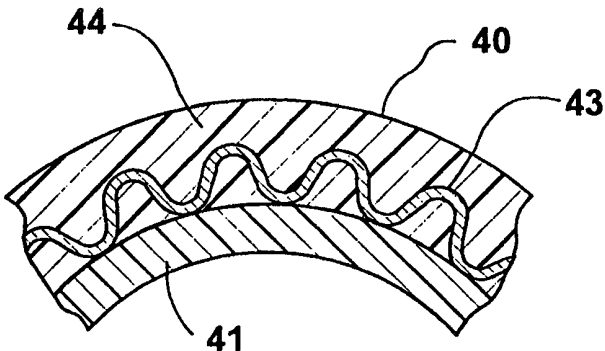


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(21) International Application Number: PCT/IL99/00569 (22) International Filing Date: 27 October 1999 (27.10.99) (30) Priority Data: 126851 2 November 1998 (02.11.98) IL (71) Applicant (for all designated States except US): PLASSON LTD. [IL/IL]; Maagan Michael, 37805 D.N. Menashe (IL). (72) Inventors; and (75) Inventors/Applicants (for US only): BEN-ARI, Shai [IL/IL]; Kibbutz Maagan Michael, 37805 D.N. Menashe (IL). EGOZI, Yigael, Moshe [IL/IL]; Apartment 14, Moskin Street 29, 42460 Natania (IL). (74) Agent: BARISH, Benjamin, J.; P.O. Box 12608, 46733 Herzlia (IL).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: FUSION BONDING METHOD AND ASSEMBLY PRODUCED IN ACCORDANCE WITH SUCH METHOD (57) Abstract A method of fusion bonding together preformed thermoplastic bodies (41, 42, 44) by means of electrical heating current passed through an electrical heater wire (43) carried in one body (44) to heat contacting surfaces of the bodies sufficiently to weld them together, and the assembly produced by such method, characterized in that the electrical heater wire is of a sinuous configuration having sinuous turns alternating in directions perpendicular to the contacting surfaces of the bodies. 		

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**FUSION BONDING METHOD AND ASSEMBLY
PRODUCED IN ACCORDANCE WITH SUCH METHOD**

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to a method of fusion bonding together two or more preformed thermoplastic bodies, and also to an assembly of thermoplastic bodies bonded together in accordance with such method. The invention is particularly useful with respect to fusion couplers for coupling pipes or other devices together, and is therefore described below with respect to such an application.

Fusion couplers are widely utilized at the present time for coupling together plastic pipes used for conveying gasses or liquids, e.g., water. Such fusion couplers include an electrical heater wire carried in a thermoplastic body and electrically energized to produce heating current which melts the thermoplastic body and fuses it to the pipe or pipes being coupled.

One type of thermoplastic fusion coupler is in the form of a thermoplastic sleeve which is applied to enclose the ends of two pipes to be coupled together such that when the electrical heater wire is energized, the thermoplastic coupler sleeve is fusion-bonded to the ends of the two pipes, thereby coupling the pipes together, for example, in an end-to-end relationship. Another type of fusion coupler is in the form of a saddle to produce a fusion bond between a pipe or device (e.g., a tap) in an angular relationship to each other, e.g., as in a T-fitting. Examples of saddle-type couplers are illustrated in US Patents 4,933,037, 5,577,529, 5,708,251 and 5,732,732; and examples of sleeve-type couplers are illustrated in US Patents 3,943,334, 4,147,926, 4,313,053, and 4,530,521. In both types of couplers, it is important to produce a strong and long-lasting fusion bond, in a minimum of time without heating the wire to an unduly high temperature which may degrade the plastic, and also to use simple and inexpensive coupler devices which can be produced in volume and at low cost.

One known type of fusion coupler saddle utilizes an electrical heater wire of a sinuous configuration, wherein the sinuous turns alternate in the direction parallel to the contacting surfaces of the two thermoplastic bodies being fused. That is, the sinuous electrical heater wire is coplanar with the plane of the two contacting

surfaces of the bodies being fused. Such a construction better assures that the wire will remain in place during uneven shrinkage between the plastic and wire.

Another type of fusion sleeve and saddle coupler utilized an electrical heater wire in the configuration of a coil wound in a helical pattern. That is, a straight wire is first wound into a coil, and then the coil is wound into the helical pattern of the coupler sleeve. Such a construction however, is complicated and expensive to produce; moreover, it does not conveniently permit minor changes to be made in the overall electrical resistance of the heater wire as may be needed for any particular application.

OBJECTS AND BRIEF SUMMARY OF THE INVENTION

An object of the present invention is to provide a fusion bonding method having a number of advantages over the above described methods. Another object of the invention is to provide an infusion bonded assembly produced in accordance with such method.

According to one aspect of the present invention, there is provided a method of fusion bonding together preformed thermoplastic bodies by means of electrical heating current passed through an electrical heater wire carried by one body to heat contacting surfaces of the two bodies sufficiently to weld them together, characterized in that the electrical heater wire is of a sinuous configuration having sinuous turns alternating in directions perpendicular to the contacting surfaces of the bodies.

According to further features in the preferred embodiments of the invention described below, the sinuous wire is produced by passing a straight wire between a pair of toothed wheels configured to crimp the wire to the sinuous configuration.

