(54) Title: WALL OR BULKHEAD FEEDTHROUGH FOR WIRING BUNDLES

(57) Abstract

Side-entry wall or bulkhead feedthrough for wiring bundles or other elongate articles, e.g. from vehicle engine compartment to passenger compartment, comprising (A) side-entry separate collar (Fig. 10, 310) and clamping plate (320) with or without heat-shrinkable plastics sleeve between them to seal the feedthrough to the wiring bundle, or (B) side-entry integral collar and clamping plate (Fig. 8, 214, 216) with gel (see below) or with sleeve (220) as aforesaid. The clamping plate is adapted for sealing to the bulkhead (222) and preferably carries sealant (gel) to seal against the bulkhead, the sleeve, and the mutually-abutting ends of the clamping plate sections. Properties are specified for sealants, especially gels, to seal adequately at the "triple point" where the sealant between the clamping parts must also seal against the bulkhead.


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WALL OR BULKHEAD FEEDTHROUGH FOR WIRING BUNDLES

This invention relates to feedthroughs for electrical wiring bundles or harnesses, which may contain individual insulated wires and/or sheathed cables composed of such wires, all hereinafter referred to as "wiring bundles", or for other elongate articles (e.g. pipes or conduits).

Wiring bundles or other elongate articles are frequently required to extend through apertures in walls or bulkheads, for example between different rooms or compartments in buildings or vehicles. It is often difficult to construct a feedthrough which seals the aperture around the bundle both reliably and cost effectively, especially in production processes where time and cost are critical, for example on automotive production lines. The present invention relates to feedthroughs which may be especially well suited to such processes.

A first aspect of the invention provides an assembly for forming a wall or bulkhead feedthrough for a wiring bundle or other elongate article, comprising (i) a substantially rigid collar of at least two hinged or separate pieces assembled to surround a portion of the bundle or other elongate article, and (ii) a substantially rigid clamping member of at least two hinged or separate parts assembled around and gripping the collar pieces; or comprising the collar (i) and clamping member (ii) together with (iii) a rubber or plastics sleeve surrounding and gripping the collar and part of the bundle or other elongate article adjacent to the said portion, with the clamping member gripping together the collar and that part of the sleeve which is between the collar and the clamping member.

The collar should be sufficiently rigid to support the clamping action on the sleeve between the collar and the clamping member. The collar could be made of metal, but will preferably be molded from plastics, for example polypropylene or nylon, especially when inductive heating is to be applied to the wiring bundle or other elongate article for purposes hereinafter described. The clamping member could also be made of relatively rigid polymers, for example glass-reinforced nylon or polypropylene or other engineering polymers, but it may be preferable to construct the clamping member out of metal,
perhaps over-molded with rubber or coated with plastics, to lend extra rigidity to thin bulkhead structures, for example in vehicles, to which it will be secured in use. It is preferred that the sleeve is at least partly composed of heat-shrinkable plastics material and has been heat shrunk to grip the collar and the adjacent part of the wire bundle or other elongate article. To avoid unnecessary repetition of the phrase “wiring bundle or other elongate article”, the following description will refer only to wiring bundles, which are an important field of use for the present invention, on the understanding that the other elongate articles are not thereby necessarily excluded.

Heat shrinkable plastics sleeves and methods of shrinking them are nowadays very well known in wire harnessing technology and selection of a suitable sleeve for some of the present purposes will be a straight-forward matter for persons familiar with this field of technology. A preferred form of sleeve carries inductively-heatable particles within or on the sleeve material or in or on a coating of heat-activatable adhesive on the inner surface of the sleeve, so that the sleeve can be shrunk by inductive heating, for example as described in WO-A-9424837 (MP1474), the disclosure of which is incorporated herein by reference.

Preferably, the clamping member is of generally plate-like form and is adapted to be secured face-to-face against a bulkhead through which the wiring bundle is to extend in use. It is furthermore preferable that the clamping member carries sealant material (a) at a position to be capable of forming a seal against a bulkhead through which the wiring bundle is to extend in use, and/or (b) at a position forming a seal against the gripped outer surface of the collar or sleeve, and/or (c) at a position forming a seal between mutually-abutting surfaces of the assembled clamping member parts. Any convenient sealing materials such as soft rubber or mastic could be used, but it is much preferred that the sealant material carried by the clamping member at one or more (preferably all) of the said positions is gel. The gel to be used may be selected from known gel materials to suit the end use conditions of the feedthrough in question. Suitable candidates may include polysiloxane gels, for example as described in our EP-A-0108518 (MP0838), styrene-alkylene-styrene triblock co-polymer gels, for example as described in our WO-A-8800603
(RK308), WO-A-9005166 (RK403), WO-A-9323472 (RK469), or WO-A-9305113 (RK451), and the triblock co-polymer gels based on polymethacrylate triblocks described in our WO-A-9700292 (RK509), the disclosures of all of which are incorporated herein by reference. It has been found, according to various aspects of the present invention, that gels, owing to their unusual physical properties, are uniquely suitable for sealing the so-called “triple point” which occurs in feedthrough structures as hereinafter described.

In preferred assemblies according to this invention, the sleeve carries sealant material forming a seal between the sleeve and the collar and/or between the sleeve and the sleeve-gripped part of the wiring bundle. Separately, or in addition, sealant material is provided which substantially blocks the interstices between the wires in the wiring bundle. Suitable sealants for these purposes are known. Preferably, the sealant material carried by the sleeve and/or substantially blocking the said interstices is heat-activated adhesive material, preferably a hot melt adhesive or a thermoset adhesive. Any of the known materials which can adequately perform the sealing and blocking functions may be used. In a preferred embodiment of the invention, the heat-activated adhesive material carried by the sleeve and/or that substantially blocking the said interstices carries inductively-heatable particles and has been inductively heated to form the said sleeve seal(s) and/or to substantially fill the said interstices. Suitable adhesive materials of this kind may be as described in the aforementioned WO-A-9424837 and may be inductively heated by methods described therein, perhaps using the improved induction coil apparatus described in a PCT application based on our co-pending British Patent Application No. 9600181.3 and corresponding German Utility Model (Gebrauchsmuster) No.29601328.5 (RK524), the disclosures of which are incorporated herein by reference. As an alternative to the use of inductively-heatable adhesive materials, it may in some cases be preferred that at least the heat-activated adhesive material substantially blocking the said interstices is not itself significantly inductively heatable and has been activated by heat derived from inductive heating of the wires forming the wiring bundle. Methods of this kind are described in our WO-A-9636976 (RK517), the disclosures of which are incorporated herein by reference.
The assembly according to the present invention will preferably include a tapering formation, preferably of flexible fingers, extending from (and preferably integral with) the collar towards the said sleeve-gripped part of the wiring bundle to provide strain relief and a graduated transition of the sleeve from the collar to the bundle, the sleeve, and thus the said sleeve-gripped part of the bundle, preferably extending beyond the end of the tapering formation. Completely reliable sealing may be more difficult, though not impossible, to achieve if the sleeve does not extend beyond the end of the tapering formation.

In the interests of resisting axial movement of the wiring bundle, it may be advantageous that the collar and the clamping member respectively have formations which interlock with each other to grip the sleeve.

The intermediate assembly of the collar surrounding the wiring bundle and the sleeve gripping the collar and the said adjacent part of the bundle, before the clamping member is applied, is also to be regarded as an inventive embodiment of the present invention, since this intermediate assembly may in practice be made at a location remote from that at which the clamping member is applied. The application of the clamping member may be effected during assembly of the wiring bundle feedthrough into a wall or bulkhead, or may be effected at a site remote from that final assembly process.

The present invention also provides a kit of parts comprising a collar and a sleeve suitable for incorporation in the feedthrough assemblies hereinbefore described according to the present invention. The kit may additionally comprise a clamping member suitable for incorporation in the assembly and/or may additionally comprise sealant material in a form suitable for insertion between wires in the said wiring bundle to substantially block interstices between the wires. Advantageous forms of sealant material for this purpose are described, for example, in WO-A-8707755 (RK310), the disclosure of which is incorporated herein by reference, and may include the aforementioned conductively-heatable particles if desired.
The invention also provides a method of making a wiring bundle bulkhead feedthrough assembly as hereinbefore described, comprising the steps of (a) assembling the said collar around the wiring bundle, (b) placing the said sleeve around, and causing it to grip, the collar and the said adjacent part of the wiring bundle, and (c) assembling the said clamping member to grip the collar and the sleeve. The method may additionally include the step of (d) activating heat-activatable adhesive material by inductive heating as hereinbefore described. The method may additionally or alternatively include the step of (e) fitting (preferably sealing) the clamping member against a bulkhead through which the wiring bundle extends. Relatively rigid, e.g. metal, clamping members may be especially advantageous in stabilising the bulkhead against flexing when it has a side-enterable aperture or slit to permit introduction of the wiring bundle from the side in preference to laboriously threading it axially through a closed aperture. The invention also includes use of an assembly, kit, or method as hereinbefore described according to the present invention to form an automotive bulkhead feedthrough, especially between the "wet" and "dry" compartments of a land vehicle.

Embodiments of the foregoing aspects of the present invention will now be described by way of example with reference to the accompanying drawings wherein:-

Figure 1 shows a heat shrinkable sleeve positioned around a wiring bundle ready to enclose cable blocking adhesive bodies inserted between the wires of the bundle;

Figure 2 shows a moulded plastics collar of the kind required for the present invention to be closed around the wiring bundle and positioned inside the sleeve of Figure 1;

Figure 3 shows the wiring bundle with the sleeve of Figure 1 shrunk around the adhesive inserts and the collar of Figure 2;

Figure 4 shows an assembly corresponding to that of Figures 1 to 3 with tapering flexible fingers extending from the collar;

Figure 5 shows the assembly of Figure 3 with a clamping plate about to be closed around it; and

Figure 6 shows schematically channels in the abutting end surfaces of the Figure 5 clamping plate, which could contain sealant material for sealing the mutually abutting surfaces.
Referring to Figures 1 to 3, an inductively-heatable sleeve 110 of known kind carrying an inductively-heatable adhesive 112 on its inner surface is positioned around a wiring bundle into which heat-activatable adhesive "combs" 114 of known form have been inserted. Both the sleeve adhesive 112 and the combs 114 incorporate conductively-heatable metal particles as described in the aforementioned WO-A-9424837. The moulded plastics collar 116, which is shown hinged in this case but could be formed in two separate parts, is then assembled around the bundle 118 and slid into position within the sleeve 110, which is itself positioned to cover both the collar 116 and the adhesive inserts 114. This assembly is then subjected to inductive heating by known methods as aforesaid, to shrink the sleeve and produce the sealed wire bundle and sleeve assembly shown in Figure 3 with a small amount of the melted blocking adhesive 114 exuded from the end of the sleeve 110. In Figure 4, the same parts as in Figures 1 to 3 are similarly numbered, except that the collar 116 is replaced by tapering-fingered collar 117 to provide some strain relief and a smoother transition of the sleeve between the collar and the wire bundle 118.

In Figure 5, a rubber-overmoulded clamping plate 120 is shown of hinged construction (which could alternatively be in two separate parts) ready for assembly around the wiring bundle to grip the shrunken sleeve between the clamping plate and the collar 117 inside the sleeve 110. Grooves 122 in the main surface of the clamping plate 120 may contain sealant, preferably the aforementioned gel, to form a seal when that surface of the clamping plate 120 is pressed against a surface of the bulkhead through which the wiring bundle and the tapering end of the sleeve assembly will project in use. Boltholes 124 are provided for a robust and convenient way of securing the plate to the bulkhead. The inner circumference of the clamping plate carries a bead of sealant, preferably gel, 126 to ensure a fluid-tight seal against the outer surface of the sleeve, which seal will be enhanced by the illustrated interlocking action of the inner edge of the clamping plate 120 into a groove 119 in the collar, which groove is followed in outline by the shrunken sleeve. The mutually-abutting end surfaces 128 and 130 of the collar are
suitably channeled (e.g. Fig. 6) and sealed with sealant (preferably gel) to ensure fluid-tight sealing at these interfaces on closure of the clamping plate.

