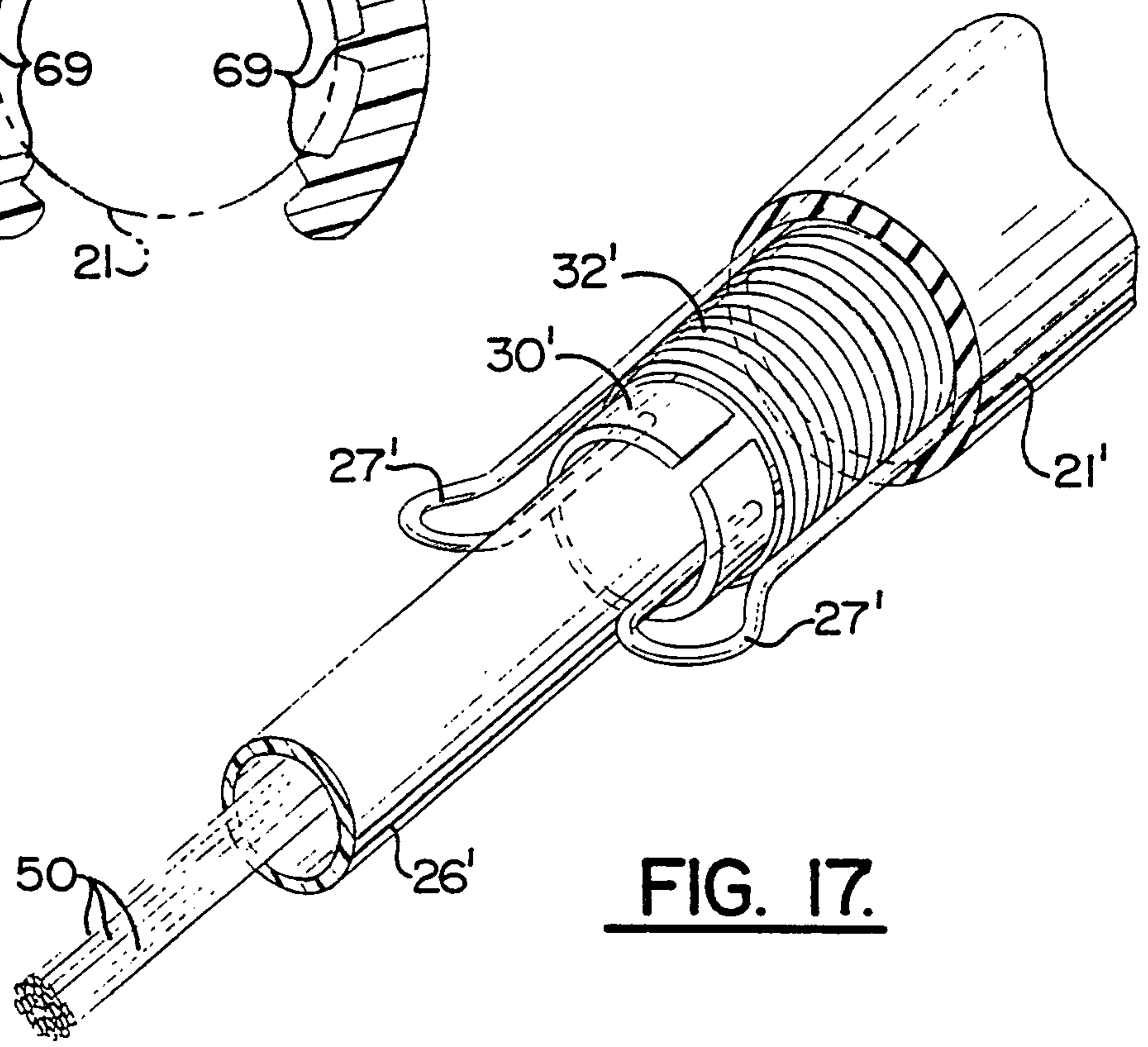


FIG. 17.

