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TERMINATION CLAMP ASSEMBLY FOR A HYBRID

ELECTRICAL/FIBER OPTIC CABLE

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) JAMES J. KASSAL, employee of the United States Government, and (2) RICHARD W. RANLET, citizens of the United States of America, residents (1) North Kingstown, County of Washington, State of Rhode Island and (2) North Kingstown, County of Washington, State of Rhode Island, have invented certain new and useful improvements entitles as set forth above of which the following is a specification:

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TERMINATION CLAMP ASSEMBLY FOR A HYBRID ELECTRICAL/FIBER OPTIC CABLE

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for Governmental purposes without the payment of any royalties thereon or therefore.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to fiber optic cable equipment and, more particularly, to cable terminations for hybrid electrical/fiber optic cables.

2. Description of the Prior Art

In typical applications where optical fibers are used, these fibers are combined with standard electrical wires to create hybrid electrical/fiber optic cables. These hybrid cables provide the optical fibers with the benefit of the electrical wires' relatively greater strength, and provide the further advantage that multiple wires are combined into a single, easily handled cable, thus requiring, e.g., fewer cable

penetrations through the walls of a building, fewer wire hangers, and fewer man-hours to run the wires throughout the installation site. In the typical installation, the optical fibers are encased within a flexible, stainless steel "k-tube" which provides further support and protection to the fragile fibers. This k-tube is then encased with the electrical wires inside the hybrid cable.

When it is necessary, however, to terminate the hybrid cable, e.g., at a connection, the optical fibers must be separated from each other and from the electrical wires. A termination apparatus is required to "fan out" the optical fibers from the cable. Terminations of this type of hybrid cable typically include a transition where the optical fiber(s) exit the k-tube and enter protective plastic tube(s); the fibers must "fan out" from the k-tube. In previous terminations, this transition (or fan out) was accomplished by means of heat-shrink tubing and adhesive and the transition was potted with polyurethane in a connector shell.

The development of this invention was prompted by a series of failures wherein one or more optical fibers broke within a hybrid cable termination/connector. The breakage occurred during routine handling of the cable and was caused by movement of the end of the k-tube within the connector. The use of heat shrink tubing and adhesive and potting the termination inside

the connector proved inadequate to stabilize the k-tube, which pushed through the potting, thereby causing the optical fibers to break. Before the present invention, there was no effective way to immobilize the k-tube and control the fan out in these hybrid cable terminations.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a simple and convenient means to terminate a hybrid electrical/fiber optic cable at a connector while further providing a secure and robust transition of the optical fibers from within a k-tube to individual protective plastic tubes.

It is therefore a further object of the present invention to provide a convenient means to manage the electrical wires and support the cable clamp assembly during the process of installing the connector.

The present invention provides a simple and convenient means to terminate a hybrid electrical/fiber optic cable at a connector while further providing a secure and robust transition of the optical fibers from within a k-tube to individual protective plastic tubes. The end of the k-tube is held firmly in place within the connector and is thereby prevented from damaging or breaking the fragile optical fibers.

Specifically, the k-tube is prevented from damaging or breaking the optical fibers by creating a swage lock on the k-tube between two halves of a clamp assembly. This swage lock prevents the k-tube from moving relative to the optical fibers that emerge from within the k-tube. A fan out chamber is located in the interior of the clamp assembly to allow the optical fibers to fan out from the k-tube. A protective plastic tube is placed over each individual optical fiber as it exits the clamp assembly. The plastic tubes are held in place as they exit the clamp assembly by swage locks created in a similar manner as for the k-tube. The swage locks are accomplished by placing the k-tube and plastic tubes within relatively shallow grooves in the mating surfaces of one or both of the half bodies of the clamp assembly and joining the halves together, thereby slightly compressing the k-tube and plastic tubes within their respective grooves.