**WALL or BULKHEAD FEEDTHROUGH GB2**

Our co-pending British Patent Application No.9603629.8 (RK552 GB1), the entire disclosure of which is incorporated herein, relates to an assembly, kit, and method for forming a wiring bundle bulkhead feedthrough, comprising (i) a substantially rigid collar of at least two hinged or separate pieces assembled to surround a portion of the bundle, (ii) a rubber or plastics sleeve surrounding and gripping the collar and part of the bundle adjacent to the said portion, and (iii) a substantially rigid clamping member of at least two hinged or separate parts assembled around and gripping together the collar and that part of the sleeve which is between the collar and the clamping member.

Further aspects of the present invention add advantageous alternative constructions to those of the co-pending application, and accordingly provide an assembly for forming a wiring bundle bulkhead feedthrough, comprising (I) a substantially rigid collar assembly of at least two hinged or separate pieces assembled to provide a projecting collar boss surrounding a portion of the bundle, and (IA) sealant material at a position on the collar assembly capable of forming a seal (a) against a bulkhead through which the wiring bundle is to extend in use and/or (b) between mutually-abutting surfaces of the assembled collar assembly parts, the sealant material carried by the collar assembly at one or more (preferably all) of the said positions preferably being a gel; or comprising the collar (I) together with (II) a rubber or plastics sleeve surrounding and gripping at least part of the said collar boss and part of the bundle adjacent to the said portion.

The materials and construction techniques described for the collar, sleeve and clamping member hereinbefore described may be applied, with routine modifications where necessary, to the collar assembly and sleeve of the present invention. In particular, preferred features may include, individually or in any appropriate combination, an assembly (1) wherein the sleeve is at least partly composed of heat-shrinking plastics material and has been heat shrunk to grip the collar boss and the adjacent part of the wiring bundle; (2) wherein the collar assembly includes a generally plate-like part which is
adapted to be secured face-to-face against a bulkhead through which the wiring bundle is to extend in use; (3) wherein the collar assembly carries sealant material (a) at a position to be capable of forming a seal against a bulkhead through which the wiring bundle is to extend in use, and/or (b) at a position forming a seal between mutually-abutting surfaces of the assembled collar assembly parts; (4) wherein the sealant material carried by the collar assembly at one or more (preferably all) of the said positions is gel; (5) wherein the sleeve or tape carries sealant material forming a seal between the sleeve and the collar boss and/or between the sleeve and the part of the wiring bundle gripped thereby; (6) wherein sealant material substantially blocks the interstices between the wires in the wiring bundle; (7) wherein the sealant material carried by the sleeve and/or substantially blocking the said interstices is heat-activated adhesive material, preferably a hot melt adhesive or a thermoset adhesive; (8) wherein the heat-activated adhesive material carried by the sleeve and/or that substantially blocking the said interstices carries inductively-heatable particles and has been inductively heated to form the said sleeve seal(s) and/or to substantially fill the said interstices; (9) wherein at least the heat-activated adhesive material substantially blocking the said interstices is not itself significantly inductively-heatable and has been activated at least partly by heat derived from inductive heating of the wires forming the wiring bundle; (10) comprising a tapering formation, preferably of flexible fingers, extending from (and preferably integral with) the collar boss towards the said gripped part of the wiring bundle to provide a graduated transition of the sleeve from the collar boss to the bundle, the sleeve and the said gripped part of the bundle preferably extending beyond the end of the tapering formation; (11) comprising the collar assembly (I) surrounding a wiring bundle and the sleeve (II) surrounding and gripping the collar boss and the adjacent part of the bundle according to any of the preceding claims, prior to heat shrinking of the sleeve; or a collar assembly per se or a kit of parts comprising a collar assembly and a sleeve suitable for incorporation in a feedthrough-forming assembly as aforesaid, possibly additionally comprising sealant material in a form suitable for insertion between wires in the said wiring bundle to substantially block interstices between the wires as aforesaid; or a method of making a wiring bundle bulkhead feedthrough assembly as aforesaid, comprising the steps of (a) assembling the said collar assembly around the wiring bundle, and (b) placing the said sleeve around, and (c) causing it to grip, the collar boss and the
said adjacent part of the wiring bundle, possibly additionally including the step of (d) activating heat-activatable adhesive material present in the assembly by inductive heating as aforesaid and/or possibly additionally including the step of (e) securing (and preferably sealing) the collar assembly against a bulkhead through which the wiring bundle extends.

The preferred tapering formation, preferably of flexible fingers, extending from (and preferably integral with) the collar boss (or from the collar according to the co-pending application) towards the said sleeve-gripped part of the wiring bundle, in addition to providing strain relief and a graduated transition of the sleeve from the collar to the bundle, has been found advantageously to improve the sound-proofing qualities of the feedthrough, compared with more abrupt, less tapered transitions.

In the interests of resisting “milk-off” of the shrinking sleeve from the collar boss, it may be advantageous that the collar boss have ridges or grooves or other formations which interlock with the shrunk sleeve.

Further aspects of the present invention provide an assembly, kit, or method as hereinbefore described, wherein the said sleeve is provided by a rubber or plastics tape or slit sleeve wrapped around, or suitable for wrapping around, the stated components of the assembly. In these “wraparound” embodiments of the invention, it may often be preferable that the said tape or slit sleeve is secured in its wrapped arrangement by an adhesive bond, preferably an overlap adhesive bond. It may also be preferred, especially when such adhesive bonding is used, that the said tape or slit sleeve is shrinkable (preferably heat-shrinkable) in the direction of wrapping by not more than 50%, preferably not more than 30%, more preferably not more than 20%, and preferably by at least 5%, more preferably at least 10%, of its unshrunk length in that direction. Some degree of shrinkability is preferable to assist blocking of the wiring bundle by driving sealants into it, while a moderate or low degree of shrinkage enhances the ability of the adhesive bonds, when used, to survive the shrinkage process. Other means of fastening the wraparounds may be used if preferred, for example clamps, staples, or stitching.
The slit sleeve or tape may be made of materials and may carry sealants or adhesives similar to those described in the co-pending application or known for heat-shrinkable articles generally. PVC tapes may be desirable for cost saving reasons in circumstances where they can meet the temperature and other physical performance requirements.

Further aspects of the invention may provide an assembly, kit, or method as hereinbefore described, wherein the said collar or collar boss and/or the said tapering formation if present, is or are curved or angled to cause or follow a change in the direction of the wiring bundle extending through the assembly in use.

When a bulkhead with which the feedthrough is to be used contains a side-entry access slot for placing the wiring bundle into position passing through the bulkhead, the invention preferably provides an assembly, kit, or method as hereinbefore described, wherein the said clamping member or the said collar assembly includes a laterally-projecting plate-like formation adapted to block (and preferably to rigidify) the side-entry access slot when the feedthrough is fitted.

The invention includes use of an assembly, kit, or method as hereinbefore described to form an automotive bulkhead feedthrough, preferably between the engine compartment and the passenger compartment of a land vehicle.

Further embodiments of the present invention will now be described by way of example with reference to the accompanying drawings wherein:-

Figures 7A and 7B show a two-part collar assembly and a heat shrinkable sleeve to be positioned around a wiring bundle (ready to enclose cable blocking adhesive bodies inserted between the wires of the bundle as described in the co-pending application);

Figure 8A and 8B shows a different form of moulded plastics collar assembly for blocking a side-entry access slot in a vehicle bulkhead; and

Figures 9A to 9E show curved or angled extensions for directing or following changes in direction of the wiring bundle.
Referring to Figures 7A and 7B, a rubber-over-moulded steel or glass-filled nylon collar assembly 214 formed in two separate parts is assembled around a wiring bundle 212 to form a collar boss 216 projecting along the bundle. Tongue-and-groove formations 215 and channels 219 are provided for sealing, preferably with gel (not shown), as described in the co-pending application. An inductively-heatable slit sleeve 210, of known heat-shrinkable material capable of about 10-20% shrinkage on heating, carrying an inductively-heatable adhesive (not shown) on its inner surface, is wrapped around the wiring bundle 212 and the projecting collar boss 216 and is secured by an adhesive overlap bond as indicated schematically at 213 in Fig. 7A. with the sleeve 210 covering any adhesive inserts (not shown) which may be inserted between the wires of the bundle as described in the co-pending application. This assembly is then subjected to inductive heating by known methods as aforesaid, to shrink the sleeve and drive the blocking adhesive in amongst the wires of the bundle to produce a sealed assembly. The lateral plate-like extension 218 is adapted to block and rigidise a side-entry access slot in a bulkhead through which the wiring bundle is to pass, as will now be described with reference to Figure 8.

In Figures 8A and 8B, the parts corresponding to those in Figure 7 are similarly numbered, except that the slit sleeve 210 is replaced by spirally-wrapped adhesive-coated PVC tape 220, and the collar boss 216 has integral flexible tapering fingers 217 to provide some strain relief and a smoother transition of the resulting wrapped-tape sleeve between the collar boss and the wire bundle 212. The lateral extension 218 is shown blocking side-entry access slot 224 in bulkhead 222 and tends to reduce or prevent potentially seal-breaking lateral movement of the opposite edges of the slot.

Figures 9A to 9C show in perspective three possible forms of tapering fingered moulded plastics collars which are curved or angled for the purposes hereinbefore described. It will be understood that such collars could be fitted onto the projecting collar boss of Fig.7B or similar formations could be provided in integral form resembling that shown in Fig.8B. Fig. 9D shows a hinged two-part curved collar which can be closed
around a wiring bundle as described in the co-pending application. Fig. 9E shows a sleeve heat-shrunk over a curved collar.

**WALL OR BULKHEAD FEEDTHROUGH**  GB3

Our co-pending British Patent Application No. 9603629.8 (RK552 GB1), the entire disclosure of which is incorporated herein, relates to an assembly, kit, and method for forming a wiring bundle bulkhead feedthrough, comprising (i) a substantially rigid collar of at least 2 hinged or separate pieces assembled to surround a portion of the bundle, (ii) a rubber or plastics sleeve surrounding and gripping the collar and part of the bundle adjacent to the said portion, and (iii) a substantially rigid clamping member of at least two hinged or separate parts assembled around and gripping together the collar and that part of the sleeve which is between the collar and the clamping member.

Our Co-pending British Application No. 9606393.8 (RK552 GB2), the entire disclosure of which is incorporated herein, relates to an assembly, kit, and method for forming a wiring bundle bulkhead feedthrough, comprising (I) a substantially rigid collar assembly of at least two hinged or separate pieces assembled to provide a projecting collar boss surrounding a portion of the bundle, and (II) a rubber or plastics sleeve surround and gripping at least part of the said collar boss and part of the bundle adjacent to the said portion.

Further aspects of the present invention add advantageous alternative constructions to those of the said co-pending applications, and accordingly provides in one aspect an assembly or kit as described in British Patent Application No. 9603629.8 and/or as described hereinafter, wherein the said pieces of the collar are substantially identical to each other.

Making the assemblable pieces of the collar identical to one another has the advantage of reducing inventory of the collar pieces to a single item, and of eliminating any possibility of mismatch of the pieces during assembly.
It is further observed that use of a separate collar with a separate clamping member has the advantage that a single size and shape of collar and sleeve may be suitable for use with a range of bulkheads and/or wiring bundle diameters, with only the clamping member needing to be provided in a range of shapes and sizes respectively adapted to secure the assembly to different bulkhead formations in use, all of such clamping members being adapted to fit the said collar (with or without gripping the sleeve). Furthermore, the collar and clamping member respectively may advantageously be made from different materials, for example relatively dense mouldable material such as glass-filled polypropylene, polyamide, or ABS engineering plastics to give the clamping member desirable sound insulating properties, and more flexible plastics materials for the collar, enabling it to flexibly adjust to various wiring bundle sizes. The separate collar also facilitates shrinking of heat-shrinkable sleeves by means of induction heating, since the region around the sleeve may be introduced into an induction heating coil while unobstructed by the clamping plate, which is added later.

