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(72) GOLDSMID, Raymond Allan, NZ

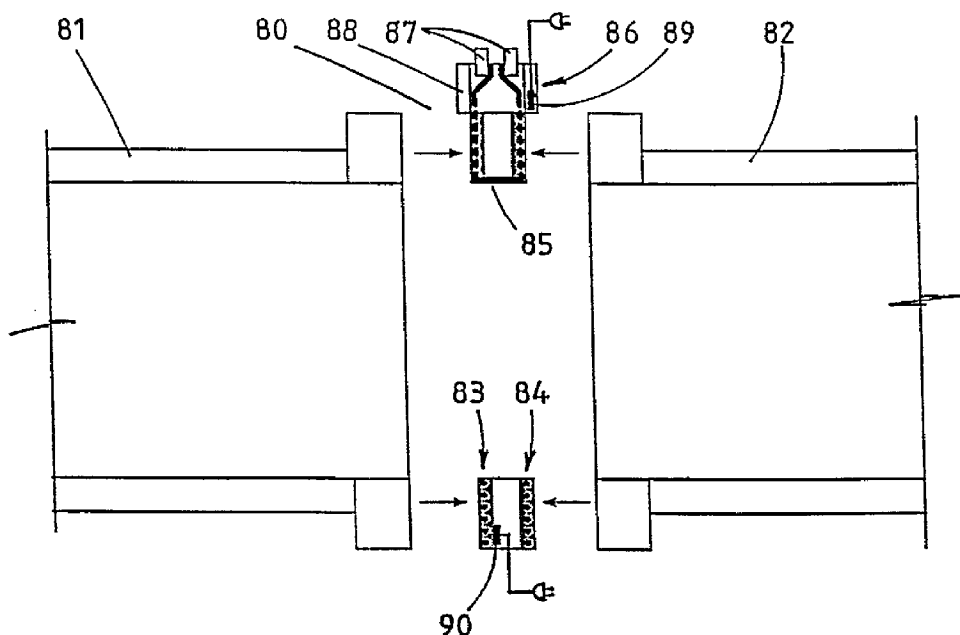
(71) GOLDSMID, Raymond Allan, NZ

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(54) **ELEMENT DESTINE AU SOUDAGE PAR FUSION DE
PLASTIQUES**

(54) **ELEMENT FOR FUSION WELDING PLASTICS**



(57) La présente invention comprend des éléments conçus pour être utilisés dans le soudage par électrofusion d'articles thermoplastiques, tels que des tuyaux. Un mode de réalisation de cette invention comporte une longueur de tuyau, ou un raccord destiné à celui-ci, présentant une interface de soudure modifiée servant à son raccordement par électrofusion à un second tuyau ou à un raccord, etc. Dans une autre forme de réalisation, l'invention concerne un élément intermédiaire que l'on peut placer entre des articles (tels que des tuyaux) afin de joindre ceux-ci par électrofusion. Dans les deux modes de réalisation, l'interface de

(57) The present invention comprises articles adapted for use in electro-fusion welding of thermoplastic articles, such as pipes. One embodiment of the invention comprises a length of pipe, or a fitting therefor, having a modified weld interface for its electro-fusion joining to a second pipe or fitting etc. In another form the invention comprises an intermediary element positionable between articles (such as pipes) for their electro-fusion joining. In both forms, the weld interface is typically characterised by being of a thermoplastic material and including at least one filament arrangement, which in turn comprises one or more filaments aligned substantially lengthwise



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soudure est généralement caractérisée en ce qu'elle est en matériau thermoplastique, en ce qu'elle comporte au moins un agencement de filaments composé à son tour d'un ou de plusieurs filaments alignés essentiellement dans le sens de la longueur par rapport à l'interface de soudure, en ce que lesdits filaments sont pratiquement parallèles à la face de contact de l'interface de soudure et en ce qu'ils se terminent au niveau de portions d'extrémité ne faisant pas partie de la soudure entre les articles.

with respect to the weld interface; and wherein the filaments of the filament arrangement are also substantially parallel to the contact face of the weld interface; and further wherein said filaments terminate at terminal portions not forming part of the weld between the articles.

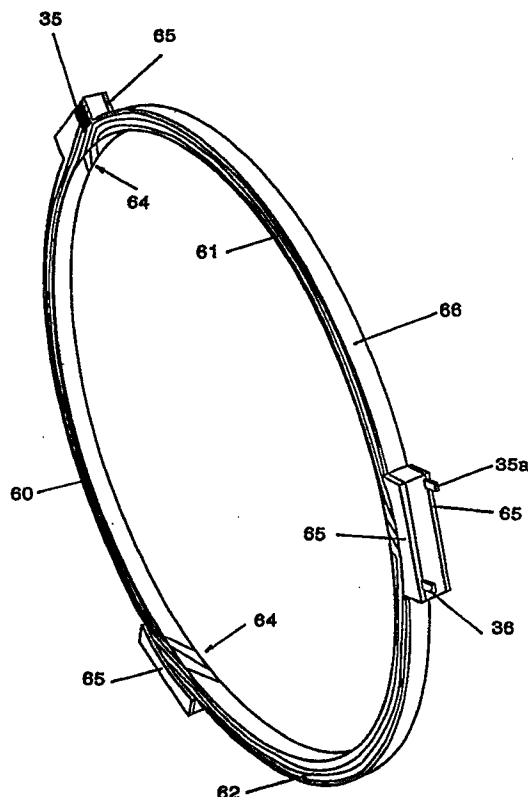
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(54) Title: ELEMENT FOR FUSION WELDING PLASTICS**(57) Abstract**

The present invention comprises articles adapted for use in electro-fusion welding of thermoplastic articles, such as pipes. One embodiment of the invention comprises a length of pipe, or a fitting therefor, having a modified weld interface for its electro-fusion joining to a second pipe or fitting etc. In another form the invention comprises an intermediary element positionable between articles (such as pipes) for their electro-fusion joining. In both forms, the weld interface is typically characterised by being of a thermoplastic material and including at least one filament arrangement, which in turn comprises one or more filaments aligned substantially lengthwise with respect to the weld interface; and wherein the filaments of the filament arrangement are also substantially parallel to the contact face of the weld interface; and further wherein said filaments terminate at terminal portions not forming part of the weld between the articles.



ELEMENT FOR FUSION WELDING PLASTICS

TECHNICAL FIELD

The present invention is directed to welding elements of thermoplastic materials. Elements particularly suitable for joining pipes and butt-joined sections are also discussed.

BACKGROUND ART

- The joining of thermoplastic materials, or the joining of other materials by thermoplastic materials, has become relatively common with many construction elements being constructed of materials amenable to welding using thermoplastic welding techniques.
- 10 While solvent welding is still commonly used (typically for non-critical joins) greater strength and reliability may often be achieved by welding techniques – especially for butt-joined members. For some plastics, such as polyethylene, solvent welding is not practical due to its inertness with respect to most solvents. Accordingly some often used plastics must rely on non-solvent welding techniques.
- 15 Early thermoplastic welding techniques were analogues of traditional metal welding techniques and relied upon a heat source or element, and a plastic welding rod. In some instances the welding or filling rod is not required and the welder merely fuses adjacent areas of thermoplastic materials from the two members together. These techniques are still acceptable for many situations though suffer several drawbacks.
- 20 For most thermoplastic materials, the heat of fusion is relatively critical. Inadequate, or excessive, temperatures can both lead to joints which may fail. In most cases the skill of the welder is relied upon, though even the most experienced welder may have difficulty in maintaining an even welding temperature, especially where joints are difficult to access.
- 25 A solution of the art was to rely upon heating filaments. One technique was to place a bare wire or metal strip between the two members to be joined. Passing a current through the wire heated the adjacent ends of the members to be joined and allowed fusion. However it was found that it can be difficult to obtain acceptable results and that the wire can actually burn holes in the members being joined.
- 30 The invention of US patent specification No. 5410131 partially addresses this problem by providing a 3-dimensional mesh. However, this invention relies upon the mesh embedding itself into the plastic of the pipes being joined, and requiring the pipes to continue being forced together during the welding process as the mesh imbeds itself within the ends of same. There is also a further problem that it is possible for air pockets

to form, resulting in a joint prone to failure should jointing be performed under less than ideal conditions. Due also to the porous nature of the mesh prior to welding, it may be difficult to keep foreign matter from entering same when joining is performed on site.

5 A further solution of the art was to coat a wire or strip in a thick layer of thermoplastic material though, due to the thickness of the thermoplastic material of the rod which surrounds the wire, it could be difficult to adequately soften the outer surface regions (ie. the surfaces which form the weld) of the rod without burning the plastic surrounding the wire or strip.

10 To address this a further modification of the art was to provide a multi-filament welding rod in which the filaments were arranged in a helical fashion and embedded just under the surface of the rod. However the present applicants have found difficulties in using this type of product. For instance, as the filaments are distributed in a helical fashion which substantially describes a cylinder, central regions of the rod may not be heated at the same rate as the outer surface. This can be a problem in some situations. A further
15 difficulty is that the round nature of the helical filament rod is not suitable for all welding situations. For instance, when welding steel pipe with a thin polyethylene outer layer, it is preferable that there is good surface contact between the welding element and the thin layer of polyethylene. Heating a cylindrical welding rod to the extent that it softens and flows out to make contact and fill any voids is more likely to burn holes in the thin layer
20 of polyethylene, as well as resulting in inadequate fusion in other regions.

A further problem with much of the existing art is that it is very difficult to produce a continuous circular weld for butt jointing ends of pipe. Using welding rods, such as the helical filament welding rod, comprises forming a loop from the rod. However there still remains a point where each end of the loop must be angled perpendicularly outwardly to
25 allow subsequent connection of an electrical supply. The problem arises at this point where the ends angle outwardly as it is a small region which is not heated to the same extent as the remainder of the loop. It is at this point that the weld is most likely to fail or have problems.

It will be appreciated that this problem cannot be overcome using sections of rod formed
30 into loops. Concentric or inwardly spiralled loops must still have a gap as the ends terminate, while side by side loops are too thick and non-planar – the result is a side-by-side spiral rather than a circle. Other configurations have been proposed though it remains that it is virtually impossible to provide an evenly heated circular welding element from sections of known welding rod.