The foregoing method provides a number of important advantages over the methods previously used for making such fusion bonds as briefly described above. Thus, by providing the sinuous configuration with the sinuous turns alternating in directions perpendicular to the contacting surfaces of the two bodies being fused, rather than parallel to them, a three-dimensional fusion area is produced having both a large wire-plastic contact surface which decreases the wire temperature, and

therefore the possibility of degrading the plastic, and also a large plastic-plastic bonding surface which increases the strength of the fusion bond.

Moreover, by using such a sinuous configuration for the electrical resistance of the heater wire, minor variations in the overall electrical resistance of the heater wire can be made in a very convenient manner. Thus, by varying the distance between the toothed wheels, the magnitude of the sinuous turns can be changed to increase the effective linear length of the electrical heater wire and thereby its overall electrical resistance, or to decrease the effective linear length of the heater wire and thereby its electrical resistance. Such changes in the electrical resistance may be effected in-line during the actual production, or off-line when preparing for new production.

Two preferred embodiments of the invention are described below for purposes of example.

In one described embodiment, the thermoplastic body containing the electrical heater wire is a saddle coupler of thermoplastic material for coupling a thermoplastic pipe thereto by a fusion bond. According to further features in this embodiment, one thermoplastic body includes a flat pad carrying the electrical heater wire in a spiral pattern, with the sinuous turns of the wire projecting out of one face of the pad. The pad is applied to the saddle coupler with that one face facing the saddle coupler, and with the opposite face of the pad facing the plastic pipe to which it is to be fusion bonded.

According to a further preferred feature in this embodiment, the sinuous wire is embedded in the pad such as to locate the outer surface of the sinuous wire facing the opposite face of the pad approximately flush with the opposite face of the pad. This can easily be done by merely applying a force to the projected side of the sinuous wire, while heating the wire, e.g., by passing electrical current through the wire, to embed it in the thermoplastic material of the pad. Such a feature provides the additional advantage of bringing the electrical heating wire very close to the surfaces to be bonded, thereby increasing the heat transfer to the fusion region.

A second embodiment is described wherein the thermoplastic body containing the electrical heater wire is a sleeve coupler in which the sinuous heater

wire is embedded in a helical configuration within a thermoplastic sleeve for coupling two pipes together.

The invention also provides an assembly comprising two (or more) thermoplastic bodies fusion bonded together in accordance with the above-described method.

Further features and advantages of the invention will be apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Fig. 1 is a plan view illustrating one form of fusion pad constructed in accordance with the present invention for use in a saddle-type coupler, such as illustrated in Fig. 5;

Fig. 2 is an enlarged fragmentary sectional view of Fig. 1;

Fig. 3 is a view corresponding to that of Fig. 2 but showing the sinuous electrical heater wire after it has been force-embedded into the thermoplastic material of the fusion pad;

Fig. 4 illustrates one manner of producing the sinuous configuration in the electrical heater wire;

Fig. 5 is a sectional view illustrating a saddle coupler including the coupler pad of Figs. 1 and 2 for producing a T-coupling between a pipe and another pipe, tap, or other device;

Fig. 5a is a sectional view along line Va-Va of Fig. 5;

Fig. 6 is a sectional view illustrating one type of coupler sleeve constructed in accordance with the present invention for coupling together two pipes in an end-to-end manner;

Fig. 6a is a sectional view along line VIa-VIa of Fig. 6 ;

Fig. 7 illustrates a coated electrical heater wire used in making the sleeve coupler of Fig. 6;

Fig. 8 illustrates the coated heater wire of Fig. 7 after being bent into its sinuous configuration; and

Fig. 9 illustrates another method of making the coupler sleeve of Fig. 6 by first bending the electrical heater wire into its sinuous configuration and then extruding a thermoplastic coating thereover.

DESCRIPTION OF PREFERRED EMBODIMENTS

Figs. 1 and 2 illustrate the invention embodied in a fusion pad for use in a saddle-type coupler as illustrated in Fig. 5. The pad includes a thermoplastic body 2 of a generally circular configuration having an inner circular edge 3 and an outer circular edge 4. The outer edge 4 of pad 2 is formed with tabs 5 having openings 6 at the four corners of the pad for mounting purposes and with further tabs 7, 8, on two opposite sides. As shown particularly in Fig. 2, one face 2a of thermoplastic pad 2 is formed with a spiral recess 9, whereas its opposite face 2b is unrecessed.

An electrical heater wire, generally designated 10, is applied to recess 9 in face 2a of the thermoplastic pad 2. Electrical heater wire 10 is wound in a spiral pattern within the spiral recess 9. However, wire 10 is first bent into a sinuous configuration having sinuous turns alternating in the directions of the two faces 2a, 2b of the pad such that the sinuous heater wire is constituted of U-shaped sections 11 received within recess 9, alternating with U-shaped sections 12 projecting outwardly of the recess in face 2a.

Electrical heater wire 10 is wound in the spiral recess 9 of the thermoplastic pad 2 in a double-up manner. That is, the middle portion of the electrical heater wire, shown at 13 in Fig. 1, is at the inner edge 3, of the pad 2 and the wire spiral thereon; and the two ends of the wire are at the outer edge of the spiral pattern at its opposite sides, as shown at 14 and 15 in Fig. 1. The wire ends are connected to terminals 16, 17 carried by the two tabs 7, 8, respectively, to permit convenient electrical connection for energizing the electrical heater wire.