It is another advantage of the side-entry feedthrough assemblies to which this application refers that they can be applied to long, complex wiring harnesses without having to manoeuvre the harness through the feedthrough assembly, which is a limitation of known rubber feedthroughs, especially when these must be held in a stretched open state during such manoeuvring on a production line such as an automotive harness assembly line. Moreover, the “hard shell” feedthrough assemblies provided by the present invention have the advantage of being able to support larger and heavier wiring bundles, which are increasingly used in vehicles, whereas the known rubber feedthroughs simply do not have sufficient strength and rigidity for such purposes.

Preferably, the said collar pieces have interfitting formations, preferably at least one male interfitting formation and at least one female interfitting formation on each piece, arranged to constrain the assembly of the said collar pieces to form a single pre-determined collar configuration. Thus, for example, each collar could be assembled from two identical half-pieces each having a tongue on one edge and a groove on the other which would interfit
with the corresponding groove and tongue of the complementary half piece when the two half-pieces are brought together to form a whole collar. Collars formed from three of more pieces fitted together would be possible, but two-piece collars are generally preferred. Suitably close-fitting tolerances on the interfitting formations, for example the aforementioned tongue and groove, would ensure substantially identical alignment of the assembled parts in each collar.

A further aspect of the present invention provides an assembly or kit as hereinbefore described for collar-and-clamping-member aspects, wherein the collar has at least two outwardly projecting formations, preferably flanges, spaced from each other along the elongate path to be occupied by the wiring bundle in use, and the clamping member has corresponding inwardly facing hollows arranged to receive the said projecting formations when the collar and clamping member are assembled together. In a less-preferred, converse arrangement, the collar might have outwardly-facing hollows arranged to receive inwardly-projecting formations on the clamping member.

The plate-like clamping member in all forms of the assemblies, whether or not having the aforementioned inwardly facing hollows which fit around projecting formations on the collar, may comprise a relatively large area of plate-like construction surrounding a majority of the collar circumference. Alternatively, the plate-like clamping member may be reduced to a more or less annular clamping ring containing the hollows, with a projecting tongue of plate-like configuration, for example adapted to cover and seal a slot-like extension of the usual harness-entry aperture in the bulkhead, which slot may be provided to facilitate initial positioning of the wiring bundle and feedthrough assembly in the bulkhead. Neither the clamping member as a whole, nor the projecting tongue, need include literally plate-like structures if a thicker, or more curved, or ribbed, or other shape is desirable in particular circumstances, but plate-like formations are generally preferred, and the assembly will in all cases be designed to make an acceptable seal against the bulkhead or wall through which the wiring bundle or cable is to pass.
The projecting collar formations, preferably flanges, may for example take the form of whole or partial rings surrounding the assembled collar and projecting from it in a plane substantially normal to the tubular collar axis. With these projecting collar formations, it may be preferred that one of them, preferably at or near one end of the collar (in the sense looking along the wiring bundle path), is a locking projection arranged to fit into its corresponding hollow in the clamping member sufficiently closely, in the absence of the said sleeve, to substantially prevent linear movement of the collar relative to the clamping member. It will generally be preferable to arrange this locking projection so that linear movement is prevented in both directions along the wiring bundle path. The locking action could of course be achieved with the locking member and its corresponding hollow dimensioned to clamp a portion of the sleeve between them, but locking in the absence of the sleeve as aforesaid may achieve greater precision by eliminating the effect of possible variations in sleeve thickness and compressibility. In a preferred form, the said locking projection projects outwardly further than the other said projecting formation(s), preferably in an arrangement such that an end of the said sleeve abuts against the locking projection when the sleeve is installed on the collar. Thus, the larger-diameter locking projection may conveniently act as a butt stop for the sleeve as it is applied over the other projecting formations and the remainder of the collar.

It may in addition, or independently, be preferred that one of the said projecting collar formations and its corresponding hollow in the clamping member constitute a gripping means arranged to receive and grip between them a part of the said optional sleeve. In this case, the sleeve may be installed to cover the selected projecting formation and may extend beyond this, for example as far as the aforementioned butt stop provided by the locking projection, with the corresponding hollow of the gripping means dimensioned either to grip the sleeve surface directly, or to include sealant material in the hollow which forms a seal between the clamping member and the gripped part of the sleeve. It will be appreciated that the flexibility of most sealant materials, especially the preferred gels, would tend to allow slight linear movement of the collar within the clamping member (possibly advantageous for shock absorption in some cases) if this form of gripping means were used without a more positive locking arrangement, preferably that described above.
A further aspect of this invention provides a collar-and-clamping-member assembly or kit as hereinbefore described, wherein the collar and the clamping member comprise stop formations (e.g. lugs) which abut in use substantially to prevent rotational movement of the collar within the clamping member.

The specific form of such abutting stop formations is not critical, and may be selected to suit the requirements of the overall design of the assembly. It will usually be preferred that the formations preventing rotational movement be used in combination with means, for example the aforementioned projecting formations and corresponding hollows, to restrict linear movement of the collar relative to the clamping member. Any convenient design may be used to prevent the linear movement instead of the projecting formations specifically described above.

A further aspect of the present invention provides an assembly or kit as hereinbefore described, wherein the said collar and/or the said clamping member, or the said collar assembly, comprise(s) at least two hinged or separate moulded plastics parts having gel sealant material thereon, preferably moulded thereon.

It has unexpectedly been found that gel sealants, especially the preferred gel sealants hereinafter described, can provide an enduring seal which passes rigorous testing, e.g. to meet automotive assembly requirements for water-tight sealing of the bulkhead between the engine and passenger compartments of a vehicle. This is contrary to expectation from the unsatisfactory performance of known soft rubbers, even thermoplastic elastomers such as styrene-hydrogenated alkylene-styrene triblock copolymer rubbers, which routinely fail to provide a lasting seal, especially at the so-called “triple point” where the seal between the separate parts of the feedthrough must also seal against the bulkhead surface. The reasons for this unexpected success with gels as opposed to rubbers is not precisely known, but may be related to the unique tack and/or surface wetting and/or adhesion properties of gels, especially the preferred gels hereinafter described. The preferred gels may also advantageously be selected to have relatively high resistance, under the
conditions of use, to compression set, which is another failing of some known soft rubbers.

With the foregoing advantages of gels in mind, it is preferable to design the attachment means (e.g. bolts, snap fittings, clamps) to hold the gel sealant under compression of within the range from 10 to 90%, preferably at least 20%, more preferably at least 30%, or better still at least 40%, and preferably not more than 80%, more preferably not more than 70%, or better still not more than 60%, usually based on its uncompressed dimension in the compression direction. In order to maintain compression, the gel sealant is preferably confined, e.g. within a channel or groove, which limits its ability to spread and/or exude from the sealing region.

It is an advantage of the preferred gel sealant materials, especially thermoplastic gels such as the styrene-alkylene-styrene triblock copolymer gels referred to hereinbefore, the disclosures of which are incorporated herein by reference, that such gels, which are nowadays well known in themselves, can be quickly and cost-effectively moulded onto plastic parts, for example by over-moulding on a pre-formed plastics part, or by “two-shot” co-moulding in which the plastic part is first moulded and the mould is then adjusted, in ways known per se, before moulding of the gel directly onto the plastics part while still in the mould. Mastic or rubber sealants cannot be so conveniently applied, owing to the unsuitable viscosity characteristics of mastics at elevated temperatures, and the need for prolonged high temperature curing of rubbers.

It will usually be preferable for the moulded gel sealant to be carried by the appropriate parts of the clamping member or collar assembly, but it would be possible for the gel also, or alternatively, to be carried by the separate collar, when used. Gel sealant on the the said clamping member only is especially preferred for automotive harnessing operations, where the collar and sleeve may be applied to the wiring bundle at a remote location, considerably in advance of the final assembly with the clamping member and attachment to the bulkhead. In such circumstances, gel sealant on the collar would run an increased risk of contamination or damage which might impair its performance in the final bulkhead
feedthrough. However, the collar may advantageously carry sealant when the assembly is to be used without any sleeve, thus relying largely on the sealant carried by the collar and clamping member, or by the said collar assembly, to effect sealing of the bulkhead feedthrough.

The sealant, preferably gel sealant, carried by the clamping member may advantageously be arranged to extend in selected places into the area of the clamping member which will in use overlie the aperture in a thin bulkhead which is to be sealed. The parts of the sealant thus extending can make sealing contact with mastic or other sealants, which are applied to seal the bulkhead to other components of a vehicle, for example, when the mastic is applied to the side of the bulkhead remote from the clamping member and across the clamping member already positioned in the said aperture. The portion of the gel sealants extending into the aperture-covering region of the clamping member is able to bulge around the edge of the bulkhead aperture when the clamping member is pressed against the bulkhead, thus enhancing the continuity of the sealing contact around that edge between the gel and the mastic or other sealant on the other side of the bulkhead. This arrangement may be regarded as an invention in its own right applicable to all forms of the feedthrough assemblies with which the present inventions are concerned.

A further aspect of the present invention provides an assembly or kit as hereinbefore described, including gel sealant material comprising a styrene-ethylene/propylene-styrene triblock copolymer (which may include some ethylene/butylene in the mid-block) extended with at least two hundred, preferably at least three hundred, more preferably at least four hundred, parts by weight of substantially non-aromatic extender liquid which extends and softens the alkylene mid-block of the said copolymer per 100 parts by weight of the said copolymer.

Such styrene-ethylene/propylene-styrene triblock copolymer gels have been found very suitable for the bulkhead feedthrough seals, especially in terms of providing an acceptably reliable "triple point" seal. In preferred embodiments of the present inventions, the gel sealant comprises 20 to 30%, preferably 22 to 27%, more preferably 23 to 25%, by
weight (of the whole gel composition) of the styrene-ethylene/propylene (and ethylene/butylene if present)-styrene triblock copolymer, and 80 to 70%, preferably 78 to 73%, more preferably 77 to 75%, by weight (of the whole gel composition) of the extender fluid, possibly including known minor additives such as antioxidants, or pigments. In particular embodiments hereinafter described, the gel sealant comprises 24% by weight of Septon 2006 (Trade Mark) styrene-ethylene/propylene-styrene triblock copolymer extended with FINA A360B (Trade Mark) oil and containing 2% by weight of known antioxidant, as generally described in the aforementioned WO-A-9323472 and other references.

One problem this invention addresses is that of positioning a cable-blocking heat-shrinkable driver sleeve onto a long, multi limbed wiring harness without having to manoeuvre the harness through the sleeve. This is achieved by making the heat-shrinkable driver out of a side-entry ("wrap-around") sleeve. The side-entry concept is known in itself and many attempted designs use a mechanical clip or an adhesive backing or a separate piece of adhesive tape to hold the sleeve together. For the present feedthrough purposes, the mechanical fastening technique is unsatisfactory since it hinders formation of a seal to the side entry feedthrough. The adhesive closure techniques have usually failed in the past because the adhesive cannot prevent the joined sleeve edges from sliding over each other when the usual hot air, flame, or IR heating is applied to heat shrink the sleeve.

The preferred induction heating techniques hereinbefore referred to provide a unique solution to this problem in as much as the heat is generated within the bundle to be sealed and heat flows from the inside to the outside of the sleeve. Moreover, the temperature can be advantageously controlled by means of the magnetic field, because both the field strength and flux density can be controlled as well as the heating cycle. This is achieved with a side-entry solenoid coil (e.g. a U-shaped coil or a so-called "clam-shell" design) by varying the diameter of the coil and the separation of the turns of the coil. Low heating levels around the collar of the feedthrough assembly may be achieved by using a larger coil diameter, thus reducing the field strength, and the coil’s diameter may be reduced to
follow the tapered section of the collar, thus increasing the field strength in the central region where the sealant block is to be formed in the harness. Finally, in the last section of the coil surrounding the part of the sleeve beyond the blocked region of the harness, the spacing between each coil turn may be increased to decrease the field strength. Hence, a temperature profile over the length of the sleeve can be designed to meet the requirements of each part and the amount of heating in any one position can be precisely controlled and regulated. This means a temperature can be achieved inside the bundle that causes the blocking sealant (e.g. hot-melt adhesive) to melt and flow whilst the wrap around outer sleeve can be at a lower temperature which is less likely to cause the adhesive closure bond to fail. This facilitates the selection of a suitable adhesive to hold together the wrap-around sleeve.