35 Some of the art has resorted on the use of sleeves into which the ends of pipe sections are fitted. Examples include the inventions of the specifications of US4224505, and

US5229581, US5320697, US5364130, and US5306377 as well as the invention of New Zealand patent specification No's NZ212786, and NZ247195. However, for many sleeve like embodiments special heating devices or clamping arrangements are required – for instance, the subject matter of US5037500, US5241157, US5290387, US4927999, 5 or US5141580. The use of such devices adds to the expense and ease of jointing and are not always suitable for use on site – e.g. pipes already laid in a trench.

The use of sleeves also has drawbacks. For instance, they are much more expensive to manufacture than non-sleeve type devices. They also rely on a significant area of the outer surface of the pipes being satisfactorily cleaned prior to use – which may be 10 difficult in an outside environment. Furthermore, they are especially sensitive to variations in the outside diameters of the pipes which they join. If one of the pipes is of a slightly different outside diameter, which may for instance result from a different supplier or batch, then a sleeve may not be able to be used unless the complex adaptor arrangement of NZ247195 is relied upon.

15 In summary there are a number of problems associated with the art. At least one of the problems is that many of the prior art welding rods and elements do not evenly heat the thermoplastic material of the rod, or adversely affect the thermoplastic members being joined. Another problem is that the many of the welding elements are not of the ideal shape for welding flat surfaces and may not evenly fuse with flat sections to be joined. A 20 further problem is that existing thermoplastic welding elements are, as a whole, unable to provide an ideal closed or circular element for joining pipe sections.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the 25 ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided an article whose body portion includes an annular or arcuate modified weld interface comprising a contact face for contacting a second surface to which said article is to be welded, 30 the weld interface comprising a thermoplastic material including at least one filament arrangement in turn comprising one or more filaments aligned substantially lengthwise with respect to the weld interface, and wherein the filaments of the filament arrangement are substantially parallel to the contact face of the weld interface; and wherein said filaments terminate at terminal portions not forming part of the weld to 35 said second surface.

According to a further aspect of the present invention there is provided an article comprising a welding element for the end-to-end joining of pipe sections, said welding element comprising an annular or part annular body portion of a thermoplastic material positionable between the ends of said pipe sections;

- 5 there being distributed along substantially the entire length of said body portion at least one substantially planar filament arrangement comprising one or more filaments aligned substantially lengthwise with respect to said body portion;
and wherein the end of a provided filament or filaments terminate at terminal portions directed inwardly or outwardly of said body portion.

- 10 According to another aspect of the present invention there is provided a welding element substantially as described above in which the two pipe contacting faces of the body portion are substantially parallel to each other.

- According to another aspect of the present invention there is provided a welding element substantially as described above wherein there are at least two provided filament
15 arrangements, one each at or near a said pipe contacting face.

- According to another aspect of the present invention there is provided a welding element substantially as described above which comprises filaments starting at a terminal portion for the first said filament arrangement, and which then extend along said first filament arrangement, then cross to said second filament arrangement, extend along same to a
20 terminal portion associated with second filament arrangement.

- According to another aspect of the present invention there is provided a welding element substantially as described above in which when viewed in frontal projection, the filament tracks of the said two filament arrangements as they divert to their terminal portion, appear to cross over, or overlap.

- 25 According to another aspect of the present invention there is provided a welding element substantially as described above in which the filament tracks of a particular filament arrangement are arranged such that when viewed in frontal projection, any radial line extending outwardly from the annular centre will either intersect at a plurality of tracks, or pass a filament track within a distance of half the average separation distance of said
30 filament tracks along the annular body.

According to another aspect of the present invention there is provided a welding element substantially as described above in which a filament arrangement comprises more than one set of filaments, each set being part of a different electric circuit.

- According to a further aspect of the present invention there is provided a method of
35 joining thermoplastic articles, comprising the use of at least one article including an

annular or arcuate modified weld interface comprising a contact face for contacting a surface of the second surface to be welded,
the weld interface comprising a thermoplastic material including at least one filament arrangement in turn comprising one or more filaments aligned substantially lengthwise with respect to the weld interface, and wherein the filaments of the filament arrangement are substantially parallel to the contact face of the weld interface;
and wherein said filaments terminate at terminal portions not forming part of the weld to said second surface,
and wherein electricity or an RF field is applied to cause said filaments to heat thereby softening surrounding thermoplastic material to an extent sufficient for welding of the articles.

According to another aspect of the present invention there is provided a method, substantially as described above, in which an intermediate welding element is employed for the end-to-end joining of pipe sections, said welding element comprising an annular or part annular body portion of a thermoplastic material positionable between the ends of said pipe sections;
there being distributed along substantially the entire length of said body portion at least one substantially planar filament arrangement comprising one or more filaments aligned substantially lengthwise with respect to said body portion;
and wherein the end of a provided filament or filaments terminate at terminal portions directed inwardly or outwardly of said body portion;
and wherein said welding element is positioned between the ends of pipe sections to be joined.

An article suitable for fusion welding, according to the present invention, may take a number of forms. Typically the article will include at least one filament arrangement (see later) embedded or adjacent a thermoplastic material at a weld interface – this is generally a face for contacting another article to which it is to be welded.

In some embodiments the article may comprise a length of pipe or a fitting therefor, with an end being modified to include a preferred filament arrangement at the weld interface.
In other embodiments the article may be a shorter intermediate item, termed a 'weld element', with typically a weld interface at each end. The same principles apply to both the larger, end modified articles and the (normally) shorter weld elements. There may be little difference other than the nature of the article to which the weld interface and its associated body portion is attached – eg it may a pipe length, or it may be only the body portion itself (in a weld interface).

For simplicity of description, the specification shall refer predominantly to an

intermediate welding element – the general principles can be readily applied to sections of pipe and fittings given the description herein. Accordingly, a welding element (or the weld forming portion of an article) of the present invention can generally be characterised into two main portions – the body and terminal portions. The body portion can be
5 generally characterised as that portion forming the active part of the welding element involved in joining the members being welded. The terminal portion, of which there may be one or more, are typically regions to which a power supply may be connected, or RF field applied, for activating the heating filaments. These are usually positioned in a manner allowing the ready access of a power supply, but without interfering with the
10 weld. Depending on the embodiment, the terminal portion(s) will be typically (but not necessarily) be provided at the end of the welding element. For looped and annular embodiments of a welding element, terminal regions are generally, but not necessarily, provided in a manner extending inwardly and/or outwardly from the loop.

Most embodiments of the present invention are characterised by the arrangement of the
15 provided filaments. In most embodiments the preferred configuration and disposition of the filaments is applicable to the body portion (which may comprise more than one portion). The same disposition may also exist in the terminal portions though as this region typically has a different function, the same preferred arrangement of filaments is not generally necessary.

20 Before proceeding further, several terms which will occasionally be used shall be explained. The first term is "welding interface" which shall refer to surface and near-surface portions of the welding element which contact, or are meant to contact, members to be joined. The welding interface will fuse with parts of the members being welded that it contacts.

25 The term 'filament' shall generally refer to a conducting element, typically a heating filament which will heat when subjected to an electrical current or RF field (RF generation techniques to induce heating are well known and shall not be described further herein). The filament may comprise a single wire strand, a strip, or in some instances several strands which are typically braided, woven or twisted.

30 The term "thermoplastic" shall be used in its normal sense and refers to a material which softens upon heating though will return to its original state upon cooling. Typical thermoplastic materials which are used in welding elements of the present invention will comprise plastics materials though other types of thermoplastics materials may also be employed.

35 The term "filament track" shall refer to the path that a filament follows. In some examples the term shall be used to describe the path that a filament shall follow in the

finished product. For instance, in some methods of manufacturing various embodiments, a track may be formed into the body portion into which a filament is subsequently inserted.

5 The term "filament arrangement" will refer to a filament track, or set of tracks, which lie substantially within a single plane. More than one filament arrangement may be provided in the body portion, and will often be positioned at or near the weld interface.

Preferably, the welding portion according to the present invention will comprise a combination of thermoplastic material and filaments, wherein the filaments are disposed such that when activated they substantially evenly heat the thermoplastic material.
10 Preferably this should be without localised overheating to the extent that holes or burning of thermoplastic material occurs. The exception would be remote, non-critical points such as the terminals for connection to a power source.

Similarly there should not be any cold spots in regions which could interfere with the integrity of any formed weld. In various embodiments it may be acceptable to merely
15 provide substantially even heating, at least in the body portion, in at least one of the following manners:

- throughout the cross-sectional area of the body portion;
- on a face of the body portion;
- across the entire surface of the body portion;
- 20 - through the weld forming portion of the body portion, and
- across the weld interface of the welding element.

Various embodiments of the present invention may take different forms. In a number of preferred embodiments, the welding element can be further characterised by comprising at least one filament set in turn comprising a plurality of conducting elements or tracks
25 which are substantially parallel to each other, and which lie (at least in the body portion) in a filament arrangement substantially within a single plane.

A welding element may comprise one or more filament arrangements and may comprise any number of filaments in addition to provide more even heating of the thermoplastic material in the body portion. These may be electrically conducting and appropriately
30 connected. Thermally conducting filaments and elements may be provided to distribute heat generated from the main filament arrangements. Where the body of the welding element has a relatively simple cross-section (eg. rectangular), then additional filaments may not be required. For more complex shapes, additional filaments may be needed. In more complex embodiments, such as the flanged elements to be described later, sets of
35 filaments may be provided in the flanged or other depending portions.

In preferred embodiments of the present invention the body portion is generally created from a thermoplastic material formed to the desired shape. When joining pipe sections in an end to end manner, the body portion will generally comprise a loop or ring corresponding to the cross section of the pipe sections. As a variation the present invention also includes body portions which comprise an arc and which may be assembled to form an annular ring or loop. This variation will typically be used for larger pipe diameters where it is difficult to manufacture or transport large diameter rings.

For embodiment used for connecting end sections of pipes, the weld interface will generally be distributed along the pipe contacting faces of the body portion. It is at, or near, these faces that there will be a filament arrangement capable of heating the thermoplastic material of the body portion. To a certain extent, these filaments will also heat the end sections of the pipe sections, or other articles to be joined.

