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(54) CLOSURE DEVICE AND METHOD FOR ITS INSTALLATION

(71) We, RAYCHEM CORPORATION, a body corporate organised according to the laws of the State of California, United States of America, of 300 Constitution Drive, Menlo Park, California 94025, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a closure device including a heat-recoverable member, and to a method for installing such a device; such devices are occasionally referred to herein as heat-recoverable devices.

There are many instances where it is desirable to provide a protective and/or insulative closure on a substrate (such as an elongate conduit or pipe) which does not have an accessible end over which conventional tubing can be drawn. Consequently, it is necessary to provide a split closure which may be positioned around a continuous elongate object and then joined at the edges. Two examples of such split closures incorporating heat-recoverable material are disclosed in United States Patent Specifications Nos. 3,379,218 and 3,455,336, the disclosures of which are incorporated herein by reference.

Heat-recoverable closure members which can be positioned around a substrate and then joined at the edges generally require a relatively strong fastening means, or retaining device, for holding and abutting or overlapping edges of the closure member during the heat recovery, more particularly heat-shrinking, process. Such retaining devices are also used to insure the integrity of the closure after it has been finally assembled around the object. The use of

heat-recoverable material complicates the proper closure of such assemblies because of the inherently flexible nature of the heat-recoverable materials normally used in such applications. This flexible nature allows the closure member to be distorted under the high forces resulting from heat-recovery of the closure member about an enclosed object. Such distortion normally results in reduced resistance to extraction of the closure member from the retaining device. Such material is also liable to be cut when stressed over sharp objects such as the sharp edges frequently found in conventional retainers.

It is also important that heat-recoverable closure assemblies, of the type discussed in the preceding paragraph, provide a seal along the joint or joints to prevent the intrusion of *inter alia*, moisture. Thus, close tolerances between closure retainers and closure members are often required as well as relatively complicated shapes for both the closure members and the retaining devices. Such close tolerances and complicated shapes adversely affect the cost of manufacturing and assembling of the closure assemblies. Further, if close tolerances and careful assembly procedures are not adhered to, such closure assemblies may fail either during heat-recovery of the closure members or at some later period. Furthermore, the bulk of such assemblies can render them impractical for use with small diameter substrates.

The present invention provides a closure device which comprises a closure member comprising dimensionally heat-unstable material the closure member having two opposite edge regions that can be brought into abutting relationship with each other, and fastening means for receiving at least a part of the edge regions and maintaining

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them in abutting relationship during heat-recovery of the closure member, the edge regions and the fastening means being such that, before installation of the device and heat-recovery of the member the fastening means may be positioned over the abutting edge regions, the space defined by the fastening means having a shape or dimension that does not conform closely to that of the abutting edge regions and such that, during installation and heat-recovery, the dimensions of the fastening means and/or of the abutting edge regions are changeable to cause their shapes to conform more closely.

Advantageously each edge region comprises an outwardly extending wedge shaped ridge having one surface for abutting the corresponding surface of the other edge region. Preferably the angle of the wedge is about 45° so that each ridge also comprises first and second surfaces disposed at that angle to the surface for abutment.

Preferably the surfaces for abutment comprise means for reducing sliding between them. Such means may be, for example, interlocking or interengaging means. The surfaces of the recoverable members or of the fastening means or both may be provided with an adhesive or sealant.

The edge regions are advantageously dimensionally heat unstable and are preferably capable of increasing in thickness on the application of heat. Advantageously if they are already wedge shaped they will change to increase the angle of the wedge and if they are not already wedge shaped they will become so on application of heat, at least in those portions which will be in contact with the free ends of the fastening means.

Advantageously the edge regions are capable of forming ridges when they are heated while being maintained in abutting relationship.

Advantageously the fastening means comprises a central portion and two side portions, each side portion being such that it is deformable during installation to contact a surface of the ridge. In certain circumstances, the shapes of the fastening means and the edge regions may conform closely before installation and recovery, the fastening means being deformable to cause it to enclose the edge regions even more closely.

The closure member may comprise a plurality of sheets of dimensionally heat-unstable material, each of the sheets having two edge regions each of which can be brought into abutting relationship with an edge region of another sheet.