One technique for achieving this wrap-around sleeve closure uses a slit tube of heat-shrinkable extruded tubing, preferably made of a low-temperature EVA compound with a liner of hot-melt adhesive loaded with inductively-heatable particles (as known per se). The tubing preferably has a 3:1 shrink ratio to accommodate the transition from the collar to the harness surface. By way of example, this tubing is positioned around a collar whose diameter is 35 mm, so that the heat-shrinkable tube so formed is as long as the harness region to be blocked. A strip of known high-temperature pressure-sensitive adhesive tape is used to secure the slit tube together. During the induction heating cycle the slit tube shrinks to conform to the shape of the collar of the side-entry feed through and to the cable being blocked. The heat in this sleeve is controlled by the field applied to the collar where the shrink forces would be greatest. A mechanical feature such as a tie wrap may be employed to fix the slit tube in place prior to recovery and to help prevent movement during the heating and recovery process. Heat generation would be maximized by concentrating the field in the region where the cable is being blocked, i.e. where the blocking sealant is located on or among the wires. At the end of the cycle, after cooling, the adhesive tape could be removed.

An alternative technique is to use a tape that has longitudinal shrinkage of about 50%, this tape could contain the inductively-heatable material within it so that this tape
would heat in the magnetic field, or alternatively could contain no inductively-heatable material if used with an inductively-heatable hot melt adhesive coating. This heating could be controlled by the magnitude and concentration of the field (achieved by varying the coil design locally). This tape could be coated either with a pressure-sensitive hot melt, or with a hot melt adhesive coating having strips of pressure-sensitive adhesive to aid location. A suitable tape may be formed by methods known per se, for example it may be extruded and orientated prior to electron beam cross-linking and then given a high-energy electron beam dose (as known per se) such that most of the longitudinal shrinkage is locked in and only 25 to 50% remains. This tape would be wrapped around the collar and spirally wrapped down the fingers, over the part of the cable carrying the blocking sealant and onto the cable, ending on the cable surface. During the induction heating process, heat would be concentrated by the coil design on the portion of the cable to be blocked and minimized at the two ends to reduce the risk of excessive shrinkage forces causing the tape to move or slip on the collar or the cable surface. The tape would attempt to shorten in length and hence compress and conform to the underlying components, and the adhesive coating would seal the wrapped tape together and help seal it to the cable bundle and the interior of the collar. An additional benefit of the relatively low tape shrinkage ratios would be that the forces applied to the blocked part of the cable during the process would be relatively low, so reducing the risk of damage to heat-sensitive wire insulation.

For this system to be optimally effective, it is preferred to use an adhesive blocking profile that is as wide as possible to reduce the height of the block adhesive within the sleeve before the shrinking process. When blocking adhesive bodies are stacked together to achieve a desired blocking sealant volume, the total stack height may be much larger than the diameter of the cable, which would necessitate a higher-than-desirable shrink ratio for the tape. This can be avoided by using a single layer of blocking sealant, for example a sealant tape having a substantially flat profile, or a new form having multiple projections for insertion between the wires (colloquially named by the present inventors as “millipede tape”), of width preferably substantially equal to the optimum width of the block and with
a low profile compared to stacked smaller bodies of blocking sealant, e.g. only 7mm wide. The single profile also makes the process simpler by reducing the number of components.

A further aspect of the present application accordingly provides an assembly or kit as hereinbefore described, wherein the said sleeve is provided by a sheet or longitudinally-slit sleeve wrapped around, or suitable for wrapping around, the wiring bundle and the collar or collar boss, and securing means are provided in the form of a pressure-sensitive adhesive tape or a tie wrap to secure the wrapped sleeve in place, especially when inductive heating is to be subsequently applied.

It has been noted above that single-wrapped closures such as the aforementioned sheet or slit sleeve secured by adhesive tape or overlap adhesive bond, for example with pressure-sensitive adhesive, work surprisingly well, with or without additional securing tie wraps or tapes, when the wrapped sleeve is to be heat shrunk by inductive heating of the assembly as described in the aforementioned co-pending applications. This unexpected success of adhesive wrap-around closures for heat-shrinkable sleeves, which may be due to the inductive heating generating the shrinkage heat from the inside of the assembly, is in sharp contrast to the external application of hot air or flame which notoriously caused adhesive wrap-around closures to fail in the past.

Such inductive heat shrinkage of adhesive-closed side-entry ("wrap-around") heat-shrinkable sleeves may thus be regarded as an invention in itself. The inductive heat may be generated by inductively-heatable material (for example particles carried by the sleeve, preferably on or near its inner surface; or carried on or in a coating, for example a hot melt adhesive coating, on the inner surface of the sleeve; or carried by sealant material on or within the wiring bundle, which may have the purpose of sealing interstices within the wiring bundle) or by the metal conductors of the wires within the bundle, or by any combination of these.

A further aspect of this invention provides an assembly or kit as hereinbefore described, wherein the said optional sleeve is provided in a tapering form which in use can be
arranged tapering from the said collar or collar boss towards the surface of the wiring bundle, prior to any heat shrinkage of the sleeve.

Use of a tapered tube or tapered slit sleeve in this way may alleviate large unresolved shrinkage which could occur in straight tubular sleeves when applied to a tapered collar or boss. A preferable solution, however, may be to use the aforementioned spirally-wrapped tape to form the said tapering sleeve.

Accordingly, a further aspect of this application provides an assembly or kit as aforesaid in which the aforementioned tapered form of the said sleeve is provided by wrapping two or more laps of a rubber or plastics tape around a correspondingly tapering part of the said collar or collar boss, the said tape preferably carrying heat-activatable sealant or adhesive material (for example as described in the aforementioned two British Patent Applications).

The tape will preferably carry a coating of inductively-heatable sealant, preferably as described hereinbefore. The tape will preferably be wrapped spirally all the way from the surface of the wiring bundle, over the narrower end of the tapering collar or boss, to its wider end, with the successive spiral wraps preferably arranged to minimise potential leakage paths.

A further aspect of this invention provides acollar-and-clamping-member assembly or kit as hereinbefore described, wherein the said collar and sleeve are suitable for use with a range of bulkheads and/or wiring bundle diameters, and the said clamping member is selected from a range of such clamping members all adapted to fit the said collar (with or without gripping the sleeve), and each respectively adapted to secure the assembly to a specific bulkhead formation. The advantages of this aspect have already been hereinbefore described.

A further aspect of this application provides an assembly comprising the said collar and separate clamping member as hereinbefore described, arranged so that the said sleeve is not gripped between the collar and the clamping member, preferably with sealant material
sealing between the clamping member and the collar. These alternative forms of assembly, in which the sleeve is not gripped between the collar and the clamping member, may be convenient for some purposes, but may tend to provide a lower degree of integrity or rigidity than the clamped forms, and may therefore be generally less preferred. For example, a tape could be spirally wound around the tapered portion of the collar projecting from the clamping member after the clamping member had been applied to the collar.

A further aspect of this invention provides a method of making a wiring bundle bulkhead feedthrough assembly as hereinbefore described by inductive heating, wherein (i) the inductive heating is effected on a tapering formation by means of a correspondingly tapering coil and/or (ii) the inductive heating is effected by means of a coil having varied spacing between its adjacent turns, so as to vary the field produced along the coil length in use. Use of an induction coil which tapers more or less to follow the taper of the assembly to be inductively heated may enable more effective application of the induction heating field to the assembly. The tapered or variably-spaced induction coil itself, preferably suitable for inductively heating a wiring bundle bulkhead feedthrough assembly as hereinbefore described, may accordingly be regarded as an inventive feature in its own right.

A wrap-around sheet or sleeve of heat-shrinkable plastics material suitable for use in a further aspect of this invention carries inductively-heatable material, preferably in a coating on the surface of the sheet or sleeve which will face inwards in use, together with adhesive, preferably pressure-sensitive, for securing the sheet or sleeve in its wrapped position, preferably by means of an overlap adhesive bond, prior to inductive heating to shrink the plastics material. This kind of wrap-around inductively heat-shrinkable sleeve may be preferred for making the assemblies hereinbefore described.

It may be preferable for induction heating coils used for forming the assemblies hereinbefore described to incorporate locating means for locating the components to be heated in a precise pre-determined position within the field generated by the coil in use. Such locating means might, for example, comprise a jig-like structure into which suitably-
formed parts of the collar would fit, thus requiring each successive collar and sleeve and the wiring bundle passing therethrough to be placed in substantially the same position for each successive induction heating operation in an assembly line process such as an automotive harness shop.

All the aspects of this application hereinbefore described are intended to be useable in any appropriate combinations, with appropriate adaptations to the specific components and circumstances involved in each case, which will be apparent to those skilled in this field of technology. The inventions accordingly include the corresponding combinations of methods and uses of the equipment, components, and assemblies hereinbefore described.

Some further aspects of the inventions hereinbefore described will now be further illustrated with reference to the accompanying drawings, wherein:

Figure 10 is a perspective view of a two-part collar and clamping ring assembled together in open formation ready for closure around a wiring bundle;

Figure 11 is a view from the other side of the clamping member shown in Figure 10 with the collar removed;

Figure 12 is a perspective view of the collar and clamping member shown in Figure 10 when closed and fitted into an automotive bulkhead; and

Figure 13 shows in partial cross section one half of the Figure 10 assembly with a heat-shrinkable sleeve added to illustrate the clamping of the sleeve between the collar and the clamping member.

Referring to Figure 10, the two identical collar portions 310, injection moulded from known plastics materials, have tapering flexible finger portions 311 and mutually interlocking tongue and slot 312, 313 which fit together when the two half collar portions are brought together into a closed position. An annular gripping projection 314 and a larger locking projection 315 fit respectively into inwardly-facing hollows 316, 317 in the two-part clamping member 320, the hollow 316 containing gel sealant material 319 as hereinbefore described substantially filling the space around the clamping projection 314. Locking projection 315 fits snugly into its corresponding hollow 317 in the clamping
member to lock the collar into the clamping member so as substantially to prevent linear relative movement of the collar and clamping member. Lugs 318 projecting from the collar portions will be gripped between abutting portions of the clamping member when in the closed position to resist rotational movement of the collar within the clamping member.

The clamping member, also injection moulded from known plastics materials, comprises two generally semi-annular portions 320 housing the aforementioned hollows, and a tongue portion 321 extending from one of the semi-annular portions adapted to close the side-entry slot in an automotive bulkhead (see Fig. 12) with which this feedthrough assembly is to be used. Bolt holes 322 are provided in extensions of the semi-annular portions 320 and the tongue 321 for securing the assembly to such a bulkhead in use. The semi-annular portions 320 of the clamping member are connected together in use by a decoupleable hinge 323 (partly obscured in this view) and snap-fit securing means 324, 325 which hold the assembly closed around the wiring bundle in use.

In Figure 11, looking from the other side of Figure 10 with the collar removed, the parts are numbered correspondingly to Figure 10. However, this view shows the face of the clamping member which in use will abut against the bulkhead through which the wiring bundle is to be fed, and a bead of gel sealant material 325 is accordingly shown in a suitable channel or depression, which sealant will in use form a seal against the surface of the bulkhead as hereinbefore described to resist transmission of fluids or noise through the bulkhead aperture. The gel sealant in this example also illustrates the aforementioned portions 326 which extend into the region which will overlie the bulkhead aperture, indicated by broken line 327, onto which region mastic sealant will be applied in continuity with a line of such sealant applied to the surface of the bulkhead which will surround the region enclosed by the broken line 327.

Figure 12 shows the Figure 10 assembly of collar and clamping member in closed position inserted in a wiring bundle feedthrough aperture of a bulkhead 330, which is shown as transparent in this view for illustrative purposes. The gel sealant beads 325 (see Figure
11) are out of sight, being compressed between the clamping member and the bulkhead to about 50% of the original bead thickness in the direction of compression. The attachment bolts which attach the assembly to the bulkhead are omitted for clarity. The neck or extension 321 of the clamping member covers and seals the extended part of the cable entry aperture in the bulkhead 330. The ends of the lugs 318 projecting from the collar parts 310 can be seen performing their anti-rotation function between the abutting portions of the closed clamping member 320. The tapered fingers 311 of the collar project through on the other side of the (transparent) bulkhead as shown.