A least one of the clamp assembly halves has one or more longitudinal passages through which the electrical wires of the hybrid cable can pass. An advantage of this feature of the invention is that the electrical wires passing through the passages can support the clamp assembly halves while the k-tube and optical fibers are being positioned in the clamp assembly and while the clamp assembly halves are being joined.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the present invention will become better understood with regard to the following description, appended claims and accompanying drawings where:

FIG. 1 depicts an isometric view of the assembled termination clamp assembly of the present invention;

FIG. 2 depicts an alternate isometric view of the assembled termination clamp assembly of the present invention;

FIG. 3 depicts a plan view of a first clamp body half of the present invention;

FIG. 4 depicts an end view of the first clamp body half of the present invention with the view taken from reference line 4-4 of FIG. 3;

FIG. 5 depicts a plan view of a second clamp body half of the present invention;

FIG. 6 depicts an end view of the second clamp body half with the view take from reference line 6-6 of FIG. 5 of the present invention; and

FIG. 7 depicts a plan view of the first clamp body half of the present invention with a k-tube, optical fibers, and plastic tubes in position during assembly of the termination clamp assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1 - 5 depict the preferred embodiment of the invention, which is a cable termination clamp assembly **10** for use with a hybrid cable comprising one k-tube with two optical fibers and a plurality of electrical wires (not shown). In the preferred embodiment of the invention, the clamp assembly **10** is proportioned so that its length is nearly equal to its width. It will be apparent from the following description that the present invention may be modified for use with hybrid cables comprising more than one k-tube and any number of optical fibers and electrical wires.

The clamp assembly **10** comprises two clamp body halves **12** and **14** having mating surfaces **16** and **18**, respectively (see FIGS. 3 and 5). Referring to FIG. 3, the k-tube **100** (not shown in this figure for clarity and for depiction of structure of the clamp) is positioned in a preferably semi-cylindrical k-tube groove **20** of the clamp body half **12** so that the end of the k-tube **100** is within the guide mark region **22**. The guide mark region **22** provides a visual indication to the assembler that the k-tube **100** is properly positioned in the k-tube groove **20**. The guide mark region **22** can be etched or otherwise cut or molded into the surface of clamp body half **12**, as shown in FIGS. 3 and 5, or it can be marked with ink, paint or equivalent marking means.

As shown in FIG. 5, the clamp body half **14** has a k-tube groove **20** and guide mark region **22** similar to those on the clamp body half **12**. When the clamp body half **12** is positioned over clamp body half **14** and the clamp body halves are joined together, the k-tube **100** is captured within the assembly. This capture occurs because the diameter of a k-tube channel **24** formed by k-tube grooves **20** of the two clamp body halves **12** and **14**, is slightly smaller than the outside diameter of the k-tube **100** (See FIG. 1). In typical use, the diameter of each of the k-tube grooves **20** is 4% to 5% smaller than the diameter of the k-tube **100**. Joining the clamp body halves **12** and **14** together creates a swage lock of the clamp assembly **10** onto the k-tube **100**. Four (4) screws **26** or similar mechanical fasteners are used to fasten the clamp body halves **12** and **14** together. Laboratory tests have demonstrated that the resulting swage lock will sustain a linear force during typical operations.

As shown in FIG. 7, two optical fibers **200** emerge from the end of the k-tube **100** within a fan out cavity **28**. These fibers are routed through individual protective plastic tubes **220** which are placed in separate, preferably semi-cylindrical, fiber grooves **30** in the clamp body halves **12** and **14**. The fiber grooves **30** capture the plastic tubes **220** in a swage lock during assembly in the same way that the k-tube **100** is captured by the k-tube grooves **20** when clamp body halves **12** and **14** are joined.

Preferably, the fiber grooves **30** are sized so that the swage lock is tight enough to prevent the plastic tubes **220** from moving while still allowing the optical fibers **200** to move within the plastic tubes **220**. FIG. 2 shows the cylindrical fiber channels **32** formed by the fiber grooves **30** that capture the individual plastic tubes **220**.