The invention also provides a method of joining two opposite edges of a closure

member comprising dimensionally heat-unstable material, which comprises bringing the edge regions into abutting relationship with each other, positioning fastening means to receive at least portions of the edge regions, and heating the edge regions whereby they change in dimensions to conform more closely to the dimension of the space defined by the fastening means, the method advantageously employing the advantageous forms of the assembly.

Preferably the remainder of the closure member is heated to cause recovery over the substrate to be protected and most preferably this is effected after at least partial recovery of the edge regions. The invention also provides a substrate, especially a cable splice, covered by the device or the method of the invention.

The present invention also provides an elongate, tubular closure device for conduits including one or more sheet-like closure members capable of being deformed into tubular configurations with abutting edge regions and retaining members or channels capable of holding the abutting edge regions of the closure members. The closure members are of dimensionally heat-unstable material which, when assembled with the channel members, may be heated to advantageously recover to tightly hold an enclosed object. Wedge-shaped ridges may extend along each of the abutting edge regions of the closure members. The edge regions, sometimes referred to herein as edges, are engaged by converging legs of the retaining members to complete the closure. The edge regions may deform as part of the heat recovery process to form a tight seal with the retaining members.

The closure device of the present invention may include one or more closure members and one or more fastening means, otherwise referred to subsequently in this description as retaining devices. The retaining devices form channels which may be positioned over abutting edges of heat-recoverable closure members to form tight joints that will withstand and, preferably, be enhanced by, heat-recovery of the closure members. Ridges may be created along the edges of the closure members to engage the closure members more securely with the retaining devices. These ridges may be formed during fabrication of the elongate closure members or during the heat recovery step. The edges may be such as to present a small cross-section for easy location in the channel-like retaining device, and, upon recovery, may expand to become tightly held within the retaining device. This expansion may either increase with width of existing ridges or create ridges to fit more closely into the interior of the retaining device and thus

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become tightly held. In this way, integrity of the closure may be assured without the need for close tolerances and careful attention to assembly detail.

5 The forces which come into effect during heat-recovery of the closure members may also operate to insure integrity of the joint between abutting portions of the closure members. Wedge-shaped ridges, designed to
10 create an ever-increasing width of material being presented to the retaining device as two contiguous edges of the closure member or members are extracted therefrom, have been found to be advantageous.
15 Thus, the flexible nature of the recoverable material can be prevented from resulting in a distortion which would decrease the ability of the member to resist extraction. The ridge configuration also tends to resist
20 moment forces which would otherwise cause counter-rotation of two retained edges from the retaining device. The edges of the closure members may be fabricated, along with the main body of the recoverable
25 members, such that advantageous dimensional change of the edges will occur once these have been positioned in the retaining device and subjected to sufficient heat to initiate recovery. In this way, a ridge may be
30 developed or reconfigured on each edge only upon the heat recovery of the edge within the constraining confines of the retaining device. With this available
35 flexibility in the closure member edge, it becomes possible to use a loose-fitting retaining device which may be more easily slipped over edge regions of the closure member and which does not require
40 crimping.

40 Accordingly, the present invention makes it possible to provide an improved heat-recoverable closure device and method, and a heat-recoverable closure device having an improved joint.

45 The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

50 Figure 1 is a perspective view of a closure device according to the present invention during installation;

Figure 2 is an end view of a closure member before installation;

55 Figure 3 is an end view of a closure device according to the present invention during installation;

Figure 4 is an end view of an assembled closure according to the present invention;

60 Figure 5 is an end view of a tool which may be used in the installation of the closure device of the present invention;

Figure 6 shows part of a second embodiment of a closure member used according to the present invention;

Figure 7 shows the use of multiple closure

65 sheets and retaining devices for a single closure;

Figure 8 is an end view of a further embodiment of the invention illustrating unrecovered edges of a closure member in a retaining device;

70 Figure 9 is an end view of the embodiment of Figure 8 illustrating the closure member after recovery;

75 Figures 10 and 12 are end views of two further embodiments of the invention each illustrating unrecovered edges of a closure member in a retaining device; and

80 Figures 11 and 13 are end views of the embodiments of Figures 10 and 12, respectively, illustrating the closure member after recovery.