In the partially-sectioned view of Figure 13, a wrapped or tubular heat-shrinkable sleeve 340 has been shrunk over the clamping projection 314 by inductive heating as hereinbefore described, and is sealed by the gel 319 within the gel-containing hollow 316 in the clamping member 320. The sleeve 340 extends beyond the clamping projection 314 towards the locking projection 315 which fits snugly into the corresponding hollow 317 in the clamping member 320, as previously described. The tapering collar fingers 311 form a smooth transition for the sleeve from the collar onto the portion of the wiring bundle 350 shown in broken lines which is to be gripped by the far end of the sleeve in use. The blocking sealant, which preferably blocks the interstices of the wiring bundle after the heat-shrinking operation has caused the blocking sealant to flow, is indicated schematically by the cross-hatched area 351 underlying the driver sleeve 340.

**WALL OR BULKHEAD FEEDTHROUGH GB4**

Our British Patent Application No.9613580.1 (RK552 GB4), the entire disclosure of which is incorporated herein, adds advanced designs, embodiments, materials, components, and techniques to the feedthrough assemblies, kits, and methods hereinbefore described.

A heat-shrinkable (preferably fabric) article suitable for use in aspects of the present invention hereinbefore described is capable of being wrapped around an object about which the article is to be heat shrunk, the respective end regions of the article having
fastening means capable of fastening the wrapped article around the object before and during heat shrinking of the article, wherein the fastening means of at least a first one of the end regions comprises a fastening strip extending transversely to the shrinkage direction of the article, which fastening strip is attached to the fabric article substantially only along one edge of the strip which lies nearer to the other end region of the article (measuring along the surface of the article).

The precise shape of the fastening strip is not critical to the invention. The strip may be composed of a number of separate pieces and/or may be of curved or irregular shape, but a single substantially straight-edged strip extending substantially all the way across the shrinkable article (fabric) will generally be preferred. It will be understood that the fastening of the strip "along one edge" means that the fastening is effected along the edge region of the strip, not necessarily exactly at its edge.

A great advantage of the specified attachment of the fastening strip to the shrinkable (preferably fabric) article is that, when the said first end region having the said fastening strip is capable of being wrapped and fastened outside and overlapping the other end region of the article, the subsequent heat shrinkage forces will be less likely to peel open the overlapping fastening than would be the case if the whole surface of the fastening strip were attached to the shrinkable article. In the present case, the shrinkage forces will act on the fastening strip only through its attached leading edge ("leading" in the direction of the shrinkage "pull" on the strip), resulting in less peeling leverage than may be the case when the shrinkage forces act over the whole strip surface including its trailing edge. This effectively "hinged" attachment of the fastening strip to the shrinkable article may help to alleviate the problems of bond failure which are well known to occur when adhesive overlap bonds are used to fasten wrap-around sleeves.

Although the said fastening strip attached to one end region of the heat-shrinkable (preferably fabric) article could interact with formations integral with the other end region of the article in order to fasten it in wrapped-around arrangement, it will usually be preferred that the fastening means of the other end region of the article comprises a second
fastening strip extending transversely to the shrinkage direction of the article and capable of engaging with the strip of the said first one of the end regions. In this case, the said second strip is preferably also attached to the shrinkable article along one edge of the strip which lies nearer to the said first end region, so that both fastening strips will be pulled by their leading edges in the direction of fabric recovery thus reducing the risk of opening of the fastened wraparound article during shrinkage.

Any form of fastening strip capable of interacting with the fastening means at the other end of the shrinkable article to secure the wrapped-around article in use may be used for the present purposes, but it is preferred that the fastening strip of the said first end region and the fastening means of the other end region together comprise a "touch-to-close" fastener, preferably of the type well known under the Trade Mark "VELCRO", or similar thereto.

Preferably, the fastening strip(s) is(are) attached to a fabric heat-shrinkable article by sewing along the said edge of the strip(s). Other forms of attachment, for example stapling or bonding with high strength (preferably curable) adhesives may also be useable, but sewing is generally preferable, being well suited to use on fabric articles. The specified edge attachment of the fastening strip(s) may be applicable to heat-shrinkable articles made of plastics film, especially when non-penetrative attachment techniques such as the aforementioned high strength adhesives are used. However, penetrative attachment such as the preferred sewing may cause such film articles to tear during shrinkage, whereas it is a unique advantage of heat-shrinkable fabric articles that they can be highly resistant to such tearing or splitting during shrinkage.

It is preferred for the present purposes that the heat-shrinkable fabric article have a polymeric sheet laminated to one of its main surfaces, for example a sheet of low density polyethylene. Whether or not the said laminate is present, the heat-shrinkable fabric article preferably carries a heat-activatable (preferably induction-heatable) sealant layer on one of its main surfaces, preferably the surface which does not have the aforementioned polymeric sheet laminate which is preferably present. Heat-shrinkable fabric articles of
this general kind are nowadays well known from a number of commercially available products supplied by Raychem, and from a number of Raychem patents, for example EP-
(RK357), the disclosures of all of which are incorporated herein by reference. Suitable
structures and techniques for making the fabric articles for the present purposes may
readily be selected by persons familiar with such technology. As an alternative to coating
the heat-activatable sealant on the fabric article, a separate layer of such sealant could be
applied to the object about which the fabric article is to be shrunk in use, followed by
shrinking of the fabric article resulting in consolidation of the sealant and the fabric.

This new form of heat-shrinkable article (hereinafter referred to for brevity in terms of the
preferred fabric) with the edge-attached fastening strip(s) is regarded as an invention in its
own right, and will preferably be used in an assembly, kit, or method as hereinbefore
described. It is an advantage of the induction heating preferably used to block the wiring
bundles in the wall or bulkhead feedthroughs hereinbefore described, that the fastening
means (eg. "VELCRO" strips) is less affected by the heat generated inside the adhesive
and wires enclosed by the wrapped fabric article than would be the case if the wrapped
article were shrunk by external application of heat, for example using known flame or hot
air guns. The fastening means is thus more likely to survive the shrinkage in a state to
retain the wrapped article in place when the induction heating is used.

When a blocking sealant or adhesive is used to fill interstices within the wiring bundle
enclosed by the shrinking fabric article, the fastening means need only act as a securing
process aid until such time as the blocking adhesive has flowed and solidified to hold the
wrapped fabric article in place. However, a re-openable fastening such as the preferred
"VELCRO" closure may advantageously facilitate re-opening of the wrapped heat-shrink
article by providing a clear starting point for convenient gripping to unwrap the article
after heating to re-soften the blocking adhesive.

As an alternative to the aforementioned edge-attached fastening strips, the wraparound
shrinkable article for bulkhead feedthrough purposes could be sewn together, for example
using lightweight sewing equipment which can readily be moved into and out of position for use, for example on an automotive harness production line. It may be useful in some circumstances to use as alternatives sewn, stapled or adhesive-overlap closures of wraparound fabric sleeves, preferably carrying the aforementioned inductively-heatable blocking adhesive, for example fabric sleeve closures similar to those described for wiring splice protection in co-pending International Patent Applications No.PCT/GB96/01063 (RK512) or No.PCT/GB96/01061 (RK520), the disclosures of which are incorporated herein by reference.

When the blocking adhesive is to be used, it is usually desirable to open up the wiring bundle in order to allow the blocking adhesive to be inserted between the wires within the bundle in addition to or instead of applying bodies of the adhesive to the outside of the bundle. With this in mind, a device and method for separating a bundle of elongate flexible objects (for example the aforementioned wiring bundle) into two or more smaller sub-bundles is now described, being suitable for use in further aspects of the present invention. This device for separating a bundle of elongate flexible objects into two or more smaller sub-bundles comprises a support having a row of at least two projections (preferably substantially rigid) upstanding from the support, which projections are capable of being inserted into (preferably extending through) the bundle to divide it into the said sub-bundles in such orientation that angular movement of the row in a plane substantially normal to the direction of insertion of the projections into the bundle increases the lateral spacing between the sub-bundles.

A flat support with substantially straight projections extending from its flat surface may be preferred as a simple embodiment of this concept, although other shapes and orientations of the support and projections are not excluded. To facilitate insertion of the projections into the bundle, it may be preferred that each of the said projections has an elongate cross-sectional shape in a plane substantially normal to the said direction of insertion and that the projections are arranged with their elongate shapes lying substantially parallel with one another so that they can be inserted in the bundle with their elongate cross-sectional shapes all pointing along the bundle prior to the said angular movement. A preferred form of this
device comprises three or more of the said projections arranged in a substantially straight row.

It will be understood that a row of such projections having a total row length greater than the diameter of the bundle into which the projections are to be inserted may be inserted at an angle of less than \(90^\circ\) to the longitudinal axis of the bundle, thus sub-dividing the bundle with the ends of the row lying within or close to the original diameter of the bundle. While a row of only two such projections could be inserted with the projections aligned on the central axis of the bundle, a row of three or more such projections is preferably inserted at the aforementioned acute angle across the axis if three or more sub-bundles are desired. When the inserted row of projections is rotated in a plane substantially normal to the direction of insertion of the projections to bring the row towards an angle of \(90^\circ\) to the longitudinal bundle axis, the length of the row will increasingly project beyond the original diameter of the bundle, so that the respective projections will increasingly separate the sub-bundles from one another.

This method of separating a bundle of elongate flexible objects into two or more smaller sub-bundles, comprises inserting the row of projections of the aforementioned device into the bundle to divide it into the said sub-bundles and effecting angular movement of the row to increase the lateral spacing between the sub-bundles. This method of opening the original bundle is especially suited to a method of blocking interstices within a bundle of elongate objects using the aforementioned separating device as aforesaid, inserting blocking material between the separated sub-bundles, and removing the separating device, preferably to allow the sub-bundles to close around the inserted blocking material. The extent to which the sub-bundles close around the blocking material is not critical. External pressure may be applied to pack the sub-bundles closely together around the blocking material if desired. Preferably, the blocking material is heat-activateable (preferably induction-heatable) sealant material and is heated to cause it to flow and block the interstices within the bundle, as hereinbefore described.
This bundle-separating device and method are regarded as inventive in themselves, and are especially suited to use in a method of making a wiring bundle bulkhead feedthrough as hereinbefore described.

Advantageous tape forms of blocking material suitable for use in an assembly kit or method as hereinbefore described and in further aspects of the present invention, for example by threading between the sub-bundles and/or for wrapping around the outside of the main bundle, will now be described. This elongate tape of sealant material has transversely-extending ridges of the sealant material projecting from one or both of its main tape surface (colloquially “millipede tape”) or has transverse corrugations extending across its tape width (colloquially “sine-wave tape”), the ridges or corrugations preferably being regularly spaced along the tape, preferably at intervals within the range from 2 to 10 mm, more preferably 2.5 to 5 mm. The height of the ridges or corrugations is not critical, but the ridges may conveniently be from 2 to 5 mm high on either side of the tape and the total height from peak to trough of the corrugations may conveniently be from 4 to 10 mm. A preferred form of the ridged tape may have the said ridges projecting from both of its main tape surfaces, preferably with the ridges on one of the tape surfaces substantially aligned with those on the other surface or staggered substantially centrally between those on the other surface. Suitable heat-activateable adhesive materials and inductively-heatable metal particles for rendering these adhesives inductively heatable include those hereinbefore described. The shaped tapes may be produced, for example, by moulding the materials in discrete lengths in suitable rigid or convoluted moulds, or by continuous extrusion of a flat tape which is subsequently passed while still warm through shaping means such as intermeshing corrugating gears to produce the ridged, and especially the preferred corrugated, forms of tape.