Referring again to FIGS. 3, 5 and 7, each clamp body half **12** and **14** has a fan out cavity **28** disposed within the center of its respective mating surface **16** and **18**. These fan out cavities **28** are configured so that they form a fan out chamber (not shown) when the clamp body halves **12** and **14** are fastened together. Bumpers **34** are located on the interior wall of each fan out cavity **28** near the end where the fiber grooves **30** are located. The bumpers **34** provide the user with a tactile means to verify that the plastic tubes **220** are properly and fully positioned within the clamp assembly **10**. They also prevent the plastic tubes **220** from protruding into the fan out cavity **28** where the optical fibers **200** fan out from the end of the k-tube **100** to the plastic tubes **220**. During assembly, while the screws **26** are within a turn of being fully tightened, the protective plastic tubes **220** are loosely positioned within the channels **32** formed by the fiber grooves **30**. This feature allows the assembler to move the plastic tubes **220** within the channels **32** and feel when they hit the bumper **34**.

Threaded holes **40** are provided in clamp body half **14** and clearance holes **42** are provided in clamp body half **12**. The holes **40** and **42** are sized to receive the screws **26** to thereby fasten the two clamp body halves **12** and **14** together. As shown in FIGS. 3 and 5, the clearance holes **42** and the threaded holes **40** are located along the edges of the clamp body halves **14** and **12** near where the k-tube **100** is positioned. This location of the holes ensures maximum clamping force of the clamp body halves **12** and **14** onto the k-tube **100** when the screws **26** are tightened into the holes.

As shown in FIGS. 4 and 6, a plurality of longitudinal wire passages **46** provides passage for the electrical wires (not shown) of the hybrid cable. During assembly of the present invention, the clamp body halves **12** and **14** are slid onto the electrical wires, which then act together as an assembly aid by supporting the clamp body halves **12** and **14** while the k-tube **100** and plastic tubes **220** are positioned properly into their respective grooves **20** and **30**.

An advantageous feature of the preferred embodiment is its ability to prevent a viscous liquid such as a potting material from entering the fan out cavity **28** and contacting the exposed optical fibers **200**. The compression fit of the clamp assembly **10** around both the k-tube **100** and the plastic tubes **220** is sufficient to prevent a viscous fluid from penetrating into the

fan out cavity **28** along either the k-tube grooves **20** or the fiber grooves **30**. When the clamp body halves **12** and **14** are tightly joined together, the flat mating surfaces **16** and **18** also form a mechanical seal that is sufficient to prevent viscous fluids from entering the fan out cavity **28**. This seal is advantageous because it allows the cable clamp assembly **10**, the k-tube **100** and electrical wires, to be "potted" within a cable grip using polyurethane or epoxy resin. This potting, when adhered to both the cable grip and the clamp assembly, immobilizes the assembly and, therefore, also the captured k-tube **100**.

In practice, the preferred method of assembling and using the present invention at the termination of a hybrid electrical/fiber optic cable begins with separating the k-tube **100** from the electrical wires in the cable. One or more of the electrical wires are passed through the wire passage(s) **46** in clamp body half **12** and at least one other electrical wire is passed through a wire passage **46** in clamp body half **14**. The electrical wires can then support the clamp body halves **12** and **14** during the remainder of the clamp assembly process.

The k-tube **100** is trimmed back so that the ends of the optical fibers **200** protrude from the end of the k-tube. The k-tube **100** is then placed in the k-tube groove **20** of clamp body half **12** so that the end of the k-tube is adjacent to the guide

mark region **22** on the mating surface **16** of clamp body half **12**. A protective plastic tube **220** is slid over the portion of each of the optical fibers **200** that is outside of the k-tube **100**. Each of the plastic tubes is then placed within a fiber groove **30** in the clamp body half **12**.

At this point, the clamp body half **14** is positioned over the clamp body half **12** so that the mating surfaces **16** and **18** of the clamp body halves **12** and **14** are flush against each other in parallel contact, the k-tube **100** is inside k-tube groove **20** of clamp body half **14**, and each of the plastic tubes **220** is inside one of the fiber grooves **30** in clamp body half **14**. The screws **26** are inserted into clearance holes **42** and partially screwed into threaded holes **46** to hold the mating surfaces **16** and **18** in close proximity to each other and to loosely clamp the k-tube **100** and plastic tubes **220** in place, yet allow the plastic tubes **220** to be manually moved longitudinally (i.e., along the length of the fiber groove **30**) within the fiber grooves **30** by the assembler.