Referring now to the drawings, Figure 1 shows a closure member generally designated by the reference numeral 10. The closure member 10 comprises a single
85 elongate sheet of material capable of being deformed into a tubular configuration as illustrated in Figure 1. The present invention applies equally to a multiple sheet closure member as seen, for example, in
90 Figure 7. A specific embodiment is illustrated in our co-pending application No. 39516/75 (Serial No. 1,529,353). The closure member 10 comprises dimensionally
95 heat-unstable material. In general such material has the property of elastic or plastic memory imparted thereto to form a heat-recoverable member. The closure member 10 may be converted to the dimensionally
100 heat-unstable, heat-recoverable, state by heating it to above its crystalline melting temperature and stretching it. Stretching the closure member 10 also causes it to be reduced in thickness. The material is then cooled in this stretched
105 condition; it will then retain this stretched condition until it is again heated to the crystalline melting temperature. Once heated to that temperature, the closure member 10 will attempt to recover its
110 original shape and will tightly conform to an elongate object placed therein. Examples of materials to which the property of heat-recoverability may be applied may be found in United States Patent Specifications Nos.
115 2,027,962 and 3,086,242, the disclosures of which are incorporated herein by reference. Polymeric materials which have been cross-linked by chemical means or by irradiation, for example, which high energy electrons or
120 nuclear radiation, are preferred for use in the present invention.

As can be seen most clearly from Figure 2, the closure member 10 comprises a sheet of heat-recoverable material which
125 may have wedge shaped ridges on one side thereof extending lengthwise along two parallel edges 12 and 14 of the sheet. The

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width and length of each closure member 10 will depend on its ultimate use. The width of the sheet between the ridges must be such that it will easily wrap about the object to be enclosed when in the expanded state and yet shrink tightly to enclose the object when heated to a temperature above the crystalline melting temperature.

The elongate parallel edges 12 and 14 of the closure member 10 include wedge-shaped ridges 16 and 18 positioned on one side of the closure member 10 and flat surfaces for abutment 20 and 22 on the opposite side of the sheet from the wedge shaped ridges 16 and 18. In the embodiment of the invention illustrated in Figures 1 to 5, the flat surfaces 20 and 22 extend across the entire inner surface of the closure member 10 to form a single continuous surface.

To enclose an elongate object (substrate) with the closure member 10, parallel edges 12 and 14 are brought together about the object with the wedge shaped ridges 16 and 18 extending outwardly therefrom. In this configuration, the flat surfaces 20 and 22 are contiguous and the wedge-shaped ridges 16 and 18 form a bead which may be grasped by a retaining device.

Referring now to Figures 1 and 3 to 5, a retaining device generally designated 24 is employed with the closure member 10 to form an elongate tubular closure. The retaining device forms an elongate channel having walls 26 and 28 (see Figure 3) which extend outwardly from an apex 30. The walls 26 and 28 are preferably at an angle with respect to one another to accommodate the upper portion of the bead formed by the wedge shaped ridges 16 and 18. Depending from the walls 26 and 28 respectively are side portions, hereinafter referred to as legs, 32 and 34. The legs 32 and 34 terminate respectively in flanges 36 and 38 which extend outwardly from the channel defined by the walls 26 and 28 and the legs 32 and 34. The distance between the legs 32 and 34 is sufficient to allow the retaining device 24 to be placed over the bead formed by the wedge-shaped ridges 16 and 18. Once the retaining device is in position, the legs 32 and 34 may be crimped inwardly so that they are mutually convergent. This condition is best illustrated in Figure 4. When the retaining device 24 has been forced around the bead formed by the wedge-shaped ridges 16 and 18, the legs 32 and 34 act to engage the wedge-shaped ridges to prevent their separation. The flanges 36 and 38 are employed to prevent the lower edges of the legs 32 and 34 from biting into the closure member 10.