Fig. 4 illustrates a preferred manner of producing the sinuous configuration in the wire 10. As shown in Fig. 4, this is done by passing the straight wire 10 between a pair of toothed wheels 21, 22, which crimp the wire into the sinuous configuration. This technique is not only simple and convenient to perform, but also enables the overall electrical resistance of the heater wire to be finely controlled as may be desired according to any particular application. Thus, moving the rotary axes

21a, 22a of the two wheels 21, 22 towards each other increases the amplitude of the sinuous turns formed in the wire 10, thereby increasing the effective linear length of the wire and its overall resistance; whereas moving the rotary axes of the two wheels away from each other, decreases the effective length and thereby the overall electrical resistance of the heater wire.

This precise control of the electrical resistance of the heater wire may be effected in-line during actual production, or off-line when preparing for production. If a larger variation in the electrical resistance is desired, this can also be easily done by replacing the two toothed wheel 21, 22 by wheels having the appropriate pitches for the sinuous turns as may be desired.

Such a convenient and precise control of the overall electrical resistance of the heater wire is considerably more advantageous than the existing techniques wherein the electrical resistance is generally controlled by merely increasing or decreasing the number of windings of the electrical heater wire. The existing technique not only does not permit fine control of the electrical resistance, but may also require redesign of other parts of the coupler, and/or the apparatus for making it.

Fig. 5 illustrates a thermoplastic pad 2 according to Fig. 1 carrying the electrical saddle heater wire 10 as described above molded to a saddle-type coupler, generally designated 30. Such a coupler is used for producing a fusion bond between a section 31 of the saddle coupler and a thermoplastic pipe 32 to be fusion bonded to the saddle coupler. Section 31 of the saddle coupler may be another thermoplastic pipe, or another device, such as a tap, to be fusion bonded to thermoplastic pipe 31.

Thus, thermoplastic pad 2 is introduced into a mould with the U-shaped projections 12 (Fig. 2) of the electrical heater wire 10 projecting outwardly of the pad face 2a, and the saddle 30 is injection molded to the pad. The thermoplastic pipe 32 to be bonded to saddle 30 may then, or any time thereafter, be placed in contact with face 2b of pad 2 bonded to the saddle 30, and the electrical heater wire energized to melt and fuse the contacting surfaces of pad face 2b of the coupler 30 and the pipe 32.

Alternatively the pad may be merely inserted between the saddle 30 and the pipe 32 to be bonded thereto, and fusion-bonded to both at the same time by passing heating current through the pad.

As shown particularly in Fig. 5a, the sinuous configuration of the electrical heater wire 10, in which its sinuous turns alternate in directions perpendicular to the contacting surfaces of the two thermoplastic bodies (saddle 30 and pipe 32) bonded together, produces a three-dimensional bonding region, as distinguished from a two-dimensional bonding surface in the conventional process. Such a three-dimensional bonding region provides large wire-plastic contact surfaces and large plastic-plastic contact surfaces. The large wire-plastic contact surfaces enable more electrical heating current to be applied without unduly increasing the wire temperature which may be damaging to the plastic, thereby producing a strong fusion bond; and the large plastic-plastic contact surfaces further strengthen the fusion bond, as compared for example to the two-dimensional bonding of the conventional techniques. Another important advantage is that the sinuous configuration of the electrical heater wire may be applied in a manner which is not only simple and convenient, but which also permits fine control of the overall electrical resistance, both in-line and off-line during the manufacture of the product, as described above.

A further important advantage is that the thickness of the pad, shown at 2c in Fig. 2, which separates the electrical heater wire 10 from the surface of the pipe 32 contacting and bonded to face 2b of the pad, may be reduced such that sections 11 of the heater wire are approximately flush with face 2b of the pad, as shown in Figs. 3 and 5a. This can easily be done by merely pressing the electrical heater wire 10 into the pad while electrical current is fed through the heater wire sufficiently to soften the plastic so that the heater wire becomes embedded within section 2c of the pad. By thus reducing the distance between the electrical heater wire and the surface of the pipe to contact and to be bonded to the pad, the heat may be better concentrated at the bonding interface thereby producing a stronger fusion bond.

Fig. 6 illustrates one manner in which the novel method may be applied to produce a sleeve-type fusion coupler, generally designated 40, for fusion bonding two (or more) pipes 41, 42 in an end-to-end (or other) relationship. According to this method, the electrical heater wire, therein designated 43, previously bent to the

sinuous configuration as illustrated in Fig. 4, is wound on a mandrel (not shown) in a helical manner, and thermoplastic is injection-molded thereover to produce a sleeve 44 having the electrical heater wire 43 embedded therein in the form of a helical coil around the inner surface of the sleeve, with the opposite ends of the coil terminating in terminals 45, 46 for energizing the coil.

The two pipes 41, 42 may then, or any time thereafter, be inserted into the opposite ends of sleeve 40. The electrical terminals 45, 46 would then be energized to generate heating current which fusion bonds the sleeve 40 to the two plastic pipes 41, 42.

Before the electrical heater wire 43 is wound on the mandrel, the wire in its straight form is coated with a thin thermoplastic layer, as shown at 43a in Fig. 7, and the coated wire is then formed into the sinuous configuration, as shown in Fig. 8. After the coated, sinuously-configured wire is wound on the mandrel to form the helical coil, additional thermoplastic material is injection-molded thereover to produce the coupler sleeve with the sinuously-configured wire embedded therein.