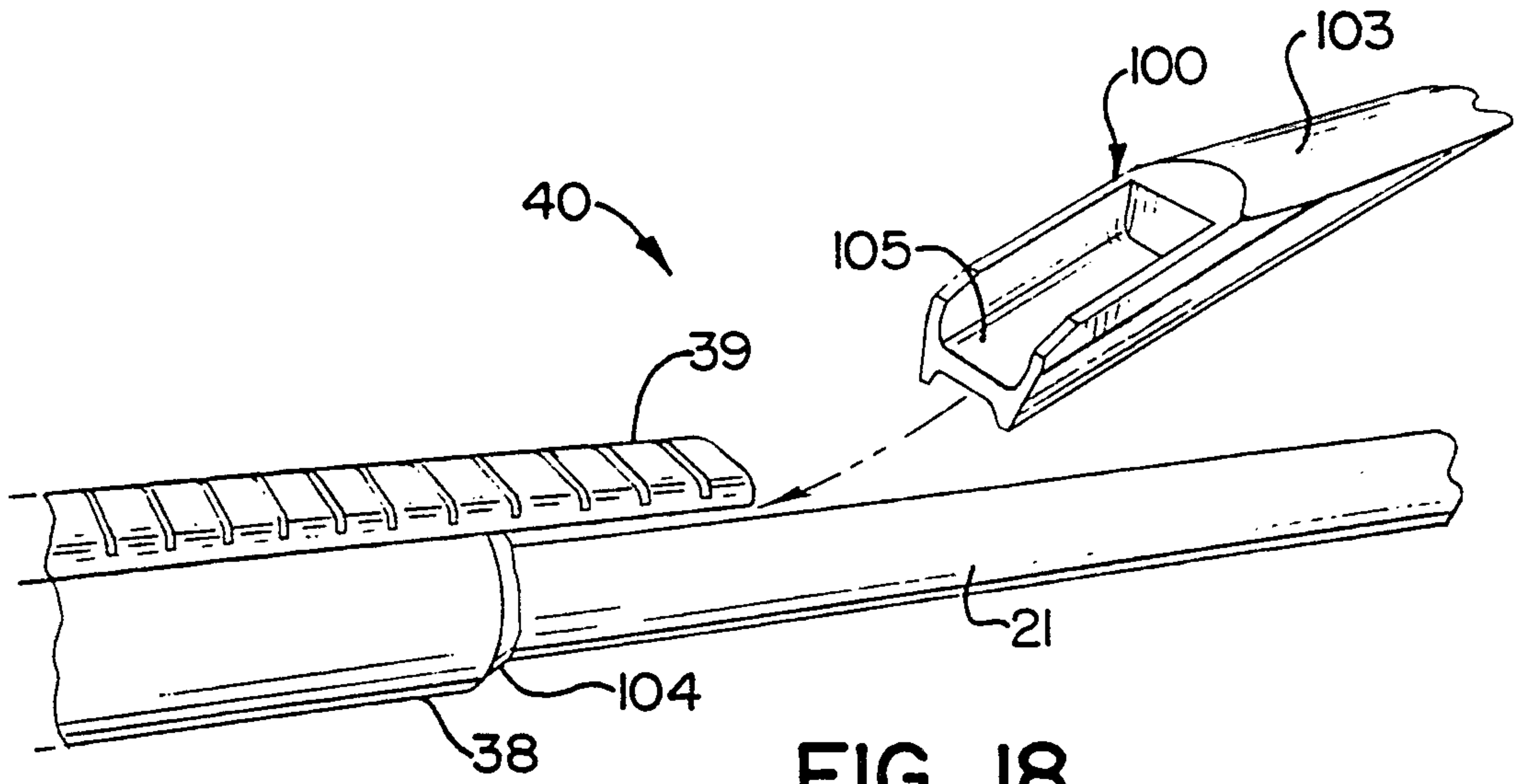


FIG. 18.