In assembling the closure, the closure member 10 is wrapped about the elongate object to be enclosed so that flat surfaces 20

and 22 are brought into contiguous relationship. An adhesive or sealant may if desired be employed between the surfaces 20 and 22 and between the closure and substrate to insure a leakproof seal. Such an adhesive may be heat-activated in order that it will better form a seal during the heat-shrinking process. With the surfaces 20 and 22 positioned together in abutting relationship, the wedge-shaped ridges 16 and 18 form a bead over which the retaining device 24 is positioned. The legs 32 and 34 are then forced inwardly to fit tightly about the wedge-shaped ridges 16 and 18 and thereby retain the elongated parallel edges 12 and 14 in contiguous relationship.

When the legs 32 and 34 have been brought into the desired position, heat is then applied to the closure member 10 to cause it to shrink about the elongate object being enclosed. The heat-recoverable material within the retaining device 24 may, if desired, be allowed to change dimensionally on heating to fill the wedge-shaped portion of the cavity within the retaining device to form or enhance the bead associated with the edges of the closure member. Once the shrinking is completed, the temperature of the closure member 10 is allowed to drop below the crystalline melting temperature of the material. Normally, tension still remains in the closure member which continues to tightly hold the object enclosed. The tension also tends to separate the edges 12 and 14 if these are not properly constrained.

Instead of being such that the legs 32 and 34 must be forced inwardly to contact the wedge-shaped ridges, the retaining device 24 may be preformed to conform closely to the bead formed by the wedge-shaped ridges 16 and 18. The retaining device may then be slid over the end of the bead into place and further crimped if desired to hold the edges 12 and 14 tightly.

Referring in detail to the mechanical relationships between the wedge-shaped ridges 16 and 18 and the enclosing legs 32 and 34, a closure device is formed which assures a compressed joining of the flat surfaces 20 and 22. It is believed that this joint is enhanced by the residual tension remaining after the heat-recovery process. The wedge-shaped ridges 16 and 18 extend outwardly defining first thrust surfaces 40 and 42 (see Figure 3). Second surfaces 44 and 46 extend upwardly to the edge of the closure member 10. These surfaces 40, 42, 44 and 46 are all, in the embodiment of the invention shown in Figures 1 to 5, disposed at 45° with respect to the surfaces 20 and 22. However, a broad range of angles is believed to be acceptable.

When the legs 32 and 34 are forced inwardly about the wedge-shaped ridges 16

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and 18, the inner surfaces of the legs 32 and 34 engage the thrust surfaces 40 and 42, preventing the extraction of the edges 12 and 14 of the closure member 10 from the retaining device 24. Tension forces, imposed during the heat-recovery of the closure 10 and remaining after recovery has been completed, tend to withdraw and rotate the edges 12 and 14 from the retaining device 24. The converging nature of the assembled retaining device 24 at legs 32 and 34 as well as the wedge-shape of the bead formed by ridges 16 and 18, however, insure proper closure between the surfaces 20 and 22. Thus, the closure member 10 is placed in tension tending to withdraw the edges 12 and 14 from the retaining device 24, the thrust surfaces 40 and 42 are forced against the inner side of legs 32 and 34. This tends to force the surfaces 20 and 22 together forming a tight seal. The tendency for the edges 12 and 14 to rotate out of the retaining device 24 also further tightens the seal. The wedge-shaped ridges 16 and 18 extend upward between the second surfaces 44 and 46; these extension of the wedge-shaped ridges 16 and 18 between the second surfaces 44 and 46 and the flat surfaces 20 and 22 resist such rotation. Thus, the surfaces 20 and 22 are forced together. In this way, the seal is tightened and the edges 16 and 18 are held within the retaining device 24.

The upward extension of the edges 12 and 14 to surfaces 44 and 46 also creates a geometrical structure which cannot be easily pulled from the retaining device. The cross-sectional width of the wedge-shaped ridge continues to increase with increasing distance from the open end of the crimped retaining device as measured along perpendiculars to a line bisecting the angle between surfaces 20 and 40 or surfaces 22 and 42. This cross-sectional dimension roughly indicates the amount of material which must be compressed for the closure member to be pulled through the opening in the retaining device 24. As the cross-section continues to increase, the resistance to extraction increases in spite of the ductility or flexibility of the heat-recoverable closure material.