Fig. 9 illustrates a variation wherein the wire 43 is first formed in its sinuous configuration and then a thicker thermoplastic layer 43b is extruded over it, wound around the mandrel, and injection-molded with additional thermoplastic fused to form the coupler sleeve with the sinuous wire embedded therein

It will be appreciated that the construction illustrated in Fig. 6 also produces a three-dimensional bonding region, as shown in Fig. 6a, and also provides many of the advantages described above with respect to the saddle coupler embodiment of Fig. 5, including the increased wire-surface contact enabling higher heating currents to be applied without producing an unduly high wire temperature, increased plastic-plastic surface contact enhancing the fusion bond between the sleeve and the two pipes, and precise control of the overall resistance of the electrical heater wire by controlling the amplitude of its sinuous turns. In addition, the thermoplastic coating (43a, Figs. 7 and 8, or 43b, Fig. 9) may also be used for controlling the overall resistance of the electrical heater wire since the thickness of this coating determines the pitch of the helical winding and thereby its linear length and resistance.

The term "sinuous", as used herein, refers to any type of repeating pattern alternating in direction, including patterns having sharp bends (e.g., square-wave and saw-tooth) as well as curved bends.

While the invention has been described with respect to several preferred embodiments, it will be appreciated that these are set forth merely for purposes of example, and that many other variations, modifications and applications of the invention may be made.

WHAT IS CLAIMED IS:

1. A method of fusion bonding together preformed thermoplastic bodies by means of electrical heating current passed through an electrical heater wire carried by one body to heat contacting surfaces of the two bodies sufficiently to weld them together, characterized in that said electrical heater wire is of a sinuous configuration having sinuous turns alternating in directions perpendicular to the contacting surfaces of the bodies.

2. The method according to Claim 1, wherein said sinuous wire is produced by passing a straight wire between a pair of toothed wheels configured to crimp the wire to said sinuous configuration.

3. The method according to Claim 1, wherein said one thermoplastic body includes a pad of thermoplastic material carrying said electrical heater wire.

4. The method according to Claim 3, wherein said sinuous wire is carried in said pad in a spiral pattern.

5. The method according to Claim 4, wherein said electrical heater wire is wound in a double-up manner on said pad such that the middle of the electrical heater wire is at the inner edge of the spiral pattern, and the two ends of the electrical heater wire are at the outer edge of the spiral pattern.

6. The method according to Claim 4, wherein said pad is in a saddle coupler of thermoplastic material for coupling a thermoplastic pipe thereto by a fusion bond.

7. The method according to Claim 6, wherein said pad is formed on one face with a recess of said spiral pattern, and said electrical heater wire is carried on said one face of the pad with its sinuous turns projecting out of said recess on said one face of the pad; said one face of the pad facing the saddle coupler and the opposite face of the pad facing the plastic pipe to which it is to be fusion bonded.

8. The method according to Claim 7, wherein said sinuous wire is pressed into the thermoplastic material of said pad such as to locate the outer surface of the sinuous wire facing said opposite face of the pad approximately flush with said opposite face of the pad.

9. The method according to Claim 1, wherein said one body is a sleeve coupler and carries said electrical heater wire of sinuous configuration in a helical pattern within a thermoplastic sleeve for coupling two pipes together by a fusion bond.

10. The method according to Claim 9, wherein said sleeve coupler is produced by forming the wire with said sinuous configuration, winding said sinuous wire in a helical pattern on a mandrel, injecting thermoplastic material around said wire to form a sleeve with said wire embedded therein, and removing said sleeve from the mandrel.

11. The method according to Claim 10, wherein said wire is formed with said sinuous configuration before winding on the mandrel by applying a thermoplastic coating over a straight wire, and then deforming said coated wire into said sinuous configuration.

12. The method according to Claim 10, wherein said wire is formed with said sinuous configuration before winding on the mandrel by deforming a straight wire into said sinuous configuration, and then extruding thermoplastic material over said sinuously-configured wire.

13. An assembly comprising preformed thermoplastic bodies fusion bonded together by means of electrical heating current passed through an electrical heater wire carried by one body to heat contacting surfaces of the bodies sufficiently to weld them together, characterized in that said electrical heater wire is of a sinuous configuration having sinuous turns alternating in directions perpendicular to the contacting surfaces of the bodies.

14. The assembly according to Claim 13, wherein said one thermoplastic body includes a pad carrying said electrical heater wire.

15. The assembly according to Claim 14, wherein said sinuous wire is carried in said pad in a spiral pattern.

16. The assembly according to Claim 15, wherein said electrical heater wire is wound in a double-up manner on said pad such that the middle of the electrical heater wire is at the inner edge of the spiral pattern, and the two ends of the electrical heater wire are at the outer edge of the spiral pattern.