Typically the filament arrangement will be substantially parallel to the weld face that it is near. As, for the jointing of pipes, the end sections of each pipe is substantially planar, so too will the filament arrangements in preferred embodiments of the present invention. In a preferred embodiment, two filament arrangements are provided, one being at or near each pipe contacting face of the body portion. Additional filament arrangements may be provided, typically intermediate between the outer two filament arrangements. These may be part of the same electrical circuit, or separate thereto.

For alternative embodiments of the present invention intended for other uses than the end joining of pipe sections, each filament arrangement may not necessarily be planar, though will typically be parallel to the contacting surface of the body portion where a weld is to be formed. However, for simplicity, the present description shall be restricted to loop and annular embodiments for joining pipes - the same principles may be applied to other configurations.

It is possible that each filament arrangement comprises a single electric circuit, and it is possible that different filament arrangements may also form part of the one circuit. As a variation, each filament arrangement may comprise several sets of filaments, each of which may belong to a different electric circuit. In one arrangement, adjacent parallel filament tracks may belong to different circuits, while in another arrangement the length of the welding element may be divided into several segments, each of which may comprise a different set of filaments and tracks.

It is also typical that the filaments, or tracks of a filament arrangement, will generally follow, or be parallel to, the length of the body portion. Where the body portion is linear, it can be said that the filament tracks of the set are parallel to the longitudinal axis of the body portion. Where the welding element is non-linear, for instance an annular

embodiment to be described later, then the tracks of the filament set are substantially concentric with the annular body – it can also be seen to be substantially parallel to the length of the body portion, which in this case would be a ring.

5 While the filaments or tracks of the filament set should maintain their relative disposition throughout a substantial proportion of the body length, occasional deviations from the preferred arrangement may be tolerable in some situations, such as the welding of complex shapes. It is also considered that deviations, when present, are likely to occur within the terminal portions, or within the body portions which approach these terminal portions.

10 In the terminal portions the filaments are generally oriented to become exposed or to contact terminals to which an electrical power source may be connected. The orientation of the filaments in these portions is primarily one of function to enable a power source to be connected. However, the transition from body portion to terminal portion should not be such that weld integrity in those regions is significantly compromised – this was a
15 problem with loops formed from rods in the prior art. For relatively simple embodiments comprising a body portion having a terminal portion at one or both ends, any welding problems can generally be overcome by ensuring that the transition portion to the terminal portion does not form part of the weld. However, this is not practical for closed loops where the transition region is still involved in forming a weld. Accordingly, the general
20 criteria for the filaments in the body portion (of which it forms a part) are also generally applied to this region so as not to overly compromise the weld in this portion.

In a preferred embodiment, the filament tracks preferably form substantially concentric rings about the centre of the annular body (in an alternative cylindrical body arrangement the filaments may be co-axial). The terminal portions comprise one or more extensions
25 which typically extend inwardly or outwardly of the ring. The manner by which they extend from the annular body portion may vary though radially outward extensions will often be employed.

In preferred annular embodiments of the present invention it is desirable that there is substantially even heating throughout the entire length of the annular body portion for
30 weld consistency. This may be achieved in a number of manners.

One such manner is to extend the filament tracks substantially tangentially (or at a slight angle there to) outwardly to the terminal portions. Travelling in a direction about the ring which begins at the angled lead-in, leading from a terminal portion, any track will eventually re-encounter the side of the lead-in where it, or another member of the parallel
35 set of tracks, has entered the ring. At this point the filaments may be altered in direction to travel inwardly and parallel to the lead-in filaments or, outwardly and parallel to the

lead-in filaments. The filaments could then be directed to terminal regions, and/or bridged to provide a return path for the electrical current.

In another alternative, a single filament can be wound spirally about the ring to provide a number of parallel and substantially concentric tracks. Each end of the filament may be
5 directed to the appropriate terminal. A plurality of spirally wound filaments may also be provided.

In a preferred embodiment, several filament arrangements are provided. When the filament track encounters the lead-in where it or another member of the parallel set of tracks has entered the ring, may divert to the edge of the body portion. At or near the
10 edge the tracks then divert and travel deeper into the body portion. They may at this stage connect to another parallel filament arrangement (which may be the arrangement present on the opposite pipe or article contacting face of the body portion near the tangential filament tracks for that particular filament arrangement) - or to a terminal portion.

The tracks from the other parallel filament arrangement may then parallel these angled tracks before performing a concentric path about the annular portion to become the angled tracks leading to a second terminal portion. As a variation, rather than leading to a second terminal portion, the tangential filament tracks may then jump to yet another filament arrangement provided within the body portion. As can be appreciated, in such
15 arrangements a single electric circuit may comprise more than one filament arrangement.
20

A further significance of annular embodiments such as described above is that there is a substantially even distribution of filaments around the entire length of the body portion. When viewed in frontal projection, it can be seen that the filaments tracks of the provided arrangements appear, as they divert to their terminal portions, to cross over or to overlap.
25 Unlike much of the prior art, which must rely on rods of straight welding elements formed into a loop, there is no point along the length of the loop which has a less dense distribution of filaments, as is the case for prior art where the rod must be bent at a right angle inwardly or outwardly to a terminal portion. Most welding elements of the present invention can be characterised such that when the ring is viewed in plan, any radially
30 extending ray from the centre of the ring, in any direction, will pass through at least one filament track. In contrast, at least one ray extending from the annular centre and between the terminal portions of prior art welding elements, will cross the ring without encountering any tracks – this being where the rod is diverted to form the terminals or where a double, concentric loop is used.

A variation of the preceding annular examples is to have the filament tracks to divert substantially perpendicularly outwardly (or inwardly) to the terminal portions. While this
35

bears some similarity to prior art devices, a distinction is that the tracks are brought into close proximity to each other before being diverted substantially perpendicularly inwardly or outwardly. For outwardly extending terminal regions, the perpendicularly directed tracks which most closely approach are those of the innermost annular filament track (in the set). For inwardly extending terminal regions, it is the outermost track - other variations in track patterns are possible. In the embodiments of the preceding paragraphs, it has been stated that no portion of the body portion is void of filament tracks for any great distance. While there is one point through which a ray extending from the annular centre may extend without touching a filament track (for the described arrangement of this paragraph), it can be further stated that when passing through this region, it is no further away from one of the filament tracks leading to the terminal portion than the distance of one half of the average separation between filament tracks about the annular body portion. Accordingly a gap where filament tracks do not completely encircle a ring is acceptable providing that the gap is small. However, even then it is desirable that the tracks are angled away from the perpendicular to avoid possible flaws extending radially through the weld thickness.

While it is possible that continuous or overlapping filament tracks can be provided about the annular body portion, and which extend outwardly to the terminal regions in a manner overlapping other concentric tracks, such embodiments have inherent problems. One problem is that the concentration of overlapping filaments leading to the terminal portions can cause overheating of the thermoplastic material in this region. Thicker filaments or conducting elements which do not warm to the same extent as the main filaments, may be used in this region to connect the main filaments to the terminal. This may be used to address possible overheating due to a larger number of filaments in a localised region, though adopting track patterns such as described or illustrated herein should reduce any such need.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the ensuing description which is given by way of example only and with reference to the accompanying drawings in which:

- Figure 1 is a perspective diagrammatic cut-away view of a portion of a possible flat, linear embodiment of the present invention;
- Figure 2 is a perspective diagrammatic cut-away view of a portion of a another possible flat, linear embodiment of the present invention;
- Figure 3 is a perspective diagrammatic cut-away view of a portion of a possible L-

shaped embodiment of the present invention;

Figure 4 is a perspective diagrammatic cut-away view of a portion of a an alternative to the complex shaped embodiment of Figure 4;

5 Figure 5 is a perspective diagrammatic cut-away view of a portion of a planar annular welding element;

Figure 6 is a perspective diagrammatic cut-away view of a portion of a possible embodiment of an annular welding element with flanges;

Figure 7 is a perspective diagrammatic cut-away view of a portion of an alternative embodiment of an annular welding element with flanges;

10 Figure 8 is a front diagrammatic view of an embodiment of an annular welding element;

Figure 9 and 10

15 a front diagrammatic views of multiple filament set embodiments of the present invention as having filament sets which contribute to more than one filament arrangement;

Figure 11 is a front diagrammatic view of a further embodiment having a single filament set filament arrangement;

Figure 12 through 14

20 are embodiments of single and multiple filament set embodiments characterised in that the terminal portions for each filament set are on the same face of the body, said body comprising a length of pipe;

Figures 15 and 16

are front diagrammatic views of arcuate segments which can be used to form closed loop assemblies;

25 Figure 17 is a perspective diagrammatic view of the embodiment of Figure 10.

Figure 18 is a side cross sectional view of two pipe lengths being joined, one of which lengths has been modified to include a weld interface such as in the embodiments of Figures 12 to 14, and

30 Figure 19 is a side cross sectional view of two standard pipe sections which are being joined through the use of an intermediate welding element, such as in the embodiment of Figure 8.

BEST MODES FOR CARRYING OUT THE INVENTION

With reference to the drawings and by way of example only there is provided a welding element (generally indicated by arrow 1) comprising at least one filament arrangement 2, in turn comprising a plurality of conducting elements 3 which are substantially parallel to each other, and (at least for other than at or near the terminal regions) substantially within a single plane, which are embedded within a thermoplastic material 4.

Figure 1 illustrates a portion of a linear welding element which is substantially rectangular in cross-section. A plurality of filaments 3 are provided which lie within a single plane and make up the filament arrangement 2. While a variety of materials may be used for the filaments, it is envisaged that they will comprise a stainless steel wire. The filaments 3 are spaced substantially equidistantly and substantially parallel to the length of the body portion of the welding element.

The diagram of Figure 1 is not to scale and the thickness of the body portion of the welding element will typically be less than that illustrated. This is to avoid problems with localised overheating when attempting to attain the correct welding temperature at the surface of the welding element. As can be appreciated, the relatively even distribution, and number, of the wires can allow for reasonably rapid and even heating of the entire weld interface (top and bottom surfaces) of the embodiment of Figure 1 without the problems of cold regions and localised overly hot spots.