In assembling the retaining device 24 about the edges 12 and 14 of the closure member 10, a tool having guide rollers may be employed. A suitable tool is illustrated by way of example in Figures 1 and 5 and includes a support member 48 and guide rollers 50 and 52 rotatably mounted on the support member. The guide rollers 50 and 52 define a passageway therebetween which approximately conforms to the desired final configuration of the retaining device 24. Mechanical leverage may be conventionally applied where high forces are required for

closure of the legs 32 and 34. The closure of the legs 32 and 34 around the wedge-shaped ridges accommodates variation in the edges 12 and 14 when the retaining member 24 is deformed. Thus, close tolerances on the closure member 10 and the retaining device 24 are not required. The ability of the device to tolerate dimensional anomalies in the component parts may also be enhanced by heat-recovery of the edges held within the retaining device 24. On such heat-recovery, the edges tend to shorten and thicken to fill the wedge-shaped cavity formed.

Referring now to Figure 6, a construction is illustrated for the elongate parallel ridges 16 and 18; Figure 6 illustrates the use of interlocking means for preventing sliding movement between edges 12 and 14. In the embodiment shown in Figure 6, longitudinal channels 54 and 56 are provided respectively in flat surfaces 20 and 22. These channels 54 and 56 form an elongate cavity in which a rod may be positioned to further insure the integrity of the closure. The surfaces 20 and 22 may also, or alternatively, be serrated to prevent longitudinal movement of one edge relative to the other.

Two further embodiments of the present invention are illustrated in Figures 8 to 11. In these embodiments, greater reliance is placed on the use of the heat-recovery properties of the closure material in obtaining a strong seal. In Figures 8 and 9, an embodiment is shown which includes ridges 58 and 60 which do not closely conform to the inner shape of the retaining device 62. Abutting surfaces are provided between ridges 58 and 60 to create a proper seal once the closure is fully assembled. A retaining device 62 may be positioned over ridges 58 and 60 and then crimped in order tightly to hold the closure member or may be preformed to approximately the width of the closure member just below the adjacent ridges 58 and 60, in which case the retaining device 62 would be slid from one end around the ridges 58 and 60. In any event, the legs of the retaining device 62 converge to create a modified channel allowing some opening for receiving the connecting portions between the edges and the main body of the closure member 10. The positioning of the retaining device 62 is facilitated by the non-conformity of the ridges 58 and 60 with the inner shape of the retaining device 62.

Once the retaining device 62 is positioned over ridges 58 and 60, heat is applied either specifically to the ridges 58 and 60 or to the entire closure member 10 in order that the dimensionally unstable, heat-recoverable material may be recovered. The closure member 10 is preferably such that its width

will diminish upon recovery so that the closure member fits tightly around an enclosed article. With the contraction of the closure member, the thickness of the material expands. This is equally true at the edges where ridges 58 and 60 tend to become thicker, as can be seen in Figure 9. Thus, the ridges 58 and 60 will tend to achieve a wedge-shape upon recovery due to the wedge-shape of the inner surface of the formed retaining device 62. When the temperature of the recovered material is again lowered below the range in which it is dimensionally unstable, relatively hard wedge-shaped ridges are formed which cannot be easily withdrawn from the retaining device.

Another embodiment of the present invention is illustrated in Figures 10 and 11. In this embodiment, no ridges are provided whatsoever along edges 64 and 66 on closure member 10 before heat-recovery of that member. When no ridges are provided, placement and retraction of the edges 64 and 66 before heat-recovery of the closure member 10 are relatively easy. The retaining device 68 used in this embodiment of the invention is preferably shaped such that some retaining force is provided to hold edges 64 and 66 when the closure member 10 is inserted therein. Thus, edges 64 and 66 may be brought together around an article to be enclosed and then forced into the retaining device 68 where they are lightly held until heat is applied.

Again, the characteristic expansion in thickness with a contraction in width obtained on heating will cause ridges to form on the edges 64 and 66. These ridges will be no greater in width than the main body of the closure 10 provided that the closure 10 is allowed to recover substantially completely. The retaining device 68 will prevent recovery at the point where the converging legs of the retaining device terminate such that the ridges formed will be separated from the equally thick main body of the closure member 10.