Specific embodiments of further aspects of the invention will now be described with reference to the accompanying drawings wherein:-

Figure 14 shows schematically in perspective a heat-shrinkable fabric article having the aforementioned edge-attached fastening means;
Figure 15 shows schematically in edge view the article of Figure 14 wrapped around and fastened by the said fastening means;

Figure 16 shows schematically in a more detailed edge view the structure of the article shown in Figure 14;

Figure 17 shows schematically in partial section the article wrapped as shown in Figure 15 around a unitary collar-and-plate bulkhead feedthrough assembly with a wiring bundle extending therethrough, prior to shrinking of the fabric sleeve;

Figures 18A to 18C illustrate an advanced design of the unitary collar-and-plate assembly as previously described in co-pending application 9606393.8, but incorporating advanced design features similar to those described for the collar and separate clamping plate assembly in co-pending Application Number 9611111.7;

Figures 19A to 19C show schematically in top, side, and end views one form of the aforementioned device for separating a wiring bundle into a number of sub-bundles;

Figures 20A and 20B respectively show in top view the device of Figure 19 as initially inserted into a wiring bundle and as subsequently rotated to separate the resulting sub-bundles;

Figure 21 shows schematically in perspective a preferred form of blocking adhesive tape having aligned ridges extending from both its surfaces (the aforementioned so-called "millipede tape");

Figure 22 shows a form of blocking adhesive tape having staggered ridges projecting from its respective surfaces (so-called "centipede tape");

Figure 23 shows in schematic perspective an undulating or corrugated form of blocking adhesive tape (so-called "sine-wave tape");

Figures 24A and 24B show in perspective front and rear views of a modified version of the Fig.18 construction having a rubber grommet 90 fitted in a suitable aperture in the bulkhead securing plate 32; and

Figure 25 shows front and rear perspective views of a suitable form of the grommet 90.

Referring to Figure 14, a known heat-shrinkable fabric 410 having heat-shrinkable filaments extending in its longitudinal direction as illustrated has one part of a "VELCRO" touch-to-close fastener 412 attached near one end of the fabric by lines of stitching 414
along that edge of the fastener part which is closest to the other end of the fabric article. The complimentary part of the "VELCRO" fastener 416 is attached to the other end region of the article by stitching 418. This part 416 of the fastener is spaced from the adjacent end of the fabric article to leave a tail 419 for purposes described hereinafter.

In Figure 15, the fabric article 410 is shown wrapped around and fastened together by the fastener strips 412, 416 so as to leave the free end tail 419 on the inside of the wrapped enclosure. On heat shrinking of the fabric, shrinkage forces are generated in the direction of the two arrows in Figure 15, but these forces pull respectively on the attached leading edge only of the fastener parts 412, 416, thus tending not to pull apart the remote unsewn edges of the respective fastener parts. The tail 419 serves to bridge the overlap "step" between the outer and inner layers of the fabric article, thus facilitating sealing of the wrapped enclosure for cable-blocking purposes.

Figure 16 shows in more detail a preferred structure of the fabric article 410, comprising a central layer of woven fabric 420 having a laminate of low-density polyethylene 422 on the surface of the fabric which will face outwards in use, and a coating of the aforementioned inductively-heatable blocking adhesive 424 on the surface of the fabric which will face inwards in use. The fastener parts 412, 416 are sewn onto this laminated structure as described above. In this and all forms of the sleeves, it may be preferred to use fastener strips of a colour which contrasts with that of the sleeve itself, thus facilitating operator accuracy in joining the fasteners together under production-line conditions, e.g. for automotive harness assembly.

As shown schematically in Figure 17, the fabric article 410 has been fastened together around the projecting collar boss 430 permanently attached to plate-like member 432 of an automotive bulkhead feedthrough assembly as generally described in the aforementioned co-pending application No.9606393.8. The sleeve has a shrinkage ratio of approximately 3:1 in the circumferential direction around the collar boss 430, through which a wiring bundle or harness 440 is shown projecting. Blocking adhesive tape (not shown) is inserted in schematically-indicated apertures 442 between sub-bundles of wires formed within the
bundle 440 for the purpose of forming a block in region of the bundle between the parallel broken lines. This blocking adhesive within the wiring bundle, together with the adhesive layer 424 on the inner surface of the wrapped sleeve 410, will subsequently be inductively heated to shrink the sleeve 410 and block all interstices within the resulting tightly shrunk enclosure around the bundle 440 and within the bundle itself. The projecting collar boss 430 may have a ridge or other formation to resist “milk-off” of the sleeve during shrinking thereof, as indicated by broken lines 434, but it may be preferred, for simplicity, to omit such ridges and use temporary clamps or ties 436 to hold the sleeve in place on the collar boss 430 until shrinkage is complete.

Figures 18A to 18C show perspective views of the unitary collar-and-plate design having features generally corresponding to those described for the separate collar and clamping plate in Figs. 10 to 13. It will be apparent without further explanation that the structures shown in Figures 18A to 18C correspond to the aforementioned two-part structure, except that the projecting collar boss 430 is now integral with the bulkhead securing plate 432, thus advantageously simplifying the structure and eliminating the need for the previously described locking structures and gel seals between the separate collar and clamping plate. The aforementioned clamping or other means to prevent “milk-off” are preferably used because, in the present structure, the sleeve is no longer clamped between the separate collar and fixing plate.

Figures 19A to 19C schematically illustrate a bundle-separating device comprising a flat support 450 with projections 452 rising substantially vertically therefrom. The projections having an elongate cross-sectional shape generally aligned with the longer dimension of the support, on which the projections are arranged in a staggered row sloping at an acute angle to the longer dimension of the support. The device may be made of metal or of sufficiently rigid engineering plastics materials.

In Figure 20A the support 450 is overlaid by wiring bundle 460, through which the projections 452 have been inserted to sub-divide the bundle, the illustrated row of projections being inclined at an angle of less than 90° to the longitudinal axis of the wiring
bundle 460. In Figure 20B, the support 450 has been rotated in the direction of the arrow, thus bringing the row of projections 452 closer to an angle of $90^\circ$ to the longitudinal axis of the wiring bundle 460. Since the total length of the row of projections is greater than the original diameter of the wiring bundle, this rotation has the effect of forcing apart the sub-bundles, and this effect is enhanced by the illustrated elongate shape of the projections which now faces transversely of the longitudinal bundle axis to hold the sub-bundles further apart than would be the case if round projections were used. The simplicity of this device and this method of sub-dividing the wiring bundles may be advantageous in assembly lines such as automotive harnessing shops, where time is at a premium.

Figure 21 illustrates schematically one preferred form of inductively-heatable blocking adhesive tape for insertion between the sub-bundles as hereinbefore described. In this form, the tape 470, for example of materials as described in the aforementioned co-pending applications, is formed into ridges 472 on its upper (as illustrated) surface substantially in alignment with corresponding ridges 474 on its lower (as illustrated) surface. The spacing $a$ (preferably regular spacing) between adjacent ridges may be 2.5 mm and the height $b$ of the ridges in this example is also about 2.5 mm.

Figure 22 shows a corresponding tape 470 in which the spacing between adjacent ridges is about 5 mm, the height of the ridges being again about 2.5 mm, and the ridges 472 on the upper surface (as illustrated) are uniformly staggered between the ridges 474 projecting from the lower surface (as illustrated).

Figure 23 shows schematically in perspective one form of regularly undulating or corrugated inductively-heatable blocking adhesive tape 480, in which the distance $a$ between adjacent peaks of the corrugations is about 5 mm and the total trough to peak height $b$ of the corrugations is also about 5 mm.

These forms of blocking adhesive tape, especially the undulating or corrugated version shown in Figure 23, have been found advantageous for threading through sub-divided wiring bundles to enhance distribution of the adhesive within the bundle when heated to
fuse the adhesive and shrink the sleeve in manufacture of automotive bulkhead feedthroughs, as described in the aforementioned co-pending applications.

In Figure 24A and 24B, a grommet 490 has closed-ended apertures in the form of nipples 492, which can be cut open to permit insertion of additional wires or cables through the bulkhead after installation of the feedthrough assembly therein. This may be useful, for example, when optional extras such as air conditioning are fitted to an already assembled car. Four different diameters of nipple are illustrated, to accommodate wires or cables of different diameters, which should preferably be a tight fit in the elastomeric nipples. The example of the grommet 490 shown in Figure 25 is moulded from rubber with nipples 492 and with lips 494, 496 defining a groove 498 for snap-fitting of the grommet 490 into a suitably-sized aperture in the bulkhead fixing plate 430 (Fig.24).

**WALL OR BULKHEAD FEEDTHROUGH GB5**

Our co-pending British Patent Application No.9613594.2, the entire disclosure of which is incorporated herein, adds further developments of the late-insertion aperture principle described in Figures 24 and 25 for use in the advanced feedthrough assemblies, kits, and methods hereinbefore described.

A further aspect of the present invention accordingly provides a wiring bundle bulkhead feedthrough assembly comprising a surround member which in use is sealable around the bundle and to a bulkhead through which the bundle is to extend, wherein the said surround member incorporates at least one aperture for later insertion of additional elongate members through the assembly after the said surround member has been sealed around the bundle or to the bulkhead, the said aperture incorporating means whereby it is sealed before such later insertion and whereby it can be sealed around the additional elongate members after such insertion.
The surround member preferably comprises at least two parts which are closable around the wiring bundle in use, as hereinbefore described, and the said aperture(s) is (are) preferably formed at the closure interface between the parts.

The said aperture(s) is (are) preferably sealed at least partly by gel, through which, or between interfacing portions of which, the additional elongate members can be inserted.

By way of example, further embodiments of this invention will now be described with reference to the accompanying perspective drawings, wherein:-

Figure 26 shows a feedthrough surround member having additional elongate members extending through a late-insertion aperture in the collar portion of the surround;

Figure 27 shows the arrangement of Figure 26 with one of the surround parts removed;

Figure 28 shows an alternative design in which the additional elongate members extend through two separate apertures; and

Figure 29 shows the arrangement of Figure 28 with one of the surround parts removed.

Referring to figures 26 and 27, the feedthrough surround member, which is generally recognisable from the description hereinbefore of such members, incorporates a late-insertion aperture 514, through which an additional four-wire bundle 510 and a pipe or cable 512 have been inserted after positioning of the surround member around the main wiring bundle (omitted for clarity) of an automotive electrical harness. A channel 516 can be seen in Figure 27, which in practice contains gel sealant (omitted for clarity) for sealing the interface between the hinged parts of the surround member. This gel sealant (or other suitable sealant material, although gel is preferred) also seals the aperture 514 before the additional elongate members are inserted, and seals around the additional members when inserted.

In the generally corresponding arrangement of Figures 28 and 29, the additional elongate members 510, 512 are respectively inserted in separate late-insertion apertures 516, 518 formed at the interface between the assemblable parts of the surround, and the apertures are sealed by the sealant (omitted for clarity) present in practice in channel 520.
The late-insertion apertures could be provided away from the assembly interface, for example in the plate-like portion 530. Sealant, preferably gel, could be provided in the late-insertion nipple apertures described in the aforementioned Figures 24 and 25. Side-entry apertures such as those illustrated by the present Figures 26 to 29 may be preferable, since they allow assembly around additional elongate members at the time of installation of the surround member on the main wiring bundle, in addition to the late insertion of such members after installation on the bundle or in the vehicle or other bulkhead.

In all forms of the present invention, the sealant material will preferably be selected from mouldable materials, preferably thermoplastics, preferably non-foamed, although curable or cross-linkable and/or foamed materials are not necessarily excluded. The sealant will preferably be selected to be capable of co-moulding with, or over-moulding onto, the more rigid parts of the feedthrough assembly, sealants which are inherently not very (preferably substantially not at all) tacky, but will bond to the material of the rigid parts during the moulding process, therefore being preferred. For example, the aforementioned triblock copolymer gels tend to bond better to polypropylene or polyester (PBT) than to nylons. Pre-formed bodies of the sealant could alternatively be glued onto the more rigid parts using suitable adhesives known per se. The sealants will preferably have cohesive strength greater than their adhesive strength to the surfaces with which they will be in contact in use, thus enabling advantageous multiple re-entry to the sealed surfaces for repositioning during assembly or for repair or other purposes.