Figure 2 illustrates an alternative embodiment of the welding element of Figure 1. In this embodiment there are intersecting cross filaments also provided. It is not envisaged that these cross filaments 5 will make electrical contact with the conducting elements 3 though this is a possibility. It is envisaged that the cross filaments 5 can be used to add additional strength to the weld region (ie. acting as a reinforcing element) though may also serve the purpose of conducting heat through the thermoplastic material to aid heat transfer and thus even heating. In this latter instance they may be acting more as a thermal conductor rather than an electrical conductor. While there may be advantage in their being electrically connected to conducting elements 3 and acting as further heating filaments, the electrical connection and inclusion of these cross-wire connectors introduces other problems. Accordingly it is preferable that electrically heated filaments are restricted primarily to those extending lengthwise with respect to the body portion.

Figure 3 illustrates an L-shaped embodiment of the present invention which may be used in a number of different types of joins. In the embodiment of Figure 3, cross filaments 5 have been included though these may be absent in other embodiments of this general configuration. As can be readily appreciated from Figure 3, there are two sets of filaments provided, one set for each arm of the body.

Figure 4 illustrates a further complex shaped element which may be used for various types of connections. Other configurations are also possible – the configurations of embodiments of Figures 1 through 4 are also meant to be illustrative of a range of possibilities for forming different welding elements according to the present invention.

- 5 Figure 5 through 7 illustrate some annular embodiments of a welding element. Figure 5 illustrates a substantially planar annular embodiment 7, though for clarity only a cut away portion is shown. In many respects the embodiment 7 of Figure 5 is very similar to the embodiment 1 of Figure 1, though has been formed into an annular ring. In the body portion of the element the filaments 3 remain substantially parallel and concentric with the
10 annular centre. To prevent localised overheating, the body portion is relatively thin so that the filaments are new each welding face 15 (contacting each end of a pipe section).

- Figure 6 illustrates a further embodiment 8 of an annular welding element though with outwardly extending flanges 9. This type of embodiment 8 is also envisaged for use in joining sections of pipes, with the flange providing additional reinforcing and sealing for
15 the joined pipe sections.

Figure 7 illustrates a similar embodiment but wherein a second filament set 2 is provided for heating material in the flange. This is more likely to be used where the pipe sections are of thermoplastic materials, or have thermoplastic coatings with which the flanges can interact.

- 20 Figure 8 illustrates from a frontal view, an annular embodiment of a welding element such as those of Figures 5 through 7. The outwardly extending terminal portion 11 has fittings 12 for the connection of an electrical supply. In electrical contact with these fittings 12 are the filaments which enter the annular body portion tangentially (or at an angle approximating same) and follow concentric filament tracks 13 about the annular
25 portion. When the filament tracks 13 re-encounter the tangential portion of the filament tracks, they are redirected to run parallel to the tangential lead-in portions, then encounter the edge (20), cross or fold to the other side (21) perform another loop before connecting to the alternate terminal portion (12a). The terminal portion (12a) and the tangential tracks leading to it on the opposite face have been partially shown in dotted outline.
- 30 In Figure 8 there is one electric circuit and this extends twice about the entire circumference of the annular body portion through tracks which lead through two parallel filament arrangements, each at or near the pipe contacting face of the body portion. In some situations, especially for larger pipe diameters, electrical problems may arise if significant lengths of filament are used between each terminal. This may, for instance,
35 impose excessive requirements on voltage and current generating equipment connected to the terminals. Accordingly, in some situations it may be desirable to divide the filaments

into two or more filament sets, each set being identified by the fact that it corresponds to a different electrical circuit (though it may share terminals) rather than the fact that the filament tracks lie substantially within a single plane (which characterises a filament arrangement).

- 5 Figure 19 illustrates the use of an annular welding element 80 for joining two lengths of pipe or fittings 81, 82. In figure 19 the two filament arrangements 83, 84 can be seen, as well as some of the crossover wires 85. Also visible is the terminal portion 86 and contacts 87. Optional covers 88 are provided to act at least partially as a heat sink due to the greater concentration of filaments in this area. Also in the embodiment illustrated in
- 10 figure 19, one of the terminal covers houses a thermocouple device 89 which can be externally monitored to provide an indication of the temperature at the weld interface (or at least a value which is proportional thereto). This may also be incorporated in equipment controlling the electrical supply for contacts 87, to ensure that a preferred temperature range is maintained during a welding operation.
- 15 Also illustrated is a piezo electronic pressure device 90 which can be used to provide an indication of the applied pressure at or near a weld interface. This can be used to ensure that adequate pressure is applied during a welding operation.

- Figures 9 and 10 illustrate annular embodiments which comprise more than one set of filament tracks. In Figure 9 there are two filament sets, generally indicated by arrows 30 and 31. The filaments of set 30 begin at terminal contact 32, travel halfway around the
- 20 length of the body portion until near terminal post 33. At that point the tracks divert substantially tangentially inwardly and cross to the alternate face of the body portion. At that point they complete the return portion of their path underneath the top filament tracks (in the illustration) of filament set 31 until near contact 32. At that point they divert
- 25 substantially tangentially outwardly and connect to terminal contact 32a, on the opposite hidden face of the body portion (shown in outline only). The filament of the second filament set 31, performs substantially the same path but beginning at terminal contact 33 and terminating at terminal contact 33a. The result is that each filament arrangement (of each pipe contacting face) comprises approximately 50% of the filament tracks of each
- 30 filament set 30, 31.

- Figure 10 is another multiple filament set embodiment, but with three terminal portions shown. For simplicity, the terminal contacts have been numbered to indicate the beginning and end points of each filament set e.g. 35 and 35a are the contacts for a first filament set, 36 and 36a are the contacts for a second filament set, and 37 and 37a the
- 35 contacts for the third filament set. The suffix a indicates (for these figures) that the contact is on the rear, hidden face, of the illustrated device.

During welding, the use of multiple circuits can reduce the current required for long filament paths. For embodiments such as shown in Figures 8 through 10, the welds can be performed simultaneously or individually. The number of different filament sets (and circuits) is up to the user and the equipment being used. As a rough guide, there may be
5 up to 8 segments for a 3 metre diameter pipe.

Figure 11 illustrates an alternative embodiment of a welding element. Here the filament tracks 36 run substantially concentrically with respect to a body until they near a terminal portion 37. At this point the tracks divert substantially perpendicularly outwardly to connect to terminals 38 and 38a. The innermost track should approach itself by a
10 distance substantially the same as the average distance between the concentric tracks, before diverting perpendicularly outwardly. This avoids any large gaps about the circumference which is not heated to the same extent as the others. It is typical that a similar filament arrangement is provided on the opposite face of the element.

Figures 12 through 14 illustrate embodiments having similar characteristics to the
15 embodiments of Figures 8 through 10, as well as characteristics of the embodiment of Figure 11. These characteristics are that there is a semi-tangential angling of the tracks 40-45 to the terminal contacts 46-52. The characteristic of the embodiments of figures 12 through 14 that is shared with that of figure 11 is that each filament set remains on the same face of the body portion, and does not cross to the opposite side. In one respect
20 this can be an advantage as the crossing of filaments from one side to the other can create additional heating in this region. As this may, in some instances, be detrimental to the forming of a uniform weld, it is sometimes necessary to rely on positioned heat sinks when using embodiments such as shown in Figures 8 through 10. Such heat sinks may be provided through a provision of extra thermoplastic material positioned inwardly of
25 the ring in the vicinity of the cross over, or, perhaps, removable elements which bear against same during a welding operation. The applicant has found that an inflated neoprene bag within the pipe section is sufficient to act as a heat sink during a welding operation, as well as helping to maintain items in the correct position for welding and joining.

30 However, the embodiments of Figures 11 through 14, because they lack cross overs between filament arrangements, do not require such considerations. A limitation however of the embodiments of Figures 12 through 14 is that it may be difficult to access the internal contact from the outside of the pipe during a welding operation. Accordingly, such embodiments are typically only used during connection of short
35 sections of pipes bends and other fittings of short length, or at the end of pipe sections.

As a variation, the filament arrangements of Figures 11 through 14 may be applied to the

end of a pipe section. The result is a pipe length, or pipe fitting, having at least one end pre-fitted with an integral weld interface with filament arrangement. In many respects the result is equivalent to a welding element though with the mid portion of the body of greater thickness. Filament arrangements may be provided at each end of the pipe or fitting. Bridging conductors could be provided to link the rearwardly diverted tracks of arrangements similar to the embodiments of Figures 8 through 10, to terminals so as to allow similar filament arrangements to be used on pipe end sections.

Figure 18 illustrates, from the side, the use of a pipe length or fitting of which at least one end has been modified through the inclusion of a weld interface 70 with a filament arrangement 71. The terminal portion 72 is shown extending from the main body portion 73, as is the electrical contact 74 and optional cover 75. In practice two pipe sections 76, 77 are brought together, and electricity applied to contacts 74. This softens plastic in the vicinity of a weld interface 70, as well as plastic material at the end of pipe section 76. This is maintained until an adequate weld is formed.

Figures 15 and 16 illustrate welding elements which are arcuate in configuration. These segments are intended to be joined together to form a complete loop. Such segments are typically for use with large diameter pipes where it is impractical to manufacture a single large loop. These segments 55, 56, may be assembled prior to use, and may make use of bridging conductor strips to connect terminated filament tracks (e.g. 57-60) to the next segment in the assembly.

While each segment 55, 56 could comprise its own independent electrical circuit (in which case filament tracks near each end of the segment would resemble those (37) at the terminal portion of Figure 11) the illustrated embodiments of Figures 15 and 16 still rely on the substantially tangential or outwardly angled filament tracks so that the resulting assembly resembles the embodiments of Figures 8 through 10, or even 12 through 14.

Figure 17 illustrates, in a perspective diagrammatic manner, the embodiment of Figure 10. Here the cross-over (64-65) of some of the filament sets can be clearly seen. It is at this point that a heat sinking material may be positioned during a welding operation, to absorb extra heat from increased density of filaments at these particular points.

The terminals (35, 35a, and 36 shown) can be clearly seen, as are optional terminal covers 65. These covers also act as heat absorbers and are typically made of the same material as the ring. These absorb additional heat from the filament as they approach the terminals and also act as locating members to help maintain the body 66 in the correct orientation with respect to the pipe ends (not shown).