After the screws **26** are partially screwed into the threaded holes **46** as described above, each plastic tube **220** is moved longitudinally until the assembler feels the end of the plastic tube touch one of the bumpers **34** in the fan out chamber **28**. This indicates to the assembler that the plastic tube **220** is fully inserted into the clamp assembly. When all of the plastic

tubes **220** are so positioned, the screws **26** are further tightened as necessary to create a firm swage lock of the clamp body halves **12** and **14** onto the k-tube **100** and plastic tubes **220**. The resultant cable clamp assembly **10**, and the k-tube 100, optical fibers (in their protective plastic tubes) and electrical wires, are now ready to be potted within a cable grip using polyurethane, epoxy resin, or other viscous potting compound.

In one alternative embodiment of the invention, only one of the clamp body halves **12** and **14** has the fiber grooves **30**. In this embodiment, the fiber grooves **30** in the second clamp body half will necessarily be deeper to accommodate nearly the entire diameter of the plastic tubes **220**, yet remain small enough to provide the swage lock required to hold the plastic tubes **220** in place.

In yet another alternative embodiment of the invention, one of the clamp body halves **12** and **14** has only a flat mating surface, without a k-tube groove, fiber grooves, or a fan out cavity. In that embodiment, the second clamp body half will necessarily have a deeper k-tube groove to accommodate nearly the entire diameter of the k-tube **100** and deeper fiber grooves to accommodate nearly the entire diameter of the plastic tubes **220**. Again, the grooves will still have to be small enough to provide the swage lock required to hold the k-tube **100** and plastic tubes **220** in place.

While the above discussion describes the preferred embodiment of the invention and some alternative embodiments, it should be understood that they have been presented by way of example and not limitation. It will become apparent to those skilled in the art that equivalent alternative embodiments and alternative methods are possible. It is intended that all such alternative embodiments and methods shall be covered by the claims set forth herein.

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TERMINATION CLAMP ASSEMBLY FOR A HYBRID ELECTRICAL/FIBER OPTIC CABLE

ABSTRACT OF THE DISCLOSURE

A device for terminating a hybrid electrical/fiber optic cable at a connector comprising a clamp assembly affecting a swage lock on a k-tube to prevent movement of the k-tube within the connector and resultant damage to the optical fibers. The clamp assembly comprises two clamp halves, at least one of which includes a k-tube groove, one or more optical fiber grooves, a fan out cavity, and means for joining the clamp halves. When the clamp halves are joined, the k-tube grooves form an enclosed k-tube channel that is slightly smaller than the outside diameter of the k-tube, thereby creating a swage lock to prevent movement of the k-tube. Similarly, the optical fiber grooves create a swage lock on protective plastic tubes that are placed over the optical fibers as they exit and fan out from the k-tube in the fan out cavity.