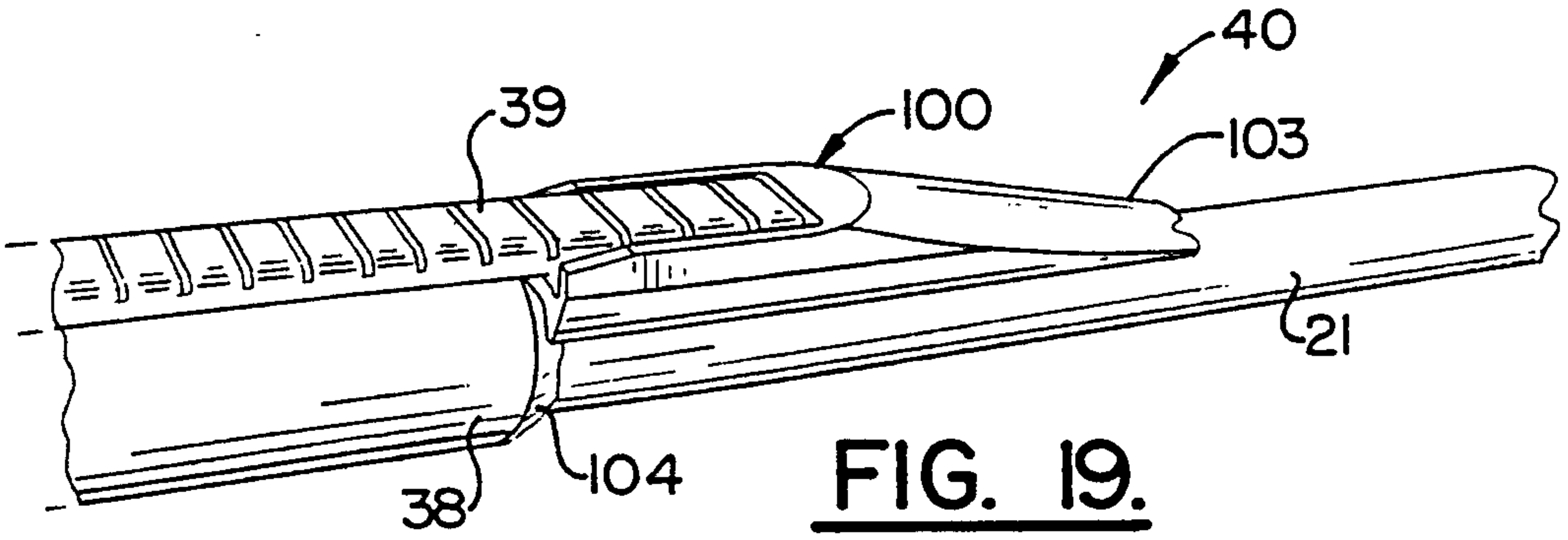


FIG. 19.