Soft rubbers or thermoplastic elastomers may be suitable as sealants for some designs, and it has been found in connection with the present invention that elastomeric materials of room temperature hardness not greater than Shore A 13 are preferable for commercially-acceptable ease of manual closure to seal side-entry feedthrough housings which compress the sealant between their opposed parts. Sealants of hardness not greater than Shore A 10, especially those of hardness not greater than Shore A 5, have been found particularly useful. Very much softer gel sealants, for example having room temperature hardness less than 200g measured on a Stevens Texture Analyser, have been found especially
advantageous in their "range-taking" ability to compensate for dimensional variations, defects, weld lines, roughness, etcetera, in the surfaces and apertures to be sealed. Materials, preferably gels, having a dynamic storage modulus $G'$ of less than 400kPa, preferably less than 300kPa, at temperatures from 20 to 80°C, or possibly 20 to 100°C, have also been found advantageous for the purposes of the present invention.

It has been further discovered according to the present invention that preferred sealants may be chosen from resilient materials, preferably rubbers or gels, having room-temperature compression force, measured on a 6mm thick circular disc of 25mm diameter by Instron Tensometer using compression jaws whose opposed compressing surfaces extend beyond all parts of the perimeter of the test disc, within the following range (a), preferably within the following ranges (a) and (b), especially, for maximum ease-of-closure and range-taking ability, within the following ranges (a) and (b) and (c).

(a) Resilient materials, preferably rubbers or gels, having 30% compression force of less than 200N, preferably gels having 30% compression force less than 100N, more preferably less than 50N.

(b) Resilient materials, preferably rubbers or gels, having 50% compression force less than 500N, preferably less than 400N, more preferably less than 300N, still more preferably gels having 50% compression force less than 200N, especially less than 100N or even less than 50N.

(c) Resilient materials, preferably rubbers or gels, having 60% compression force less than 500N, preferably less than 400N, more preferably gels having 60% compression force less than 300N, especially less than 200N.

Thermoplastic styrene-alkylene-styrene triblock copolymer elastomers and gels made therefrom, especially those hereinbefore mentioned, are particularly preferred.

The use of the preferred sealants outlined above to seal substantially rigid feedthrough parts against each other and/or against a wall or bulkhead in use constitutes a further aspect of the present invention, especially in view of the outstanding ability of the preferred sealants to seal at the aforementioned difficult "triple point".
CLAIMS: GB1

1. An assembly for forming a wall or bulkhead feedthrough for wiring bundles or other elongate articles, the assembly comprising (i) a substantially rigid collar of at least two hinged or separate pieces assembled to surround a portion of the bundle, (ii) a substantially rigid clamping member of at least two hinged or separate parts assembled around and gripping the collar pieces; or comprising the collar (i) and clamping member (ii) together with (iii) a rubber or plastics sleeve surrounding and gripping the collar and part of the bundle adjacent to the said portion, with the clamping member gripping together the collar and that part of the sleeve which is between the collar and the clamping member.

2. An assembly according to claim 1, wherein the sleeve is at least partly composed of heat-shrinkable plastics material and has been heat shrunk to grip the collar and the adjacent part of the wiring bundle or other elongate article.

3. An assembly according to claim 1 or 2, wherein the clamping member is of generally plate-like form and is adapted to be secured face-to-face against a bulkhead through which the wiring bundle or other elongate article is to extend in use.

4. An assembly according to any preceding claim, wherein the clamping member carries sealant material (a) at a position to be capable of forming a seal against a bulkhead through which the wiring bundle or other elongate article is to extend in use, and/or (b) at a position forming a seal against the gripped outer surface of the sleeve, and/or (c) at a position forming a seal between mutually-abutting surfaces of the assembled clamping member parts.

5. An assembly according to claim 4, wherein the sealant material carried by the clamping member at one or more (preferably all) of the said positions is gel.
6. An assembly according to any preceding claim, wherein the sleeve carries sealant material forming a seal between the sleeve and the collar and/or between the sleeve and the sleeve-gripped part of the wiring bundle or other elongate article.

7. An assembly according to any preceding claim, wherein sealant material substantially blocks the interstices between the wires in the wiring bundle.

8. An assembly according to claim 6 or 7, wherein the sealant material carried by the sleeve and/or substantially blocking the said interstices is heat-activated adhesive material, preferably a hot melt adhesive or a thermoset adhesive.

9. An assembly according to claim 8, wherein the heat-activated adhesive material carried by the sleeve and/or that substantially blocking the said interstices carries inductively-heatable particles and has been inductively heated to form the said sleeve seal(s) and/or to substantially fill the said interstices.

10. An assembly according to claim 9, wherein at least the heat-activated adhesive material substantially blocking the said interstices is not itself significantly inductively-heatable and has been activated by heat derived from inductive heating of the wires forming the wiring bundle.

11. An assembly according to any preceding claim, comprising a tapering formation, preferably of flexible fingers, extending from (and preferably integral with) the collar towards the said sleeve-gripped part of the wiring bundle or other elongate article to provide a graduated transition of the sleeve from the collar to the bundle, the sleeve and the said sleeve-gripped part of the bundle preferably extending beyond the end of the tapering formation.

12. An assembly according to any preceding claim, wherein the collar and the clamping member respectively are formed to interlock with each other to grip the sleeve.
13. An assembly comprising the collar (i) surrounding a wiring bundle or other elongate article and the sleeve (ii) surrounding and gripping the collar and the adjacent part of the bundle or other elongate article according to any of the preceding claims, prior to installation of the clamping member thereon.

14. A kit of parts comprising a collar and a sleeve suitable for incorporation in an assembly according to any preceding claim.

15. A kit according to claim 14, additionally comprising a clamping member suitable for incorporation in the said assembly.

16. A kit according to claim 14 or 15, additionally comprising sealant material in a form suitable for insertion between wires in the said wiring bundle to substantially block interstices between the wires according to any of claims 7 to 10.

17. A method of making a wiring bundle bulkhead feedthrough assembly according to any of claims 1 to 13, comprising the steps of (a) assembling the said collar around the wiring bundle, (b) placing the said sleeve around, and causing it to grip, the collar and the said adjacent part of the wiring bundle.

18. A method according to claim 17, additionally comprising the step of (c) assembling the said clamping member to grip the collar and sleeve.

19. A method according to claim 17 or 18, additionally including the step of (d) activating heat-activatable adhesive material present in the assembly by inductive heating according to claim 9 or 10.

20. A method according to claim 17, 18, or 19, additionally including the step of (e) securing (and preferably sealing) the clamping member against a bulkhead through which the wiring bundle or other elongate article extends.
21. Use of an assembly according to any of claims 1 to 13, or a kit according to any of claims 14 to 16, or a method according to any of claims 17 to 20, to form an automotive bulkhead feedthrough, preferably between the engine compartment and the passenger compartment of a land vehicle.

GB2

22. An assembly for forming a wall or bulkhead feedthrough for a wiring bundle or other elongate article, comprising (I) a substantially rigid collar assembly of at least two hinged or separate pieces assembled to provide a projecting collar boss surrounding a portion of the bundle, and (IA) sealant material at a position to be capable of forming a seal (a) against a bulkhead through which the wiring bundle or other elongate article is to extend in use, and/or (b) between mutually-abutting surfaces of the assembled collar assembly parts, the sealant material preferably being a gel; or comprising the collar assembly (I) together with (II) a rubber or plastics sleeve surrounding and gripping at least part of the said collar boss and part of the bundle adjacent to the said portion.

23. An assembly according to claim 22, wherein the sleeve is at least partly composed of heat-shrinkable plastics material and has been heat shrunk to grip the collar boss and the adjacent part of the wiring bundle or other elongate article.

24. An assembly according to claim 22 or 23, wherein the collar assembly includes a generally plate-like part which is adapted to be secured face-to-face against a bulkhead through which the wiring bundle or other elongate article is to extend in use.

25. An assembly according to any of claims 22 to 24, wherein the collar assembly carries sealant material (a) at a position to be capable of forming a seal against a bulkhead through which the wiring bundle or other elongate article is to extend in use, and/or (b) at a position forming a seal between mutually-abutting surfaces of the assembled collar assembly parts.
26. An assembly according to claim 25, wherein the sealant material carried by the collar assembly at one or more (preferably all) of the said positions is gel.

27. An assembly according to any of claims 22 to 27, wherein the sleeve or tape carries sealant material forming a seal between the sleeve and the collar boss and/or between the sleeve and the part of the wiring bundle or other elongate article gripped thereby.

28. An assembly according to any of claims 22 to 27, wherein sealant material substantially blocks the interstices between the wires in the wiring bundle.

29. An assembly according to claim 27 or 28, wherein the sealant material carried by the sleeve and/or substantially blocking the said interstices is heat-activated adhesive material, preferably a hot melt adhesive or a thermoset adhesive.

30. An assembly according to claim 29, wherein the heat-activated adhesive material carried by the sleeve and/or that substantially blocking the said interstices carries inductively-heatable particles and has been inductively heated to form the said sleeve seal(s) and/or to substantially fill the said interstices.

31. An assembly according to claim 29, wherein at least the heat-activated adhesive material substantially blocking the said interstices is not itself significantly inductively-heatable and has been activated at least partly by heat derived from inductive heating of the wires forming the wiring bundle.

32. An assembly according to any of claims 22 to 31, comprising a tapering formation, preferably of flexible fingers, extending from (and preferably integral with) the collar boss towards the said gripped part of the wiring bundle or other elongate article to provide a graduated transition of the sleeve from the collar boss to the bundle, the sleeve and the said gripped part of the bundle or other elongate article preferably extending beyond the end of the tapering formation.
33. An assembly comprising the collar assembly (I) surrounding a wiring bundle or other elongate article and the sleeve (II) surrounding and gripping the collar boss and the adjacent part of the bundle according to any of claims 22 to 32, prior to heat shrinking of the sleeve.

34. A collar assembly per se or a kit of parts comprising a collar assembly and a sleeve suitable for incorporation in a feedthrough assembly according to any of claims 22 to 33.

35. A kit according to claim 34, additionally comprising sealant material in a form suitable for insertion between wires in the said wiring bundle to substantially block interstices between the wires according to any of claims 28 to 31.

36. A method of making a wall or bulkhead feedthrough assembly for a wiring bundle or other elongate article according to any of claims 22 to 33, comprising the steps of (a) assembling the said collar assembly around the wiring bundle or other elongate article, and (b) placing the said sleeve around, and (c) causing it to grip, the collar boss and the said adjacent part of the wiring bundle or other elongate article.

37. A method according to claim 36, additionally including the step of (d) activating heat-activatable adhesive material present in the assembly by inductive heating according to claim 30 or 31.

38. A method according to claim 36 or 37, additionally including the step of (e) securing (and preferably sealing) the collar assembly against a bulkhead through which the wiring bundle or other elongate article extends.

39. An assembly, kit, or method according to any preceding claim, wherein the said sleeve is provided by a rubber or plastics tape or slit sleeve wrapped around, or suitable for wrapping around, the stated components of the assembly.
40. An assembly or method according to claim 39, wherein the said tape or slit sleeve is secured in its wrapped arrangement by an adhesive bond, preferably an overlap adhesive bond.

41. An assembly, kit, or method according to claim 39 or 40, wherein the said tape or slit sleeve is shrinkable (preferably heat-shrinkable) in the direction of wrapping by not more than 50%, preferably not more than 30%, more preferably not more than 20%, and preferably by at least 5%, more preferably at least 10%, of its unshrunken length in that direction.

42. An assembly, kit, or method according to any preceding claim, wherein the said collar or collar boss and/or the said tapering formation if present, is or are curved or angled to cause or follow a change in the direction of the wiring bundle or other elongate article extending through the assembly in use.

43. An assembly, kit, or method according to any preceding claim, wherein the said clamping member or the said collar assembly includes a laterally-projecting plate-like formation adapted to block (and preferably to rigidify) a side-entry access slot in a bulkhead with which the feedthrough is to be used.

44. Use of an assembly, kit, or method according to any preceding claim to form an automotive bulkhead feedthrough, preferably between the engine compartment and the passenger compartment of a land vehicle.

GB3

45. An assembly or kit according to any of claims 1 to 16, wherein the said pieces of the collar are substantially identical to each other.