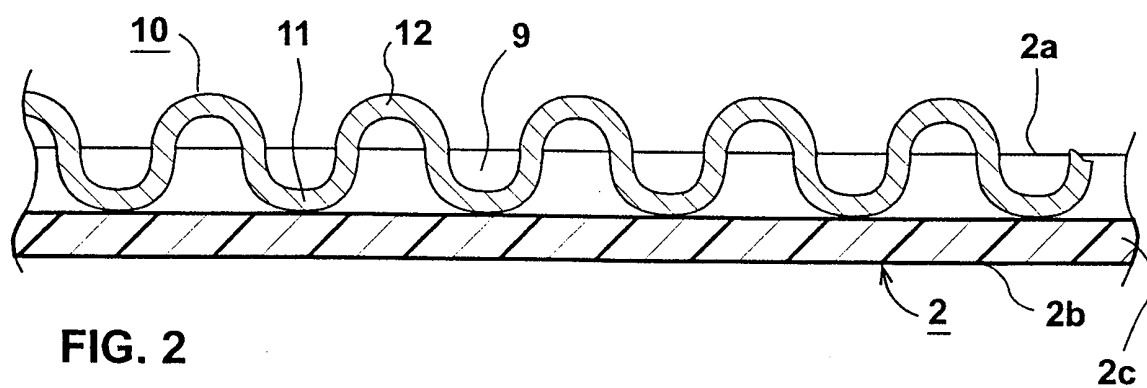
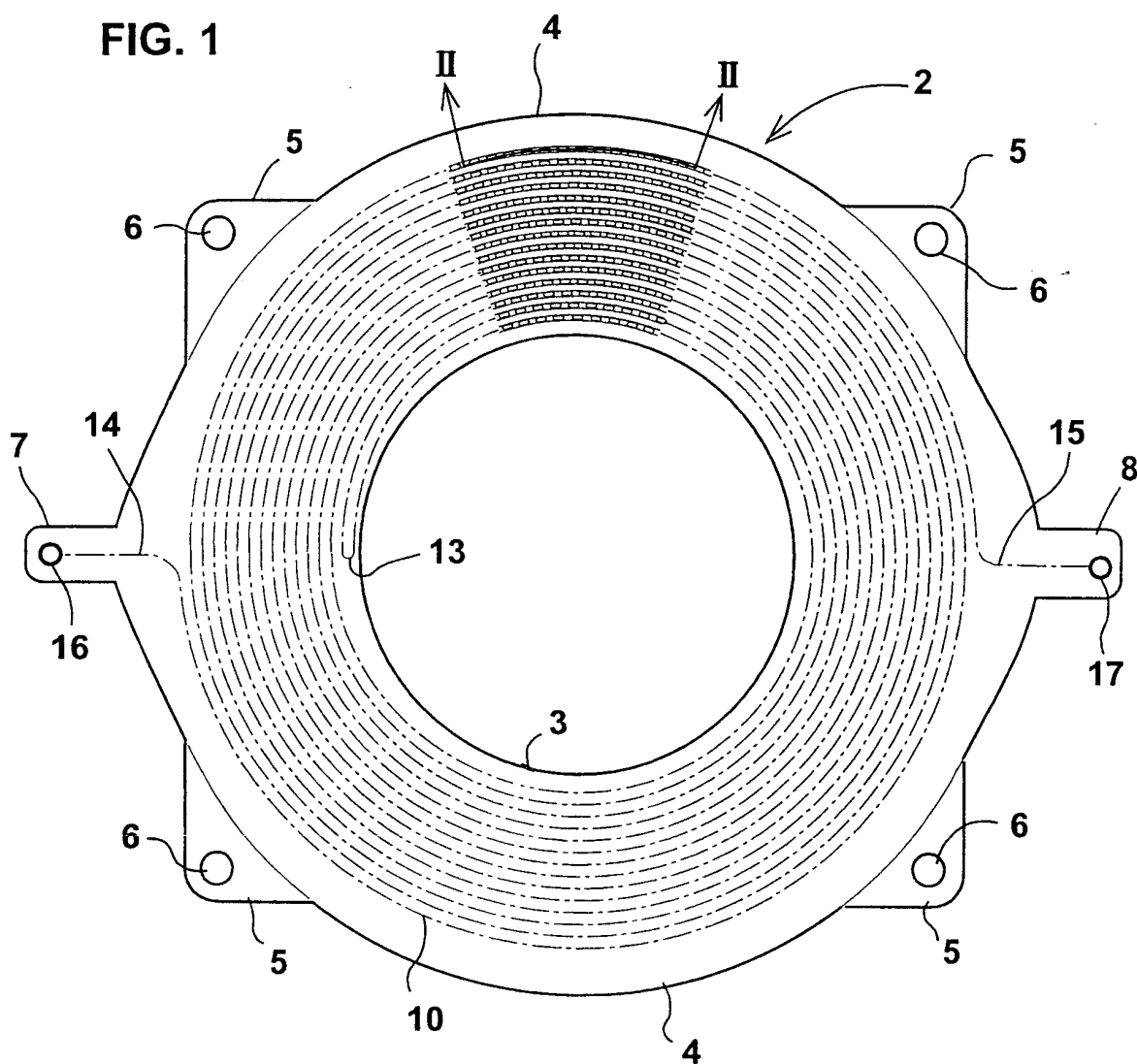
17. The assembly according to Claim 15, wherein said pad is in a saddle coupler of thermoplastic material coupling a thermoplastic pipe thereto by a fusion bond.