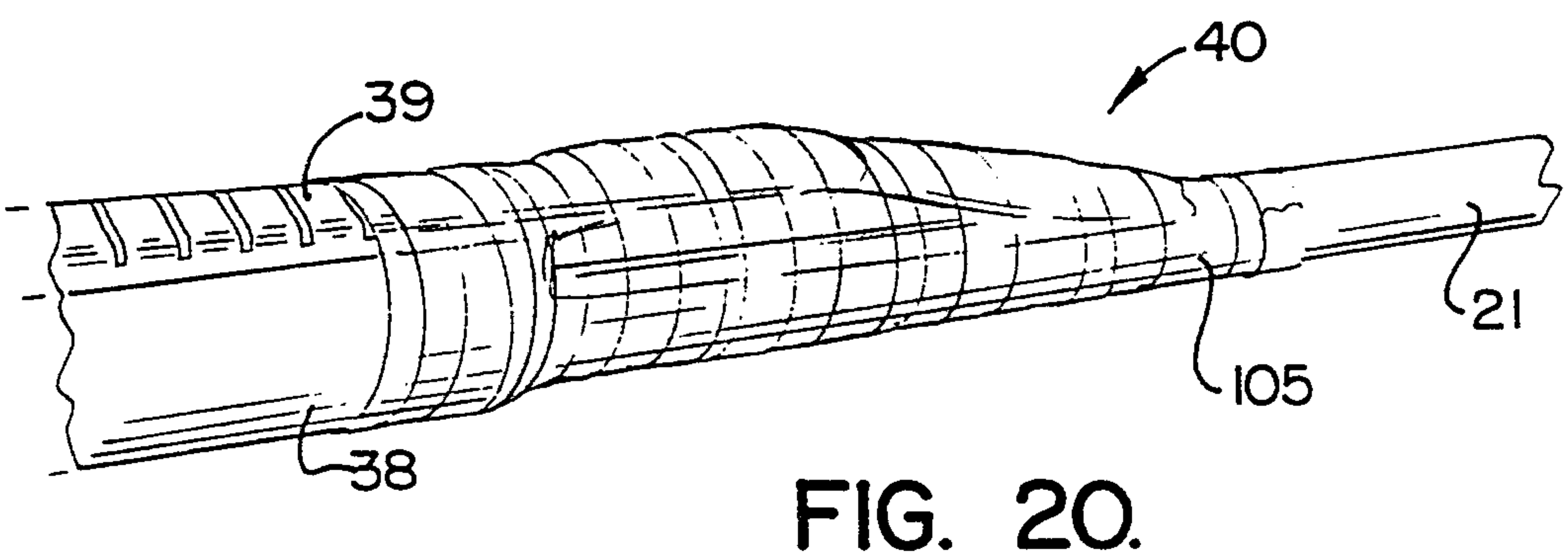


FIG. 20.