In order to prevent the closure member 10 being extracted from the retaining device 68 during recovery and before the ridges have been formed on the edges, the edges 64 and 66 are preferably heated prior to the heating of the main closure member 10 (although such prior heating may be avoided if the retaining device 68 grips the edges 64 and 66 so firmly that no extraction is possible). This prior heating may be accomplished, for example, by heating the retaining device which in turn raises the temperature of the edges to a heat-recovery level. Consequently, no tension through heat recovery is established in the closure member until after the edges 64 and 66 have had an opportunity to expand and become

locked within the retaining device 68. Again, a rigid, tightly fitting structure is formed by edges 64 and 66 which provides a tight seal not easily extracted from the retaining device 68.

It is not necessary that a wedge-shaped cavity be provided by the retaining device. Any one of a wide variety of cavities may be employed. A cylindrical cavity 70 is illustrated in Figures 12 and 13. However, as with the wedge-shaped cavity and the cylindrical cavity it is greatly advantageous to employ a configuration which includes legs that converge to a relatively narrow opening through which the closure member may extend. The combination of such a retaining device having converging legs and a closure member with heat-recoverable edges results in the various advantages mentioned above in connection with the present invention.

The cylindrical shape of the retaining device 72 shown in Figures 12 and 13 has been proposed for earlier closure assemblies or devices. However, such closures required that the fit between the retaining device and the bead formed by the contiguous ridges be as tight as possible to form a proper seal. The tightness of such assemblies was compromised by the difficulty encountered in assembling such closures. To fit selected for such assemblies was necessarily too tight for easy assembly and too loose for an ideal seal. Furthermore, close tolerances were required in the fabrication of parts if this less-than-ideal fit was to result in an acceptable product.

In the present invention, the bead formed by the closure member ridges 74 and 76 illustrated in Figure 12 is substantially smaller than the space enclosed by the cylindrical retaining device 72. Consequently, the cylindrical retaining device 72 may be easily slipped over the undersized bead. Once assembled, the bead may be heated to the heat-recovery temperature which allows ridges 74 and 76 to expand and become securely held within the retaining device 72. Thus, the closure is easily assembled and may still form an excellent seal.

In the embodiment of the invention shown in Figures 12 and 13, it is possible to distort the edges of the closure member such that the bead formed on recovery will more than fill the cylindrical cavity. Thus, on recovery, the closure member will completely fill the space available to it and conform to the whole interior surface of the retaining device, achieving optimum integrity for the closure.

Thus the invention makes it possible to provide a heat-recoverable closure device which incorporates a joint assembly that can be tightened by the shrinking of the

closure member. Further, the advantageous forming of the retaining device insures closure of the joint and accommodates wide anomalies in either the closure structure or the retaining device. While embodiments and applications of this invention have been shown and described, it should be apparent to those skilled in the art that many more modifications are possible without departing from the scope of the appended claims.

In our co-pending Application No. 1801/78 (Serial No. 1,529,357), divided from this application, there are described and claimed fastening means suitable for use in the closure device of the present application.

WHAT WE CLAIM IS:—

1. A closure device which comprises a closure member comprising dimensionally heat-unstable material, the closure member having two opposite edge regions that can be brought into abutting relationship with each other, and fastening means for receiving at least a part of the edge regions and maintaining them in abutting relationship during heat-recovery of the closure member, the edge regions and the fastening means being such that, before installation of the device and heat-recovery of the member the fastening means may be positioned over the abutting edge regions, the space defined by the fastening means having a shape or dimension that does not conform closely to that of the abutting edge regions and such that, during installation and heat-recovery, the dimensions of the fastening means and/or of the abutting edge regions are changeable to cause their shapes to conform more closely.

2. A closure device as claimed in claim 1, wherein each edge region comprises an outwardly extending wedge-shaped ridge having one surface for abutting a surface of the other edge region.

3. A closure device as claimed in claim 2, wherein each wedge-shaped ridge comprises first and second surfaces disposed at about 45° to the surface for abutment of the edge region which includes that ridge.

4. A closure device as claimed in claim 3, wherein the fastening means comprises a central portion for contacting the first surface of each of the ridges and two side portions, each of the side portions being such that it can be deformed during installation to contact the second surface of a ridge.