In the embodiment of Figures 8 through 17, various methods of manufacture may be

employed. In a preferred method of manufacture the body of thermoplastic material, and the extending terminal portions, is formed from a suitable technique, such as injection moulding. Filament tracks will typically be included on any mould or die so that they are formed during the injection or casting process. It is possible however that the filament

5 tracks may be formed after moulding such as by a suitable machining or pressing method, or that a combination of the various techniques may be relied upon. The filaments are then laid into these provided tracks, optionally being slightly heated so that they partially bond to the thermoplastic material so that they do not become loose during transport of storage. The terminal portions will generally be provided at the same time as

10 the filaments are fitted.

Various other modifications may be made to various embodiments. For instance, a thermocouple may be incorporated into various embodiments to provide an indication of the temperature of the welding element. Additional filaments may be included to connect a thermocouple(s) to an external monitoring device.

15 In other embodiments a pressure sensitive device (eg. a piezo device) may also be included to provide an indication of pressure being applied to the weld during its formation. This may be useful where parts being welded are to be forced together during formation of the weld. Such devices can be made relatively small or thin and can rely on additional filaments to connect them to external monitoring devices.

20 Another modification may be in the selection of filament material. Materials whose resistance increases significantly with temperature may be relied upon as the filaments. If the characteristics of these material are known, a way exists to limit the maximum temperature of these filaments when a current passes therethrough. In many instances this is similar to using nichrome wire for a heating element – at a certain temperature the

25 resistance of the nichrome becomes such that a higher current cannot be carried unless the voltage is also increased. The result of current limiting is also a limitation on the wattage and therefore heat output and temperature of the filament. Similar principles can be employed in various embodiments of the present invention – applying different voltages can be used to control the maximum current carried by the filament set, and thus their

30 heat output and temperature.

The welding fitting is typically made from the same thermoplastic material that is being welded. Embedded into this welding fitting is a filament wire or wires dependant on the thickness of the weld area required. The filament wires may be coated either by extrusion or thin film of the same material that the welding fitting is manufactured from.

35 The thickness of this film can alter according to the heat dispersion required to perform a weld on a particular object, ie. if, for example, one was welding very thin film

polyethylene such is present on coated steel pipe, there would be a thicker membrane covering the filament wire/wires so that the thin polyethylene film on the steel pipe did not get too hot and burn or distort etc.

5 In practice it is desirable to provide a certain wattage of power over a certain area of plastic to get the plastic to a temperature to perform a successful weld. The ideal welding situation is to have the heat dispersion between two or more wires so that the entire welding interface is the same temperature, ie the plastic immediately surrounding the filament wire is the same as the plastic in the middle of the filament wires. When the filament wires have only a thin film coating the molten plastic at the interface will spread 10 while some of the heat/energy dissipates into the member causing a molten mass which (when a small pressure is applied) becomes one homogenous mass. The fusion is completed with the two members being welded and the welding fitting still embedded between them. Preferably the filament wires do not cross and touch in the area of the actual interface as this usually increases the power requirement to achieve the welding 15 temperature. It can also cause a hot spot where the filament wires touch, although in some situations this does not overly detract from the weld quality and may in some situations of filament design be a necessity. For most filament designs however, the filament wires will run parallel and at no stage touch in the area of the interface.

20 It is also possible in some instances to make the welding fitting from a very thin membrane itself so that the heat dispersion to perform the weld is obtained from one single filament element, however it is more likely on the larger welds or welding thicker members together that there will be two or more filament circuits at each interface, even if the filament element only has one complete circuit.

25 Typically to perform a weld you apply pressure until the target weld temperature is achieved, then a slight increase in pressure ensures that the members and the welding fitting have a homogenous amount of plastic.

30 It is desirable that the same wattage is produced in each of the filament wires, ie. if you make a fitting using the same wire diameters and same wire material, the filament wires would ideally need to be the same length. Similarly the gaps between them need to be the same to get the same even heat dispersion across the entire interface. It is possible to achieve the same resultant even temperature spread by having wires of differing lengths and/or diameters and/or wire types and achieve the same results, ie. in a circular filament pattern you could have a smaller diameter wire in the centre of the fitting and a longer, larger diameter on the outside.

35 If the filament has two or more termination points, it is desirable to have these away from the weld interface as these points are a potential source of overheating. It is also

desirable to have these termination points covered by material so that any excessive heat build up is dissipated into the material or some other medium.

The welding fittings may be manufactured in many ways. For example:

- 5 1) For pipe "rings" you can mould a plastic fitting with slots in it for the filament wires, attach your electrical fittings and then mould a thin coating of material over the filament wire and a thicker "block" to act as a heat dispersant and to hold the electrical connectors in place.
- 10 2) You can laser cut or engrave the slots for the filament wires into sheet plastic of the correct thickness. You could then melt thin plastic sheet over the filament wires to get coverage. The use of coated wire is also a possibility, so that the fitting does need to be coated with the thin plastic sheet. In these types of
 embodiments the filaments are virtually at the surface, and for coated wires the actual coated wire will be visible at the surface.
- 15 3) For the "straight line" type fittings, you can do the above or have the wires inserted during extrusion etc.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.

THE CLAIMS DEFINING THE INVENTION ARE:

1. An article whose body portion includes an annular or arcuate modified weld interface comprising a contact face for contacting a second surface to which said article is to be welded,
the weld interface comprising a thermoplastic material including at least one filament arrangement in turn comprising one or more filaments aligned substantially lengthwise with respect to the weld interface, and wherein the filaments of the filament arrangement are substantially parallel to the contact face of the weld interface;
and wherein said filaments terminate at terminal portions not forming part of the weld to said second surface.
2. An article comprising a welding element for the end-to-end joining of pipe sections, said welding element comprising an annular or part annular body portion of a thermoplastic material positionable between the ends of said pipe sections;

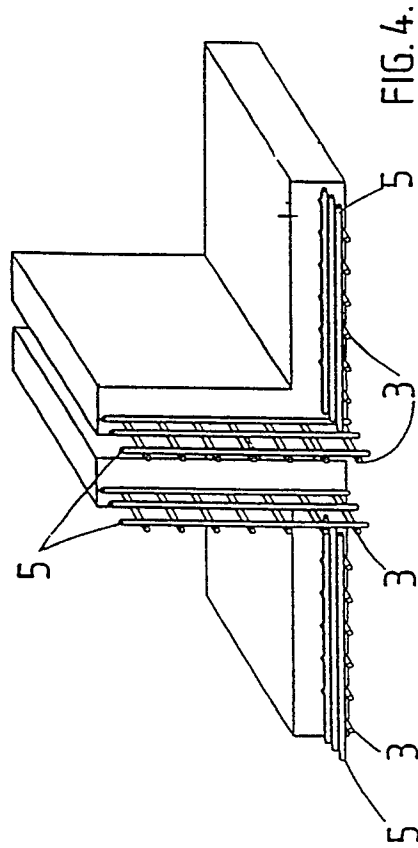
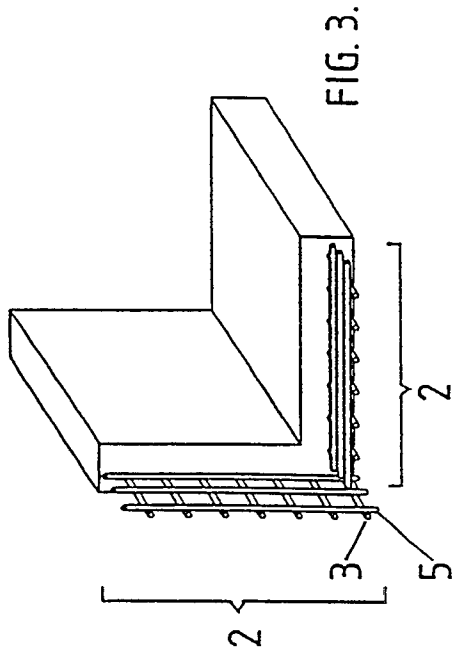
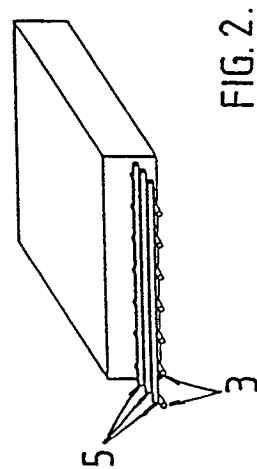
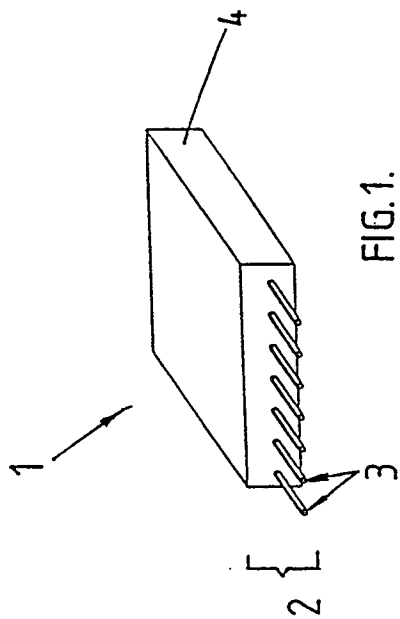
there being distributed along substantially the entire length of said body portion at least one substantially planar filament arrangement comprising one or more filaments aligned substantially lengthwise with respect to said body portion;

and wherein the end of a provided filament or filaments terminate at terminal portions directed inwardly or outwardly of said body portion.
3. A welding element as claimed in claim 2 in which the two pipe contacting faces of the body portion are substantially parallel to each other.
4. A welding element as claimed in claim 3 in which a said filament arrangement is positioned at or near one of said pipe contacting faces.
5. A welding element as claimed in claim 4 in which there are at least two provided filament arrangements, one each at or near a said pipe contacting face.
6. A welding element as claimed in claim 5 in which the filaments from one filament arrangement at or near a first pipe contacting face, cross over to a second filament arrangement on the second pipe contacting face.
7. A welding element as claimed claim 6 which comprises filaments starting at a terminal portion for the first said filament arrangement, and which then extend along said first filament arrangement, then cross to said second filament arrangement, extend along same to a terminal portion associated with second filament arrangement.