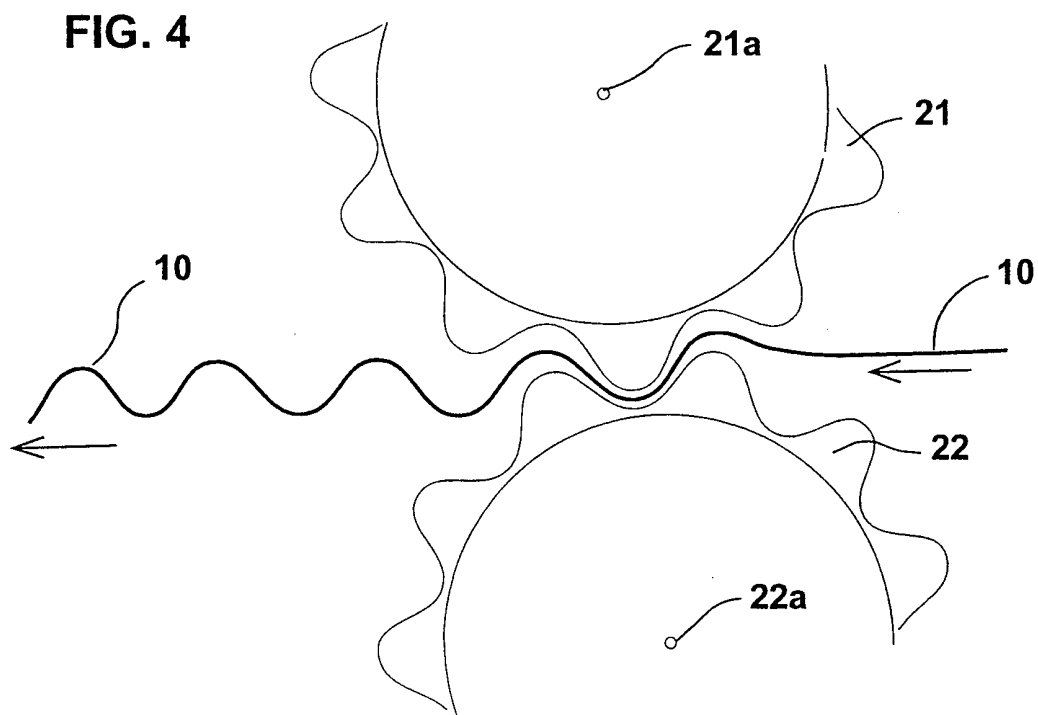
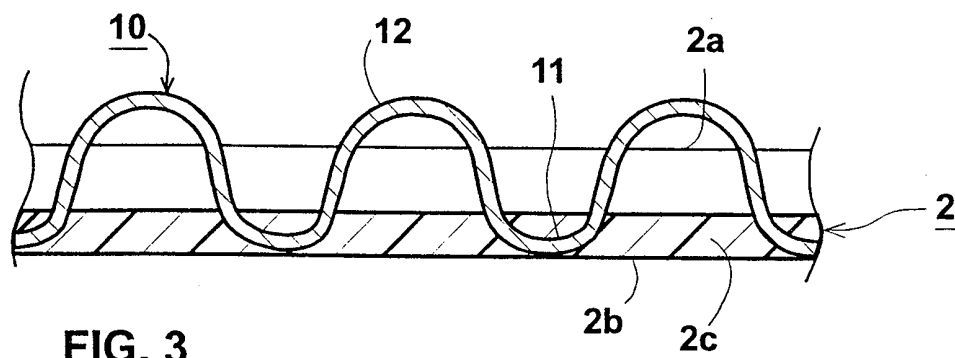
18. The assembly according to Claim 17, wherein said pad is formed on one face with a recess of said spiral pattern, and said electrical heater wire is carried on said one face of the pad with its sinuous turns projecting out of said recess on said one face of the pad; said one face of the pad facing the saddle coupler and the opposite face of the pad facing the plastic pipe to which it is fusion bonded.

19. The assembly according to Claim 18, wherein said sinuous wire is embedded in the thermoplastic material of said pad such as to locate the outer surface of the sinuous wire facing said opposite face of the pad approximately flush with said opposite face of the pad.

20. The assembly according to Claim 13, wherein said one body is a sleeve coupler and carries said electrical heater wire of sinuous configuration in a helical pattern within a thermoplastic sleeve for coupling at least two devices together by a fusion bond.