5. A modification of a closure device as claimed in any one of claims 1 to 4, wherein before installation of the device the fastening means is such that the space defined by it conforms closely to the shape of the abutting edge regions.

6. A closure device as claimed in any one

of claims 1 to 5, wherein the surfaces for abutment comprise means for reducing sliding of one abutting surface relative to the other.

7. A device as claimed in claim 6, wherein the means for reducing sliding comprise interlocking or interengaging means.

8. A device as claimed in any one of claims 1 to 7, wherein the surfaces of the member and/or the fastening means are provided with an adhesive or a sealant.

9. A closure device as claimed in any one of the preceding claims, wherein the edge regions are dimensionally heat-unstable.

10. A closure device as claimed in any one of the preceding claims, wherein the edge regions are capable of increasing in thickness on the application of heat.

11. A closure device as claimed in any one of claims 1 to 10, in which the edge regions recover to become wedge-shaped, or to increase the angle of the wedge, on application of heat.

12. A closure device as claimed in any one of claims 9, 10, or 11, as appendent to claim 1, or as appendent to any one of claims 5 to 8 when appendent to claim 1, wherein the edge regions are capable of forming ridges when they are retained in butting relationship and heated to cause recovery thereof.

13. A closure device as claimed in claim 12, wherein, before installation, the thickness of the edge regions is substantially equal to the thickness of the remainder of the closure member.

14. A closure device as claimed in any one of the preceding claims, wherein the closure member comprises a plurality of sheets of dimensionally heat-unstable material, each of the sheets having two edge regions each of which can be brought into abutting relationship with an edge region of another sheet.

15. A closure device comprising an elongate closure member of dimensionally heat-unstable material, the closure member extending to edge regions capable of being brought into mutually contiguous relationship, the edge regions admitting of dimensional instability resulting in an increase in thickness upon heat-recovery, and fastening means for co-operating with the edge regions to retain the edge regions in contiguous relationship during heat-recovery of the closure member, the fastening means defining a channel including converging legs capable of engaging the closure member to contain the contiguously arranged edge regions.

16. A closure device comprising an elongate closure member of dimensionally heat-unstable material, the closure member having two edge regions capable of being brought into contiguous relationship, the

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closure member. Further, the advantageous forming of the retaining device insures closure of the joint and accommodates wide anomalies in either the closure structure or the retaining device. While embodiments and applications of this invention have been shown and described, it should be apparent to those skilled in the art that many more modifications are possible without departing from the scope of the appended claims.

In our co-pending Application No. 1801/78 (Serial No. 1,529,357), divided from this application, there are described and claimed fastening means suitable for use in the closure device of the present application.

WHAT WE CLAIM IS:—

1. A closure device which comprises a closure member comprising dimensionally heat-unstable material, the closure member having two opposite edge regions that can be brought into abutting relationship with each other, and fastening means for receiving at least a part of the edge regions and maintaining them in abutting relationship during heat-recovery of the closure member, the edge regions and the fastening means being such that, before installation of the device and heat-recovery of the member the fastening means may be positioned over the abutting edge regions, the space defined by the fastening means having a shape or dimension that does not conform closely to that of the abutting edge regions and such that, during installation and heat-recovery, the dimensions of the fastening means and/or of the abutting edge regions are changeable to cause their shapes to conform more closely.

2. A closure device as claimed in claim 1, wherein each edge region comprises an outwardly extending wedge-shaped ridge having one surface for abutting a surface of the other edge region.

3. A closure device as claimed in claim 2, wherein each wedge-shaped ridge comprises first and second surfaces disposed at about 45° to the surface for abutment of the edge region which includes that ridge.

4. A closure device as claimed in claim 3, wherein the fastening means comprises a central portion for contacting the first surface of each of the ridges and two side portions, each of the side portions being such that it can be deformed during installation to contact the second surface of a ridge.

5. A modification of a closure device as claimed in any one of claims 1 to 4, wherein before installation of the device the fastening means is such that the space defined by it conforms closely to the shape of the abutting edge regions.

6. A closure device as claimed in any one

of claims 1 to 5, wherein the surfaces for abutment comprise means for reducing sliding of one abutting surface relative to the other.