8. A welding element as claimed in claim 7 in which said filaments, when forming part of each said filament arrangement, extend along substantially the entire length of the body portion.
9. A welding element as claimed in either claim 7 or claim 8 in which, when viewed in frontal projection, the filament tracks of the said two filament arrangements as they divert to their terminal portion, appear to cross over, or overlap.
10. A welding element as claimed in claim 2 which is annular, in which the filament tracks of a particular filament arrangement are arranged such that when viewed in frontal projection, any radial line extending outwardly from the annular centre will either intersect at a plurality of tracks, or pass a filament track within a distance of half the average separation distance of said filament tracks along the annular body.
11. A welding element as claimed in any one of claims 1 through 8 in which a filament arrangement comprises more than one set of filaments, each set being part of a different electric circuit.
12. A welding element as claimed in claim 11 in which each filament set occupies a portion of the length of the body portion, and where, for said filament arrangement, the filament sets collectively extend along substantially the entire length of the body portion.
13. A welding element as claimed in claim 12 in which, when viewed in frontal projection, the filament tracks of each lengthwise adjacent filament set cross over, or overlap, before reaching their respective terminal portion.
14. A welding element as claimed in any one of claims 1 through 8 in which annular portions can be assembled to form a closed loop.
15. A welding element as claimed in claim 14 in which the formed loop is such that when viewed in frontal projection, any radial line extending outwardly from the annular centre will either intersect at a plurality of tracks, or pass a filament track within a distance of half the average separation distance of said filament tracks along the annular body.
16. A welding element as claimed in any one of claims 1 through 8 or 10 in which the filaments within a filament arrangement are substantially parallel to each other.
17. A welding element as claimed in claim 16 in which the filaments within a filament arrangement are substantially non-serpentine in nature.
18. A welding element as claimed in any one of claims 1 through 8 or 10 in which a single terminal portion is provided to which the filaments of all the filament arrangements are directed.

19. A welding element as claimed in any one of claims 1 through 8 or 10 in which the body portion is of substantially constant cross-section.
20. A welding element as claimed in any one of claims 1 through 8 or 10 which includes a temperature sensing device.
21. A welding element as claimed in claim 20 in which the temperature sensing device is a thermocouple within the body portion.
22. A welding element as claimed in any one of claims 1 through 8 or 10 which includes at least one pressure sensing device, and means for the external monitoring of same.
23. A welding element as claimed in claim 22 in which the pressure sensing device is a piezo-electronic device.
24. A welding element as claimed in any one of claims 1 through 8 or 10 in which there is included cross member which are either or both thermally and electrically conductive, and which are angled with respect to the direction of the filament tracks they overlie.
25. An article as claimed in any one of claims 1 through 8 or 10 which comprises a length of pipe, at least one end of which is modified to represent the thermoplastic body portion in which said filament arrangement, or arrangements, are present.
26. A article as claimed in any one of claims 1 through 8 or 10 which comprises a pipe fitting, at least one end of which is modified to represent the thermoplastic body portion in which said filament arrangement, or arrangements, are present.
27. A method of joining thermoplastic articles, comprising the use of at least one article including an annular or arcuate modified weld interface comprising a contact face for contacting a surface of the second surface to be welded, the weld interface comprising a thermoplastic material including at least one filament arrangement in turn comprising one or more filaments aligned substantially lengthwise with respect to the weld interface, and wherein the filaments of the filament arrangement are substantially parallel to the contact face of the weld interface; and wherein said filaments terminate at terminal portions not forming part of the weld to said second surface, and wherein electricity or an RF field is applied to cause said filaments to heat thereby softening surrounding thermoplastic material to an extent sufficient for welding of the articles.
28. A method as claimed in claim 27 in which one article comprises a pipe section with an integral welding interface with filaments provided at at least one end thereof, and which is brought into end to end contact with another pipe section.

29. A method as claimed in claim 27 in which an intermediate welding element is employed for the end-to-end joining of pipe sections, said welding element comprising an annular or part annular body portion of a thermoplastic material positionable between the ends of said pipe sections;
there being distributed along substantially the entire length of said body portion at least one substantially planar filament arrangement comprising one or more filaments aligned substantially lengthwise with respect to said body portion;
and wherein the end of a provided filament or filaments terminate at terminal portions directed inwardly or outwardly of said body portion;
and wherein said welding element is positioned between the ends of pipe sections to be joined.
30. A welding element, substantially as described herein with reference to the accompanying drawings.
31. A method of joining thermoplastic articles, substantially as described herein with reference to the accompanying drawings.