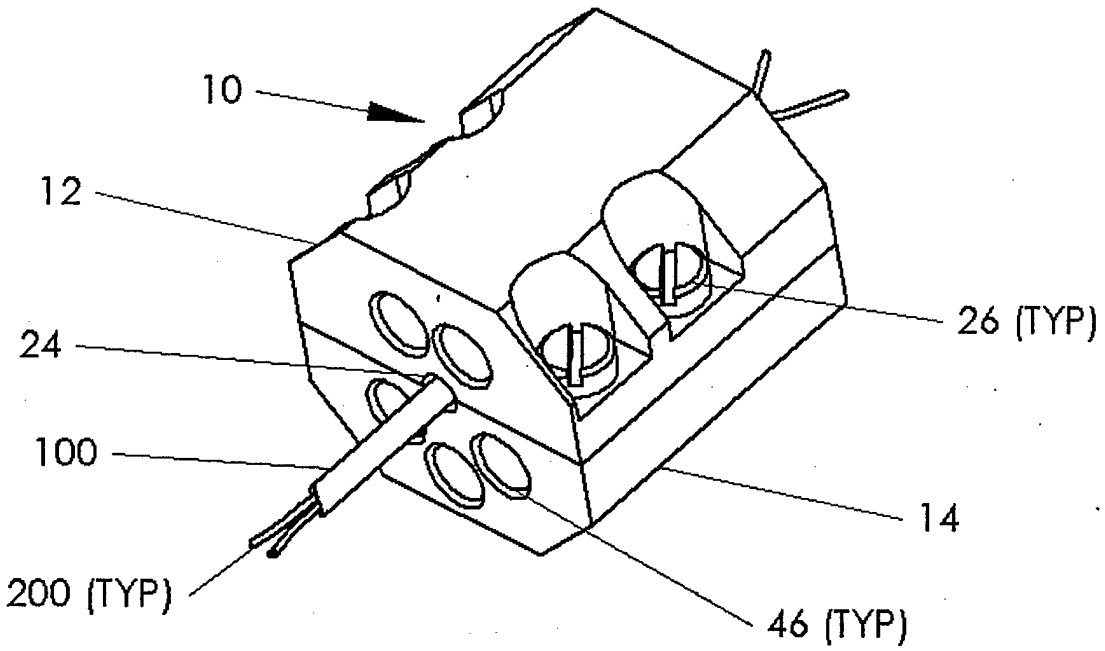

FIG. 1

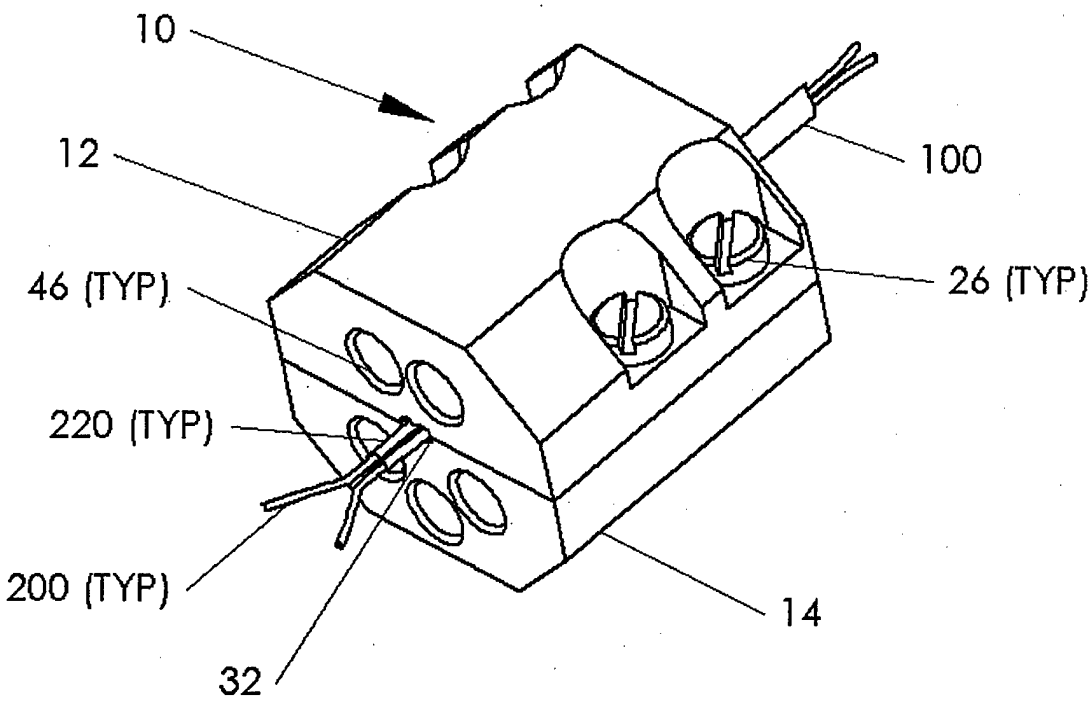

FIG. 2