7. A device as claimed in claim 6, wherein the means for reducing sliding comprise interlocking or interengaging means.

8. A device as claimed in any one of claims 1 to 7, wherein the surfaces of the member and/or the fastening means are provided with an adhesive or a sealant.

9. A closure device as claimed in any one of the preceding claims, wherein the edge regions are dimensionally heat-unstable.

10. A closure device as claimed in any one of the preceding claims, wherein the edge regions are capable of increasing in thickness on the application of heat.

11. A closure device as claimed in any one of claims 1 to 10, in which the edge regions recover to become wedge-shaped, or to increase the angle of the wedge, on application of heat.

12. A closure device as claimed in any one of claims 9, 10, or 11, as appendent to claim 1, or as appendent to any one of claims 5 to 8 when appendent to claim 1, wherein the edge regions are capable of forming ridges when they are retained in butting relationship and heated to cause recovery thereof.

13. A closure device as claimed in claim 12, wherein, before installation, the thickness of the edge regions is substantially equal to the thickness of the remainder of the closure member.

14. A closure device as claimed in any one of the preceding claims, wherein the closure member comprises a plurality of sheets of dimensionally heat-unstable material, each of the sheets having two edge regions each of which can be brought into abutting relationship with an edge region of another sheet.

15. A closure device comprising an elongate closure member of dimensionally heat-unstable material, the closure member extending to edge regions capable of being brought into mutually contiguous relationship, the edge regions admitting of dimensional instability resulting in an increase in thickness upon heat-recovery, and fastening means for co-operating with the edge regions to retain the edge regions in contiguous relationship during heat-recovery of the closure member, the fastening means defining a channel including converging legs capable of engaging the closure member to contain the contiguously arranged edge regions.

16. A closure device comprising an elongate closure member of dimensionally heat-unstable material, the closure member having two edge regions capable of being brought into contiguous relationship, the

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closure member including a surface for abutment and an outwardly extending wedge-shaped ridge extending along each of the edge regions, each ridge being defined by two surfaces disposed at about 45° relative to the respective surface for abutment, and a fastening means for cooperating with the outwardly extending wedge-shaped ridges to retain the abutting surfaces in contiguous relationship during heat-recovery of the closure member, the fastening means being capable of being positioned over the wedge shaped ridges such that the converging legs engage the wedge shaped ridges preventing extraction of the closure member from the fastening means.

17. A closure device constructed substantially as described herein with reference to, and as illustrated by, Figs. 1 to 5, or Fig. 6, or Fig. 7 of the accompanying drawings.

18. A closure device constructed substantially as described herein with reference to, and as illustrated by, Figs. 8 and 9, or Figs. 10 and 11, or Figs. 12 and 13 of the accompanying drawings.

19. A method of joining two opposite edges of a closure member comprising dimensionally heat-unstable material, which comprises bringing the edge regions into abutting relationship with each other, positioning fastening means to receive at least portions of the edge regions, and heating the edge regions whereby they change in dimensions to conform more closely to the dimension of the space defined by the fastening means.

20. A method as claimed in claim 19, wherein the edges of the closure member expand in width on heating.

21. A method as claimed in claim 19 or claim 20, wherein the fastening means

comprises converging legs and the legs are crimped, before or after the fastening means is positioned to receive the edges, to engage the edges and to form a wedge-shaped cavity between the legs.

22. A method as claimed in any one of claims 19 to 21, wherein the closure member is heated to cause recovery thereof.

23. A method as claimed in claim 22, wherein recovery of the closure member is effected after at least partial recovery of the edge regions thereof.

24. A method for joining elongate mutually contiguous edge regions of a closure device including the steps of placing two edge regions of a closure member in mutually contiguous orientations, placing a channel member over the mutually contiguous edges, the channel member having converging legs, and heating the edge regions of the heat-recoverable closure member to bring about their recovery such that the mutually contiguous edges expand in width to conform to the inner shape of the channel between the converging legs.

25. A closure member having two opposite edges joined by a method as claimed in any one of claims 19 to 24.

26. A substrate covered by a method as claimed in any one of claims 19 to 24.

27. A substrate whenever covered by an assembly as claimed in any one of claims 1 to 18.

28. A substrate as claimed in claim 26 or 27, which is a cable splice.

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