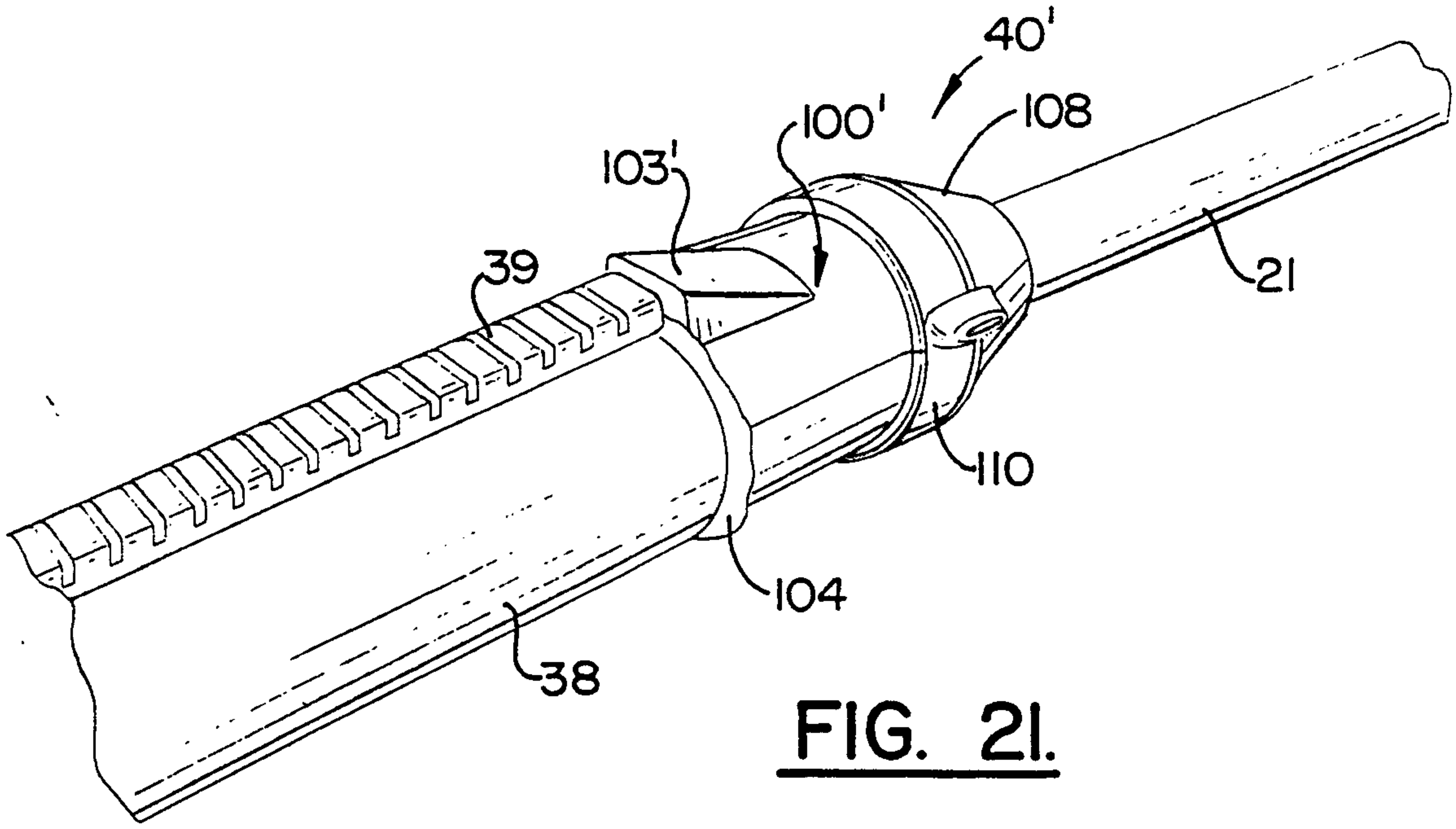


FIG. 21.