46. An assembly or kit according to claim 45, wherein the said collar pieces have interfitting formations, preferably at least one male interfitting formation and at least one
female interfitting formation on each piece, arranged to constrain the alignment of the said collar pieces to a single pre-determined assembled collar configuration.

47. An assembly or kit according to claim, or any of claims 1 to 16, 45 or 46, wherein the collar has at least two outwardly-projecting formations, preferably flanges, spaced from each other along the elongate path to be occupied by the wiring bundle or other elongate article in use, and the clamping member has corresponding inwardly-facing hollows arranged to receive the said projecting formations.

48. An assembly or kit according to claim 47, wherein one of the said projecting collar formations, preferably at or near one end of the collar, is a locking projection arranged to fit into its corresponding hollow in the clamping member sufficiently closely, in the absence of the said sleeve, to substantially prevent linear movement of the collar relative to the clamping member.

49. An assembly or kit according to claim 48, wherein the said locking projection projects outwardly further than the other said projecting formation(s), preferably in an arrangement such that an end of the said sleeve abuts against the locking projection.

50. An assembly or kit according to claim 47, 48 or 49, wherein one of the said projecting collar formations and its corresponding hollow in the clamping member constitute a gripping means arranged to receive and grip between them a part of the said sleeve.

51. An assembly or kit according to claim 50, wherein the said gripping means includes sealant material in the said hollow which forms a seal between the clamping member and the gripped part of the sleeve.

52. An assembly or kit according to any of claims 1 to 16, and 45 to 51, wherein the collar and the clamping member comprise stop formations which in use substantially prevent rotational movement of the collar relative to the clamping member.
53. An assembly or kit according to any of claims 1 to 16, 22 to 35, 39 to 43, and 45 to 52, wherein the said clamping member and/or the said collar comprise(s) at least two hinged or separate moulded plastics parts having gel sealant material thereon, preferably moulded thereon.

54. An assembly or kit according to any of claims 1 to 16, 22 to 35, 39 to 43, and 45 to 53, including gel sealant material comprising a styrene-ethylene/propylene-styrene triblock copolymer extended with at least 200, preferably at least 300, more preferably at least 400, parts by weight of substantially non-aromatic extender liquid which extends and softens the alkylene end-block of the said copolymer, per 100 parts by weight of the said copolymer.

55. An assembly or kit according to any of claims 1 to 16, 22 to 35, 39 to 43, and 45 to 54, wherein the said sleeve is provided by a sheet or longitudinally-slit sleeve, preferably heat-shrinkable, wrapped around, or suitable for wrapping around, the wiring bundle and the collar or collar boss, and securing means are provided in the form of a pressure-sensitive adhesive tape or a tie wrap to secure the wrapped sleeve in place, preferably prior to induction heating.

56. An assembly or kit according to any of claims 1 to 16, 22 to 35, 39 to 43, and 45 to 55, wherein the said sleeve is provided in a tapering form tapering from the said collar or collar boss towards the surface of the wiring bundle or other elongate article in use, prior to any heat shrinkage of the sleeve.

57. An assembly or kit according to claim 56, wherein the tapered form of the said sleeve is provided by wrapping two or more laps of a rubber or plastics tape around a correspondingly tapering part of the said collar or collar boss, the said tape preferably carrying heat-activated adhesive material.
58. An assembly or kit according to any of claims 1 to 16, and 45 to 57, wherein the said collar and sleeve are suitable for use with a range of wiring bundle or other elongate article diameters and/or bulkheads, and the said clamping member is selected from a range of such clamping members all adapted to fit the said collar (with or without gripping the sleeve), and each respectively adapted to secure the assembly to a specific bulkhead formation.

59. An assembly comprising the said collar and separate clamping member according to any of claims 1 to 13 and 45 to 58, arranged so that the said sleeve is not gripped between the collar and the clamping member, preferably with sealant material sealing directly between the clamping member and the collar.

60. A method of making a wall or bulkhead feedthrough assembly for a wiring bundle or other elongate article by inductive heating, preferably to form an assembly according to any of claims 1 to 13, 22 to 33, 39 to 43, and 45 to 59, wherein the inductive heating is effected (i) on a tapering formation by means of a correspondingly tapering induction coil and/or (ii) by means of an induction coil having varied spacing between its adjacent turns so as to vary the field produced along its length in use.

61. A method according to claim 60, wherein a wrap-around sheet or sleeve of heat-shrinkable plastics material carrying inductively-heatable material, preferably in a coating on the surface of the sheet or sleeve which will face inwards in use, is wrapped around parts of the said assembly and secured in its wrapped position, preferably by means of an adhesive tape or an overlap adhesive bond, followed by inductive heating to shrink the plastics material.

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62. An assembly, kit or method according to any preceding claim, wherein the said sleeve comprises a heat-shrinkable (preferably fabric) article capable of being wrapped around an object about which the article is to be heat shrunk in use, the respective end regions of the article having fastening means capable of fastening the wrapped article
around the object before and during heat shrinking of the article, wherein the fastening means of at least a first one of the end regions comprises a fastening strip extending transversely to the shrinkage direction of the article, which fastening strip is attached to the fabric article along one edge of the strip which is nearer to the other end region of the article.

63. An assembly, kit or method according to claim 62, wherein the said first end region having the said fastening strip is capable of being wrapped and fastened outside the other end region of the article.

64. An assembly, kit or method according to claim 62 or claim 63, wherein the fastening means of the other end region of the article comprises a second fastening strip extending transversely to the shrinkage direction of the article and capable of engaging with the strip of the said first one of the end regions.

65. An assembly, kit or method according to claim 64, wherein the said second strip is attached to the shrinkable article along one edge of the strip which lies nearer to the said first end region.

66. An assembly, kit, or method according to any of claims 62 to 65, wherein the fastening strip of the said first end region and the fastening means of the other end region together constitute a touch-to-close fastener, preferably “Velcro” (Trade Mark) or similar.

67. An assembly, kit, or method according to any of claims 62 to 66, wherein the fastening strip(s) is (are) attached to the shrinkable article by sewing along the said edge of the strip(s).

68. An assembly, kit, or method according to any of claims 62 to 67, wherein the said article is a fabric article having a polymeric sheet laminated to one of its main surfaces.
69. An assembly, kit, or method according to claim 68, wherein the fabric article has a heat-activatable (preferably induction-heatable) sealant layer on the other of its main surfaces.

70. A method of making a wiring bundle bulkhead feedthrough according to any of claims 17 to 20, 36 to 44, 60 and 61, comprising
(a) providing a device for separating the wiring bundle into two or more smaller sub-bundles, the device comprising a support having a row of at least two projections upstanding from the support, which projections are capable of being inserted into (preferably extending through) the bundle to divide it into the said sub-bundles in such orientation that angular movement of the row in a plane substantially normal to the direction of insertion of the projections into the bundle increases the lateral spacing between the sub-bundles;
(b) separating the bundle into smaller sub-bundles by inserting the said row of projections into the bundle and effecting angular movement of the row to increase the lateral spacing between the sub-bundles;
(c) inserting blocking material between the separated sub-bundles, and removing the separating device, preferably to allow the sub-bundles to close around the inserted blocking material; and
(d) causing the blocking material to flow and block the interstices within wiring bundle.
wherein blocking of interstices within the wiring bundle is effected by a method according to the foregoing claim 14 or 15 of the present application.

71. A method according to claim 70, wherein the blocking material is heat-activatable (preferably induction-heatable) sealant material, and is heated to cause it to flow and block the interstices within the bundle.

72. A method according to claim 70 or 71, wherein each of the said projections of the said separating device has an elongate cross-sectional shape in a plane substantially normal to the said direction of insertion and the projections are arranged so that they can be
inserted in the bundle with the longer dimension of their elongate cross-sectional shapes extending along the bundle prior to the said angular movement.

73. A method according to claim 70, 71 or 72, wherein the said separating device comprises three or more of the said projections arranged in a substantially straight row.

74. An assembly, kit, or method according to any preceding claim, including or using an elongate tape of sealant material having transversely-extending ridges of the sealant material projecting from one or both of its main tape surfaces or having transverse corrugations extending across its tape width, the ridges or corrugations preferably being regularly spaced along the tape, preferably at intervals within the range from 2 to 10 mm, more preferably 2.5 to 5 mm.

75. An assembly, kit, or method according to claim 74, wherein the tape has the said ridges projecting from both of its main tape surfaces, preferably with the ridges on one of the tape surfaces substantially aligned with those on the other surface or staggered substantially centrally between those on the other surface.

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76. A wall or bulkhead feedthrough assembly for a wiring bundle or other elongate article comprising a surround member which in use is sealable around the bundle or other elongate article and to a bulkhead through which the bundle or other elongate article is to extend, wherein the said surround member incorporates at least one aperture for later insertion of additional elongate members through the assembly after the said surround member has been sealed around the bundle or other elongate article or to the bulkhead.

77. An assembly according to claim 76, wherein the said aperture incorporates means whereby it is sealed before such later insertion and whereby it can be sealed around the additional elongate members after such insertion.
78. A wall or bulkhead feedthrough assembly according to any of claims 1 to 16, 22 to 33, 39 to 43, 45 to 59, and 62 to 75, comprising at least one aperture for later insertion of additional elongate members through the assembly after the said surround member has been sealed around the bundle or to the bulkhead.

79. An assembly according to claim 78, wherein the said aperture incorporates means whereby it is sealed before such later insertion and whereby it can be sealed around the additional elongate members after such insertion.

80. An assembly according to any of claims 76 to 79, comprising at least two parts which are closable around the wiring bundle in use so that the said aperture(s) is (are) formed at the closure interface between the parts.

81. An assembly according to any of claims 76 or 80, wherein the said aperture(s) is (are) substantially completely sealed at least partly by gel, through which gel, or between interfacing portions of which gel, the additional elongate members can be inserted.

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82. An assembly, kit, or method according to any of the preceding claims, wherein the sealant material is selected from elastomeric (preferably non-foamed) materials having properties within any one or more of the following classes (a) to (h):

(a) Elastomeric materials, preferably thermoplastic elastomers or gels, having 30% compression force (measured at room temperature on a 6mm thick circular disc of the sealant of 25mm diameter by Instron Tensometer using compression jaws whose opposed compressing surfaces extend beyond all parts of the perimeter of the test disc) of less than 200N, preferably gels having 30% compression force less than 100N, more preferably less than 50N;

(b) Elastomeric materials, preferably thermoplastic elastomers or gels, having 50% compression force (measured as above) less than 500N, preferably less than 400N, more preferably less than 300N, still more preferably gels having 50% compression force less than 200N, especially less than 100N or even less than 50N;
(c) Elastomeric materials, preferably thermoplastic elastomers or gels, having 60% compression force (measured as above) less than 500N, preferably less than 400N, more preferably gels having 60% compression force less than 300N, especially less than 200N;
(d) Elastomeric materials of room temperature hardness not greater than Shore A 13, preferably not greater than Shore A 10, more preferably not greater than Shore A 5;
(e) Elastomeric materials of room temperature hardness less than 200g measured on a Stevens Texture Analyser;
(f) Elastomeric materials having room temperature dynamic storage modulus G' less than 400kPa, preferably less than 300kPa;
(g) Elastomeric materials, preferably gels, having cohesive strength greater than their adhesive strength to surfaces with which they will be in contact in use;
(h) Elastomeric materials, preferably gels, capable of remaining substantially resilient and substantially non-flowable at the maximum service temperature, preferably up to 90°C, more preferably up to 100°C.

83. An assembly for forming a wall or bulkhead feedthrough, comprising at least two substantially rigid parts (hinged together or separate) and sealant material having any one or more of the properties (a) to (h) specified in claim 82, the sealant material being capable of sealing the said parts to each other and/or against a wall or bulkhead in use, and the rigid parts preferably being arranged to be capable in use of closing and possibly rigidifying the feedthrough aperture in the wall or bulkhead around an elongate body (preferably a wiring bundle) extending therethrough.

84. Use of a sealant material having any one or more of the properties (a) to (h) specified in claim 82 to seal two or more substantially rigid parts (hinged together or separate) of a wall or bulkhead feedthrough assembly to each other and/or to the wall or bulkhead in use.
Fig. 24B.