FIG. 1





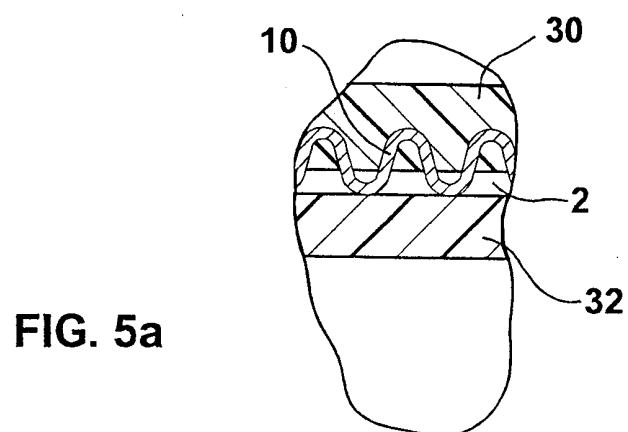
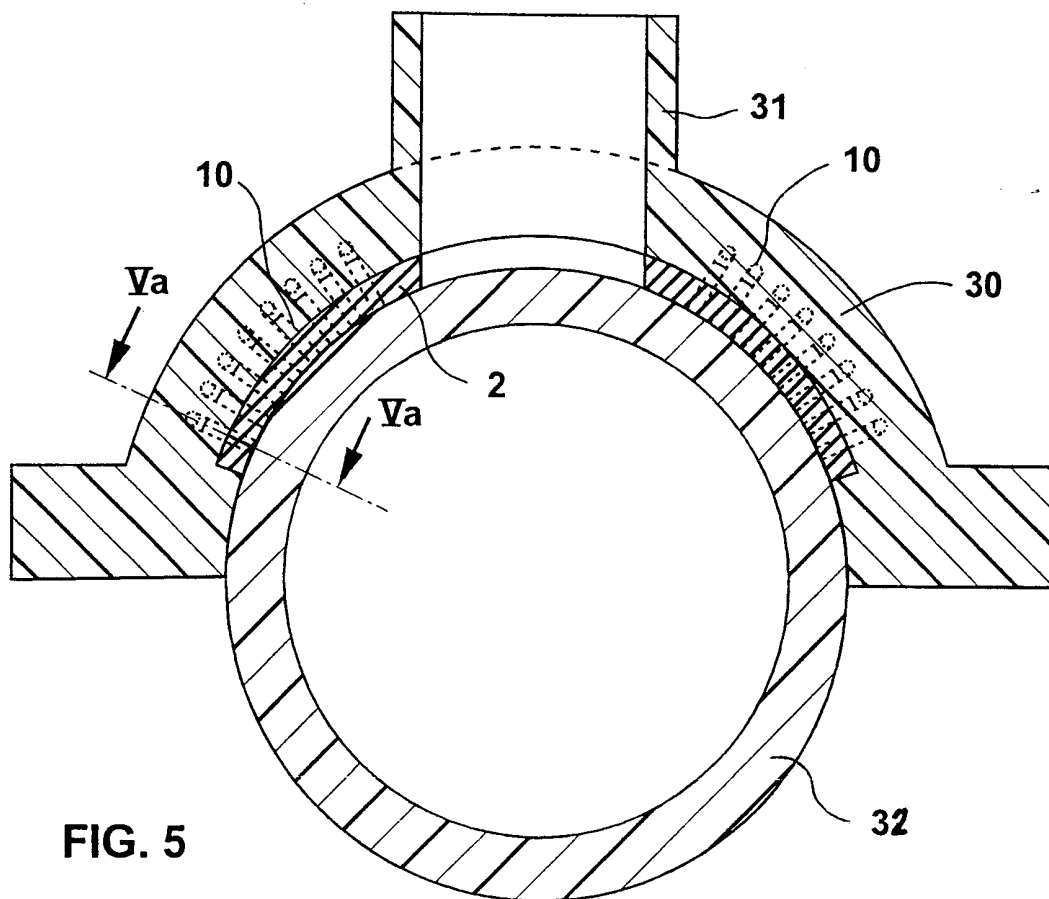