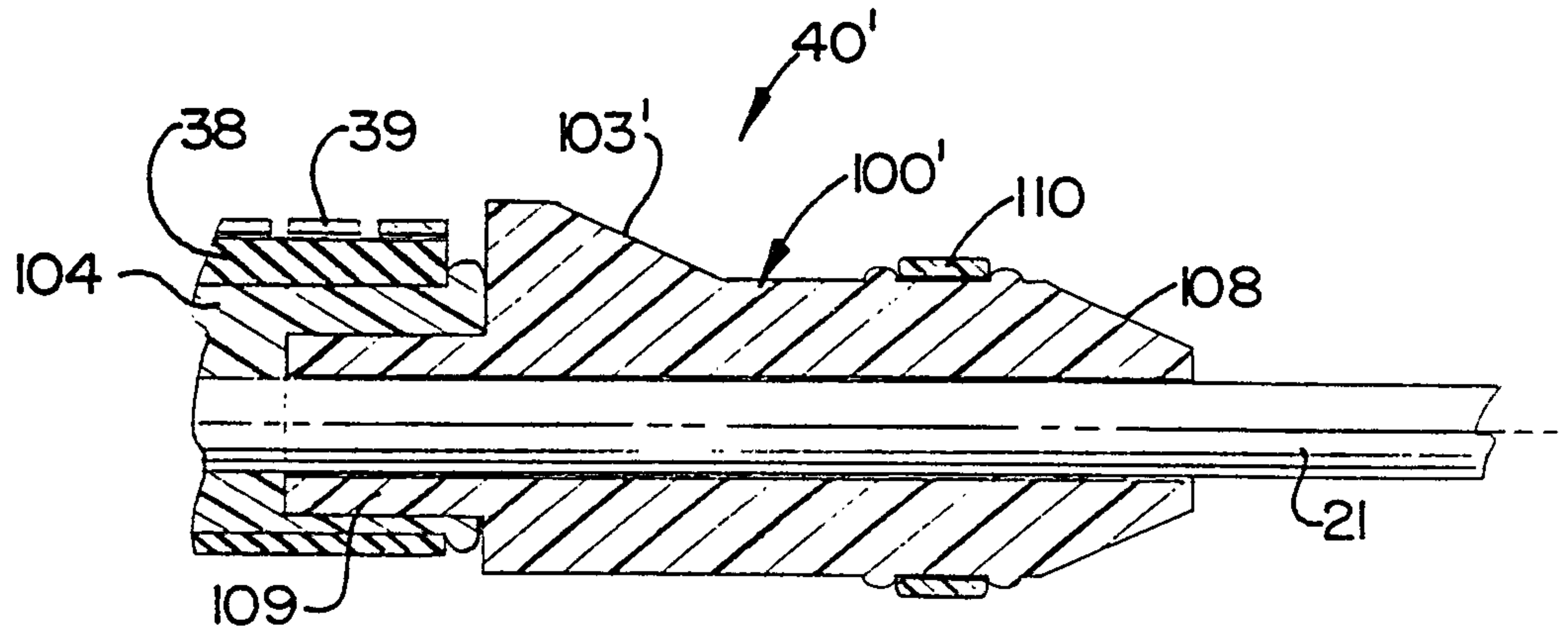
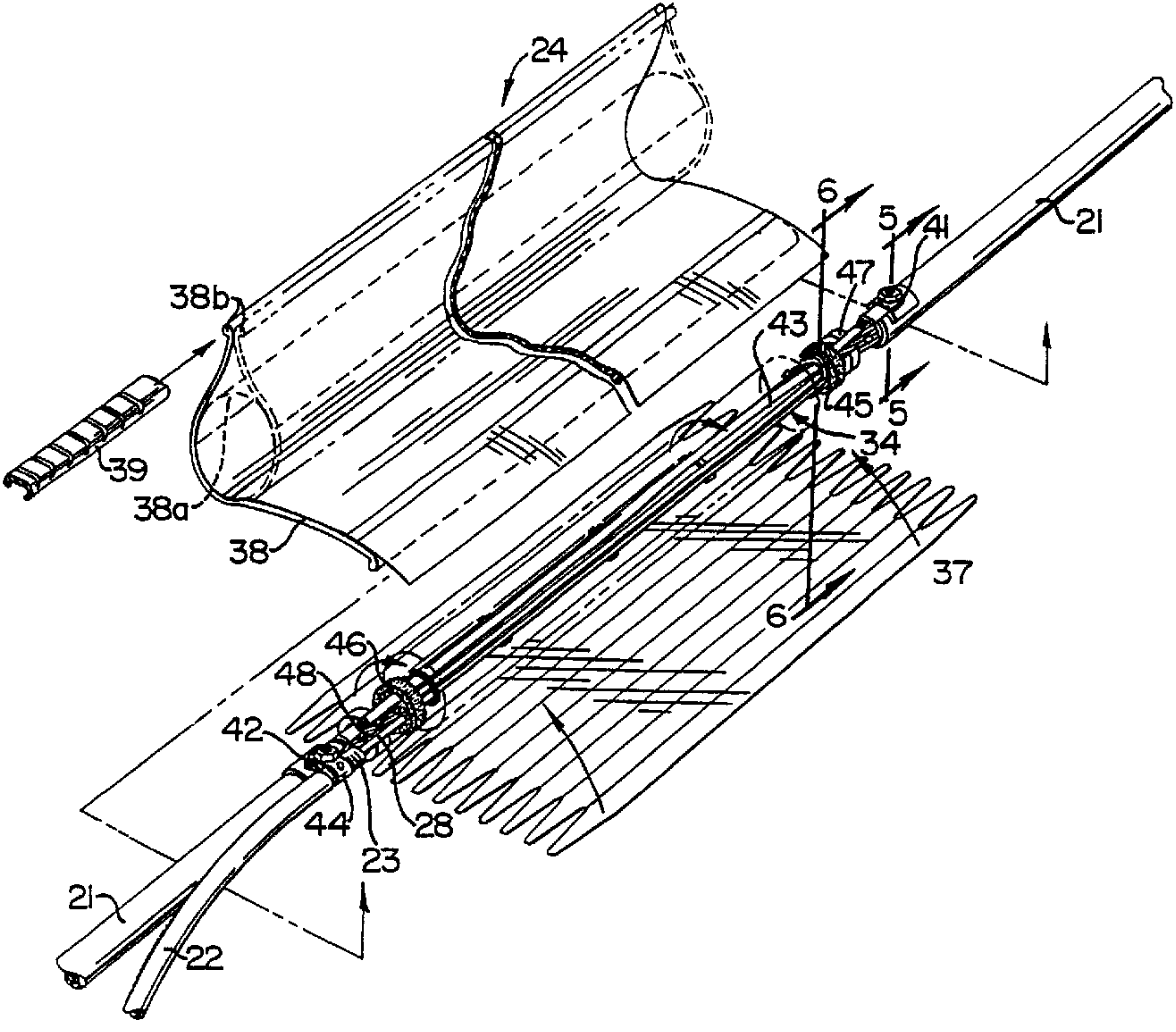


FIG. 22.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