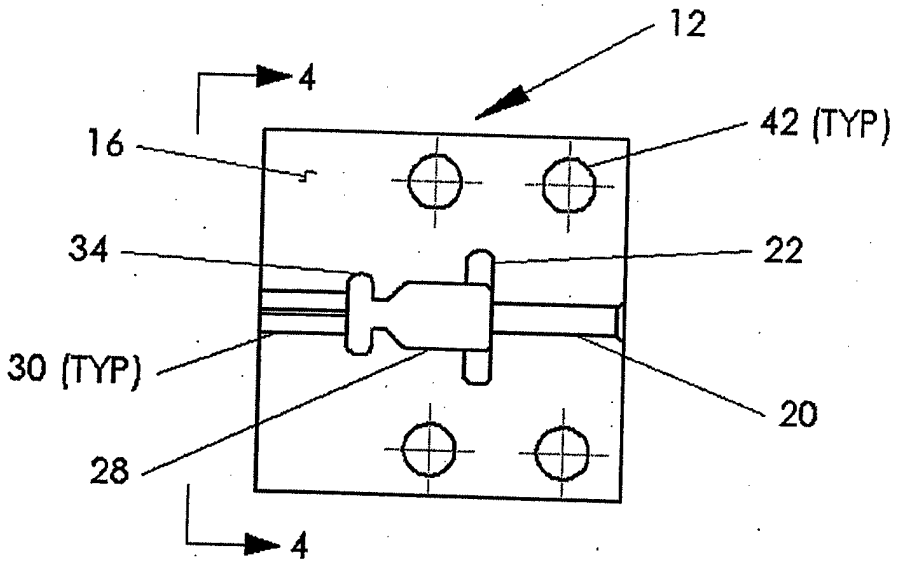

FIG. 3

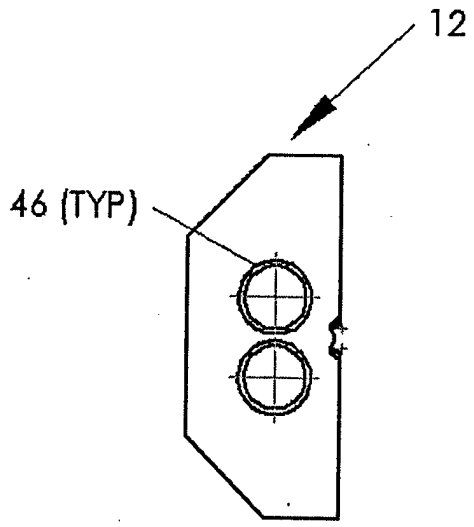

FIG. 4

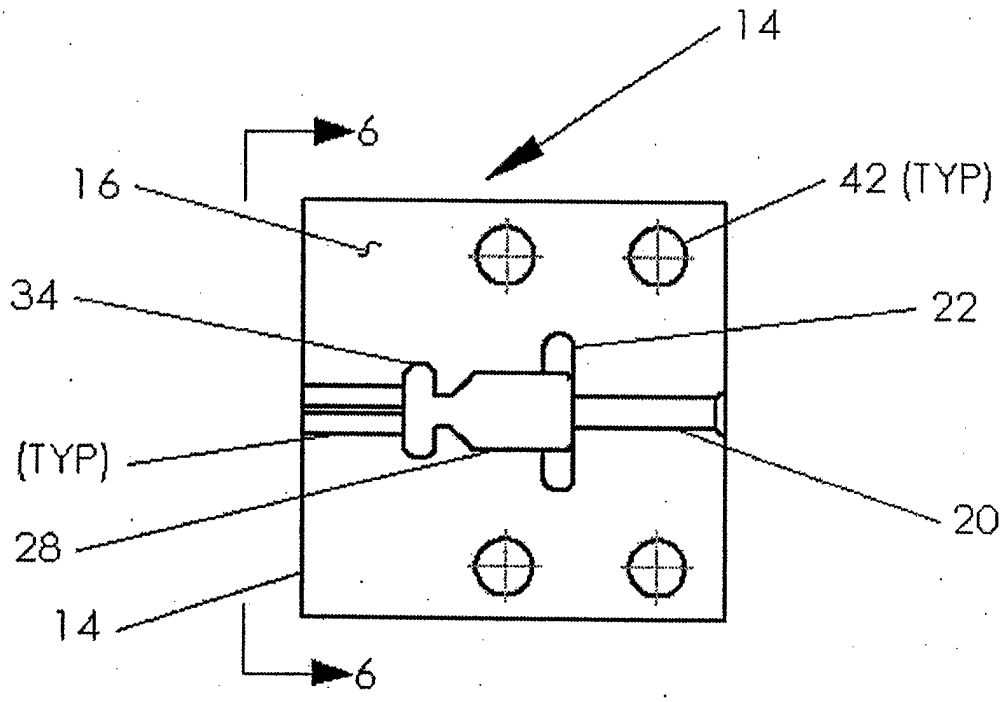