FIG. 6

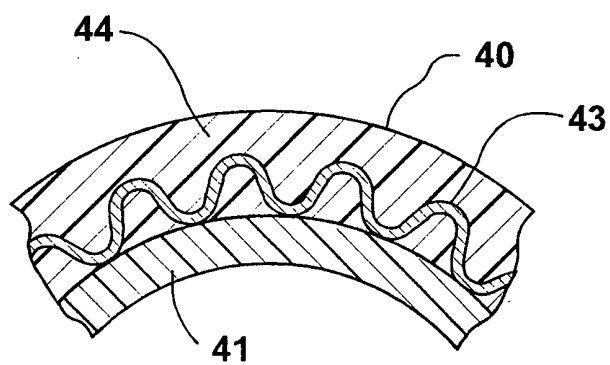
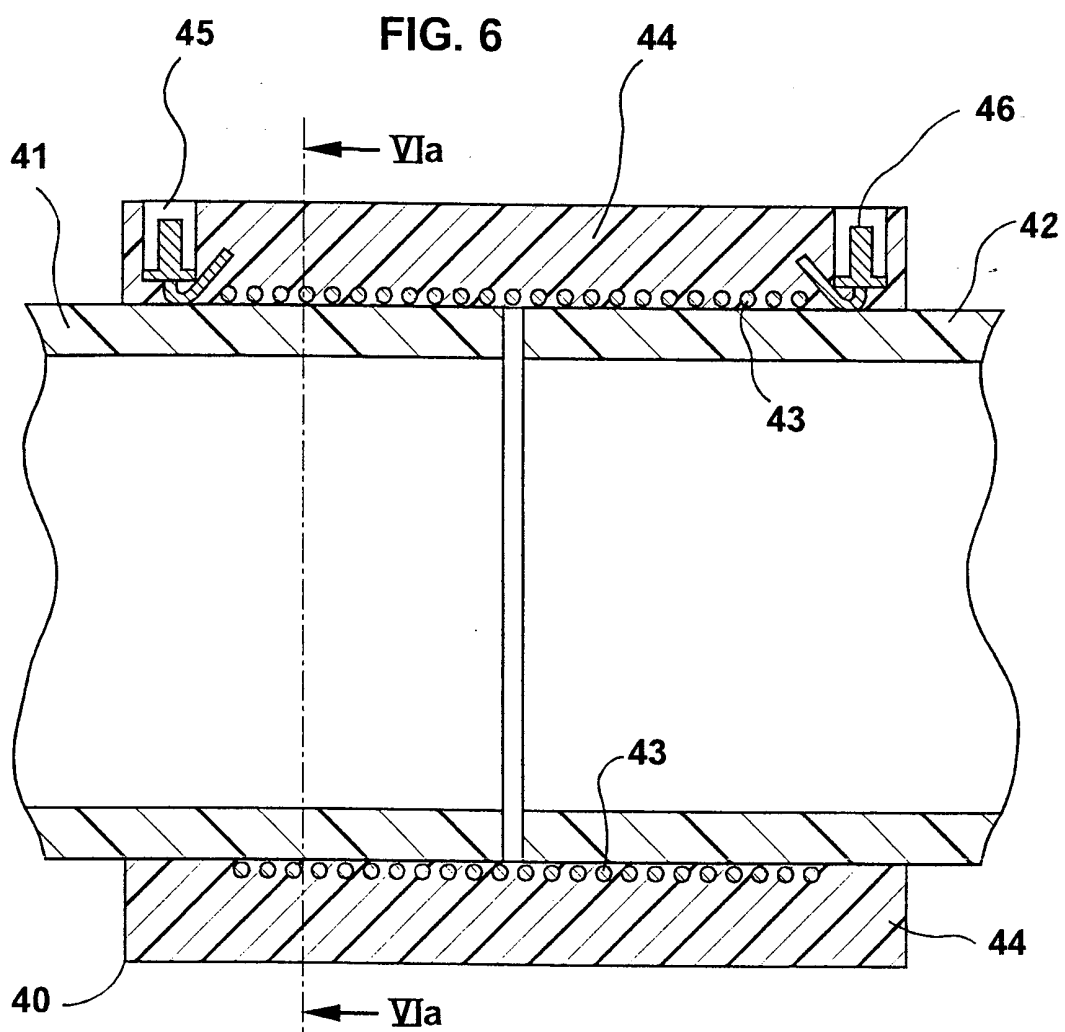
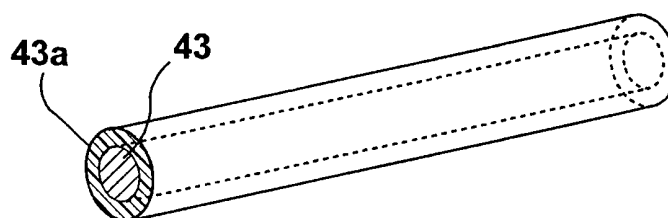
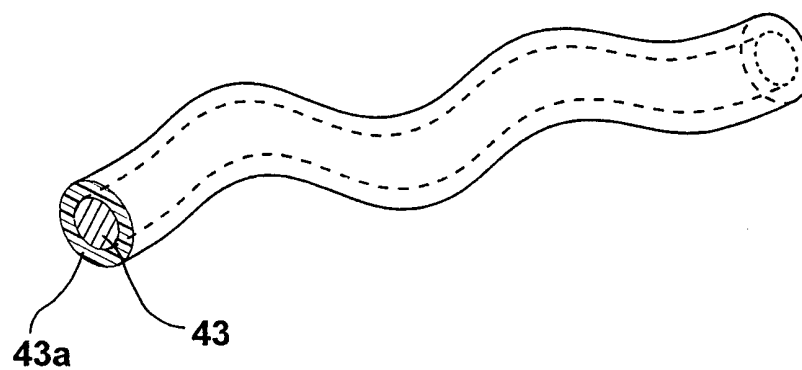
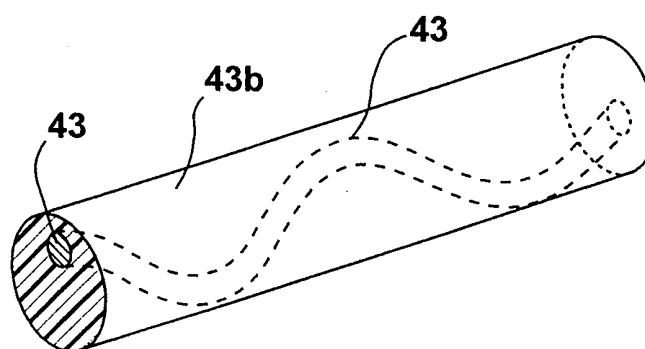


FIG. 6a

FIG. 7**FIG. 8****FIG. 9**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL99/00569

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B32B 31/24

US CL :156/273.9, 274.2; 219/535, 544; 285/21.2; 428/300.1, 300.7

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 156/273.9, 274.2, 294; 219/535, 544; 285/21.2; 428/300.1, 300.7

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US 5,407,520 A (BUTTS et al) 18 April 1995, Figs. 4, 7, 16, col. 2, lines 59-61.	1, 3, 9 ---- 10-14, 20
Y	US 5,104,468 A (DE JONG) 14 April 1992, Abstract, col. 4, lines 30-40.	4-8, 15-19
A	US 3,468,747 A (TATNALL) 23 September 1969, Fig. 1.	
A	US 5,478,118 A (BARQ et al) 26 December 1995, Abstract, Figs. 1, 4.	

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

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