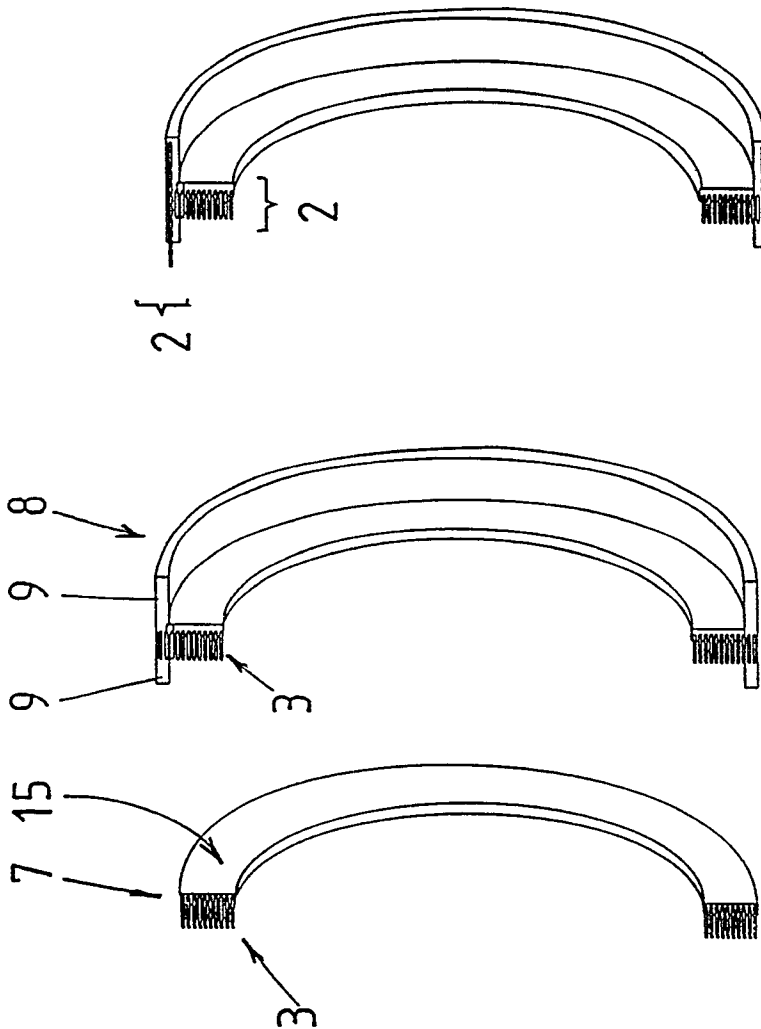
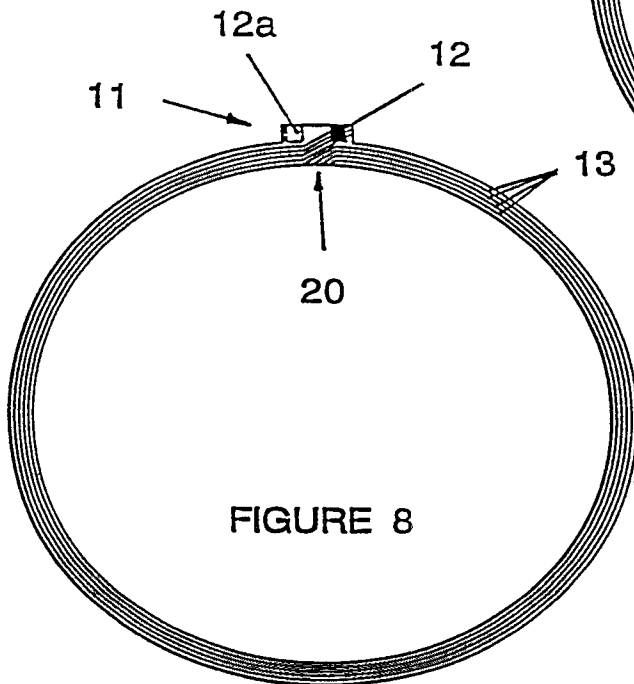
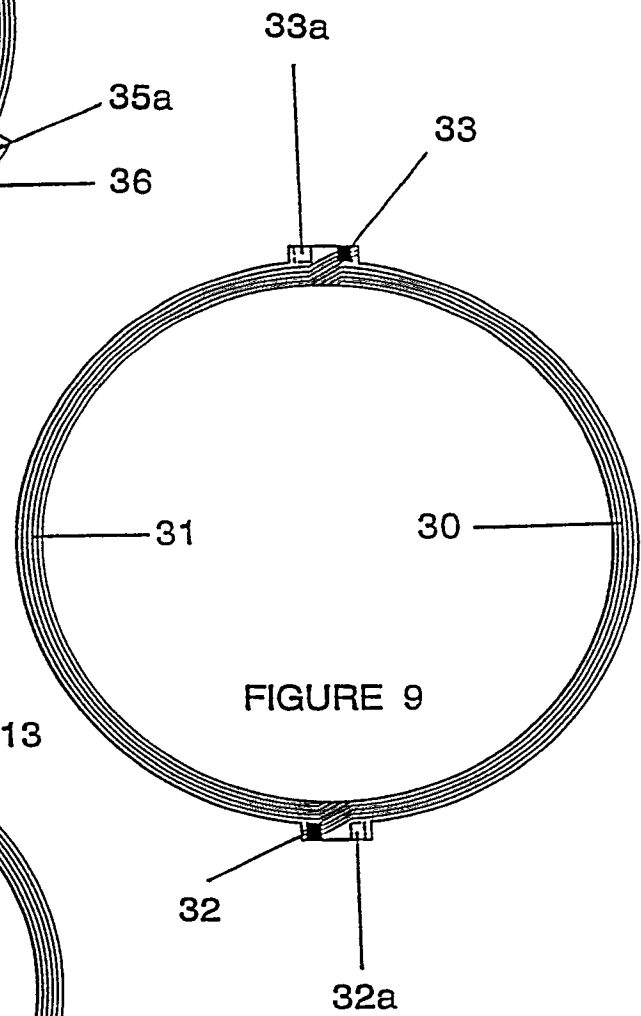
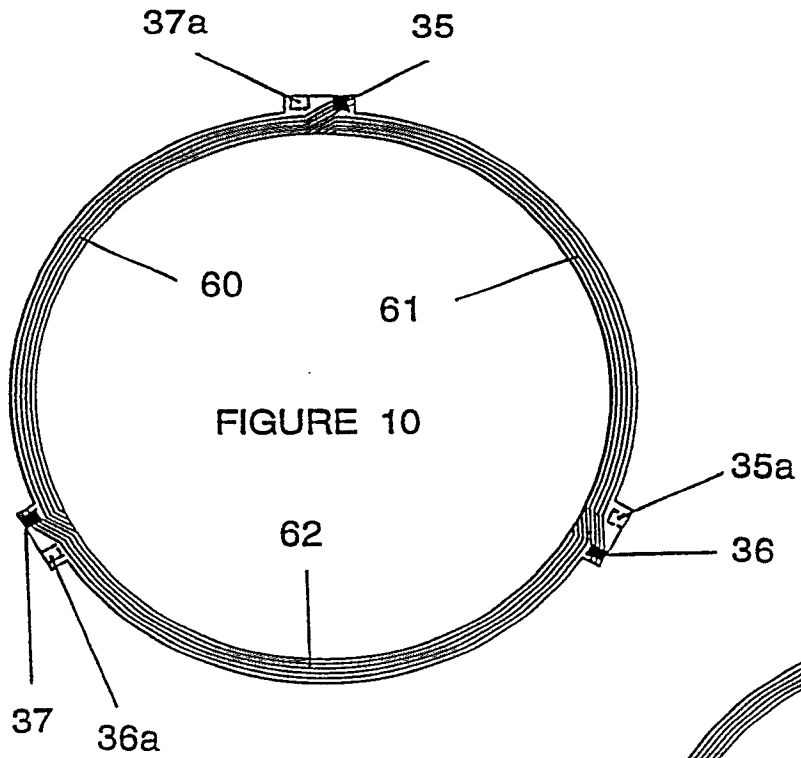
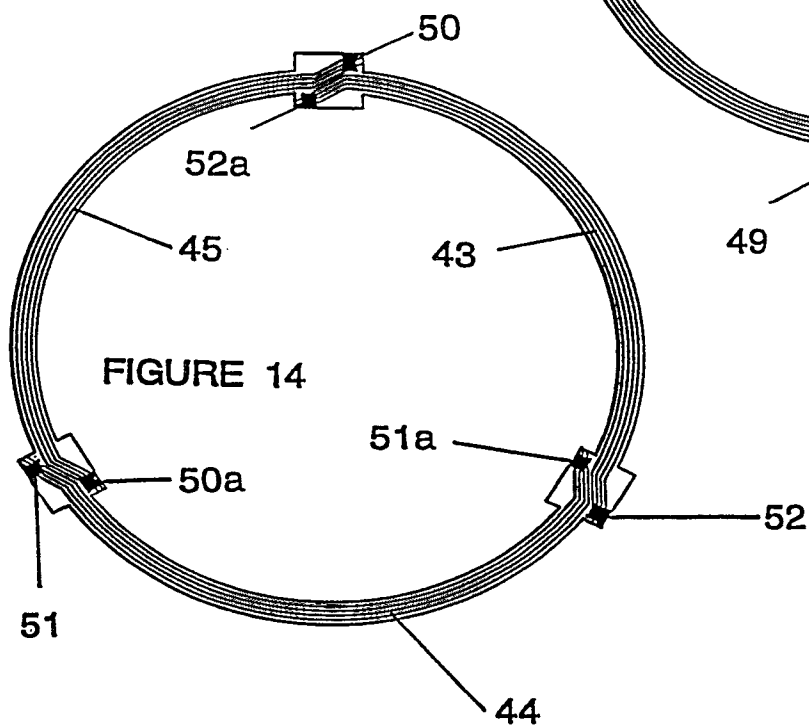
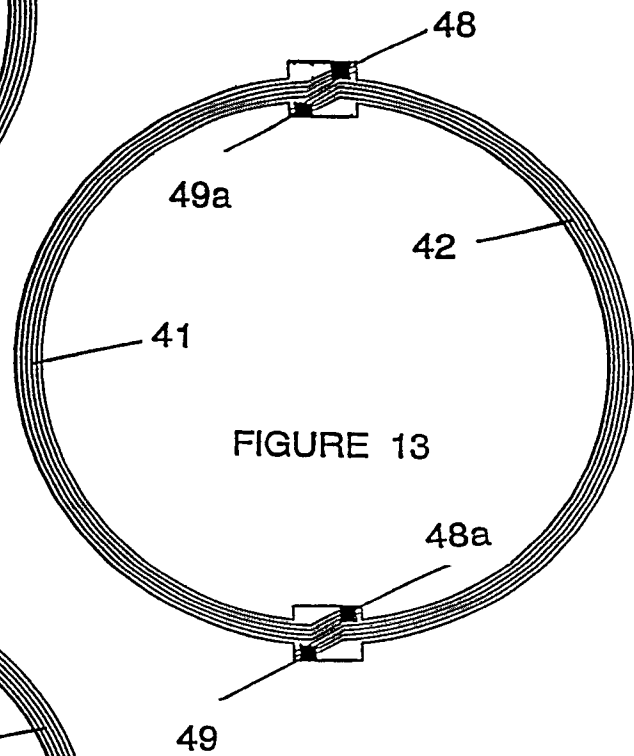
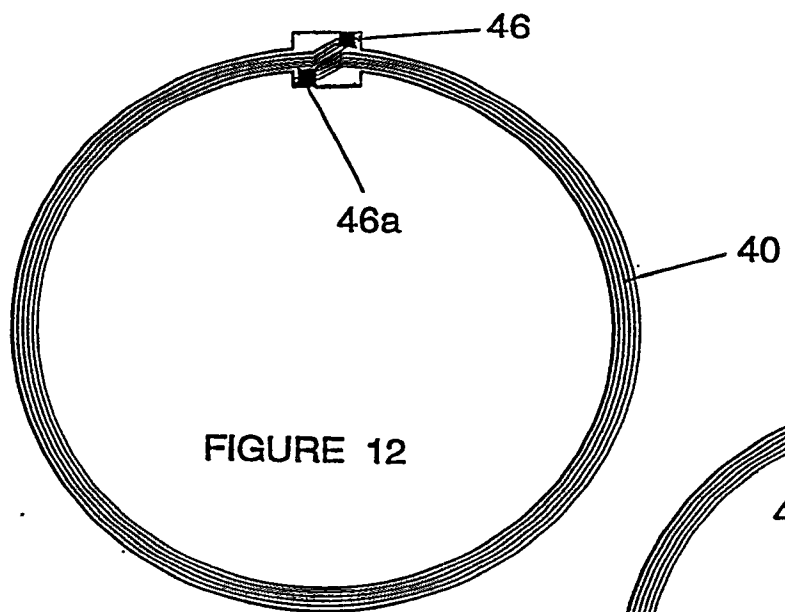


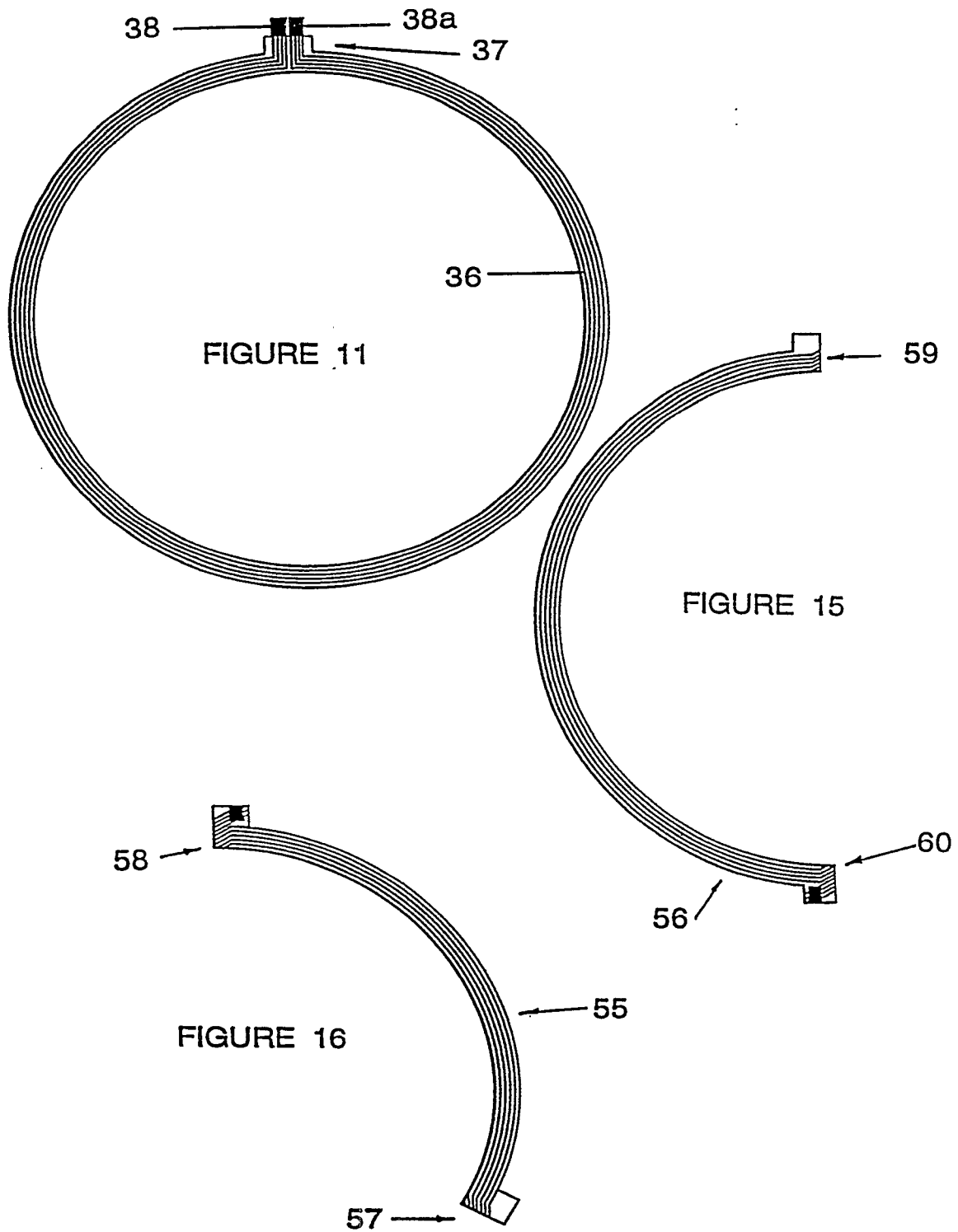
FIG. 7.