FIG. 5

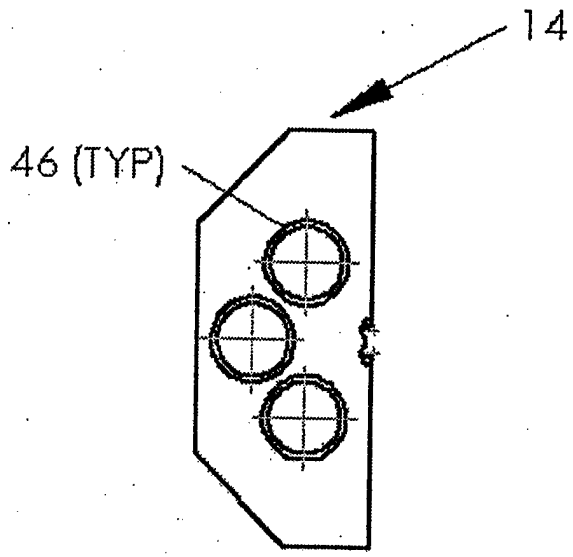

FIG. 6

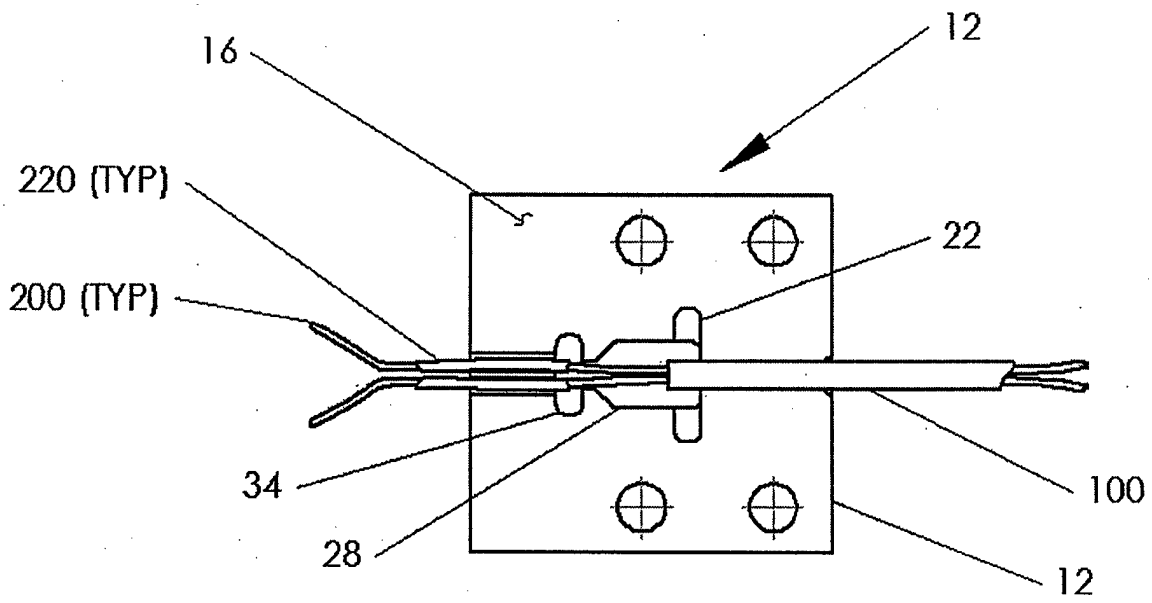

FIG. 7