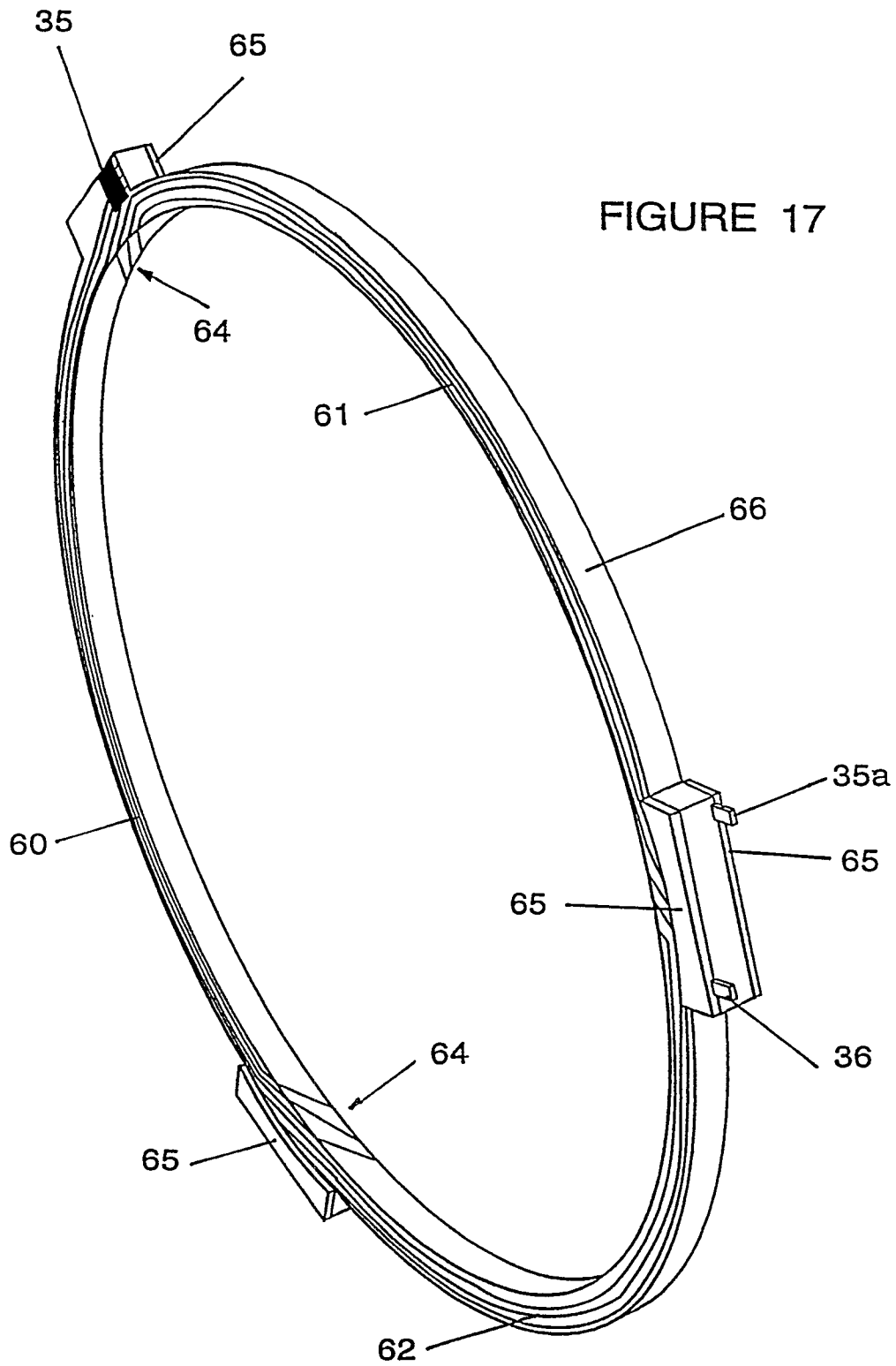
FIG. 6.

FIG. 5.









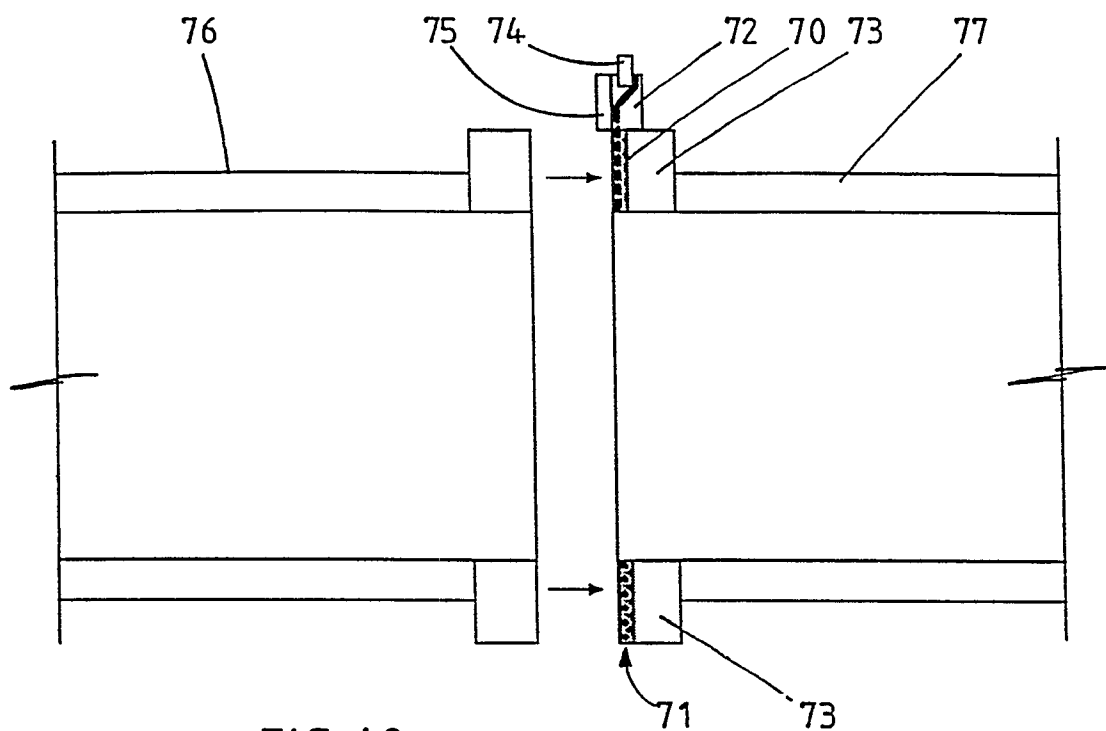


FIG. 18.

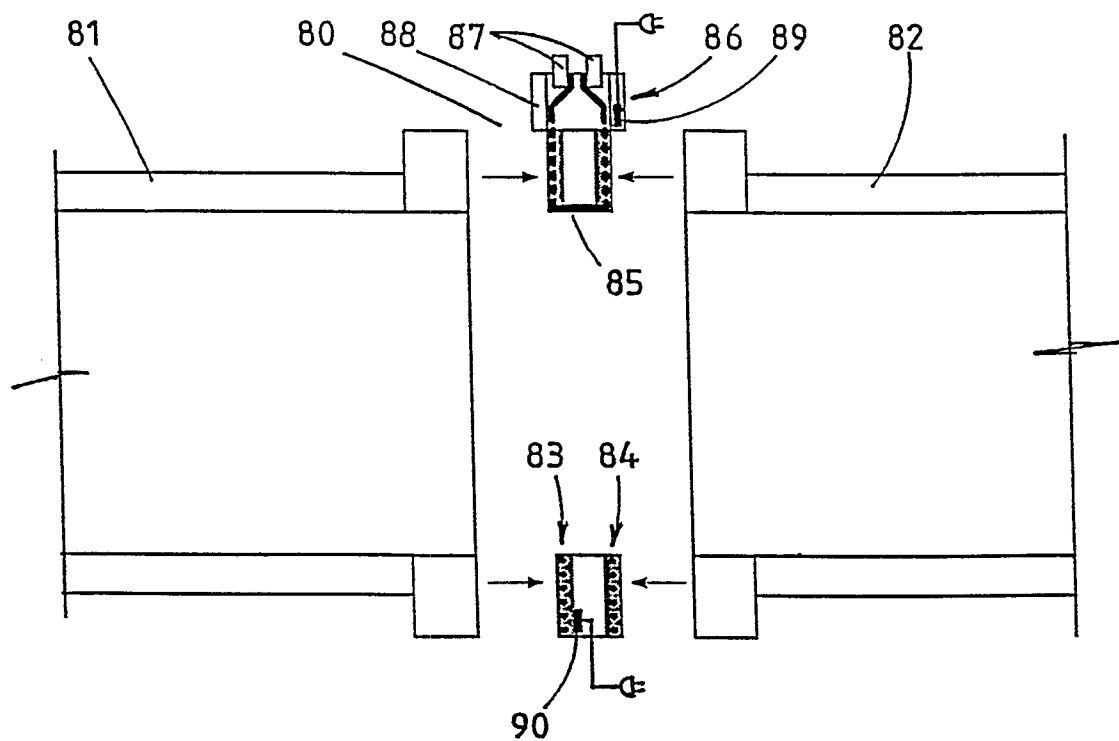


FIG. 19.

