

ELECTROFUSION FASTENING APPARATUS

This invention relates to electrofusion fastening apparatus that, by supplying an electric current to a heat generating body set up in proximity to a surface of a spigot or socket of a joint made from thermoplastic resin, fuses and fastens the spigot into the socket.

The invention also relates to methods of fusion control.

The technology set out in this specification is particularly suitable for use with the tube joining element described in EP 0467309, which avoids short-circuiting of its linear heating element.

Conventionally, even if the pipe spigot is not inserted correctly in the joint socket, the fusion and fastening operation is carried on until its end by turning the start button on.

It is a problem that, when fusion is attempted in a condition where the pipe spigot is not inserted correctly in the joint socket, the connection easily separates after fusion.

According to a first aspect of the invention, there is provided an electrofusion fastening apparatus in which, by supplying an electric current to a heat generating body set up on the inner circumference surface of a socket of a joint made from thermoplastic resin, the spigot of a thermoplastic pipe is fused and fastened into the above-mentioned socket; characterised in that when the time it takes the electric current value flowing into the heat generating body to rise to a fixed electric current value exceeds a fixed time, measures are taken to detect poor insertions of the pipe judged to have the pipe spigot incorrectly inserted into the joint socket, and the electric current supply to the heat generating body is discontinued while the poor pipe insertion is being detected according to the detection measures.

Therefore, in this aspect of the invention, since poor insertions of pipe that cannot be judged visually are correctly detected, and the fusion and fastening operation is discontinued while the detection is made, conventional fusion and fastening failure due to poor insertions of pipe disappear, and correct fusion and fastening is normally carried out.

Conventionally, after the pipe spigot is inserted and set in the joint socket, the thermoplastic resin is fused by being heated once to more than its fusion temperature by the heat generating body. This is done by turning the start button on.

It is a problem that, if water adheres to the pipe spigot or the joint socket whilst fusion is attempted, the risk of a short circuit arises that might damage the electrofusion fastening apparatus and the heat generating body. Also, the fused resin ends up with air bubbles inside and "pores", and the bonding strength is very weak.

According to a second aspect of the invention there is provided electrofusion fastening apparatus in which, by supplying an electric current to a heat generating body set up on the inner circumference surface of a socket of a joint made from thermoplastic resin, the spigot of a thermoplastic pipe is fused and fastened into the above-mentioned socket; characterised in that the apparatus performs a drying process in which thermoplastic resin is heated by the above-mentioned heat generating body to below its fusion temperature, before a fusion process in which thermoplastic resin is heated by the above-mentioned heat generating body to above its fusion temperature.

Therefore, in this aspect of the invention even if water adheres to the pipe spigot or the joint socket, since the fusion process is carried out after the water is evaporated and the fusion section is completely dried, the previous problems of damage to electrofusion fastening apparatus and heat generating bodies due to water and poor

bonding strength are avoided. As a result a proper fusion operation can normally be carried out.

There have conventionally been electrofusion devices whereby a pipe and a joint are fused together by allowing an electric current to flow to an electrical resistance wire which has previously been wound in a spiral on the inner circumference of the socket of a resin joint into which is inserted the end of a resin pipe.

With such conventional electrofusion devices there has been the problem that it was difficult to fuse the resins properly. This is because the heat element was controlled by a heat pattern, whereby the current rose after commencement of the fusion process, was maintained for a set time at a set current value once it reached that value, and the process terminated when that set time had elapsed. In addition to this, changes in heat conductivity resulting from differences in the space between the pipe and the joint and from the outside air temperature in the workplace meant that working with only the heat pattern of the initial setting, made it difficult to fuse the resins properly.

According to a third aspect of the invention, there is provided an electrofusion device for resin products wherein the resin of a joint component is fused by supplying power to a heat element attached to a resin product to which it is to be fused; characterised in that it is provided with a controller which controls the amount of heat applied by the aforesaid heat element in accordance with a heat pattern, whereby the power level rises at commencement of the fusion process until it reaches a first set power level, which is maintained for the duration of a first period of time before being lowered by a specified amount for the duration of a second period of time, after which it reaches a second set power level and is maintained there for the duration of a third period of time before the fusion process terminates.

Preferably the device detects a gap between the resin products which are to be fused by the time needed to reach the first set power level from commencement of the fusion process. In one preferred embodiment a connector of the controller for connection to a resin product which is to be fused is provided with a temperature sensor which detects an outside air temperature. The device may amend the heat pattern on the basis of a gap between resin products which are to be fused and of the outside air temperature. Preferably, the device, by means of the first set power level, brings the temperature of the resin product which is to be fused to one which is above the melting point of the resin but below the point at which it deteriorates or is damaged.

Consequently, because this electrofusion device is provided with a controller which controls the amount of heat of the aforesaid heat element in accordance with the described heat pattern it is possible to fuse the resins of resin products correctly.

Because it detects the space between the resin products which are to be fused by the time needed to reach the first set power level from commencement of the fusion process, it is possible to detect the space between the resin products which are to be fused correctly and without need for any special means.

Because the connector of the controller whereby it is connected to the resin product which is to be fused is provided with a temperature sensor which detects the outside air temperature, it is possible to detect correctly the outside temperature in the immediate vicinity of the resin products which are to be fused.

Because it amends the heat pattern on the basis of the space between resin products which are to be fused and of the outside air temperature, it is possible to obtain the correct amount of heat which corresponds to differences in the measurements of the resin products which are to be fused and to the environment of the place where the fusion process is performed.

Because by means of the first set power level it brings the temperature of the resin product which is to be fused to one which is above the melting point of the resin but below the point at which it deteriorates or is damaged, it is possible to prevent deterioration in or damage to the resin caused by over-heating the resin products which are to be fused.

There have conventionally been electrofusion devices whereby a pipe and joint are fused together by allowing an electric current to flow to an electrical resistance wire which has previously been wound in a spiral on the inner circumference of the socket of a resin joint, into which is inserted the end of a resin pipe.

With conventional electrofusion devices there has been the problem that they required training and experience in their handling, because before commencing the fusion process the operator himself had to determine the amount of heat (work) needed for the type of resin and the products to be fused (material, shape and size of the joint), input the heat pattern into the controller, and perform the fusion process in line with that heat pattern.

According to a fourth aspect of the invention there is provided an electrofusion device for resin products wherein the resin of a joint component is fused by supplying power to a heat element attached to a resin product to which it is to be fused; characterised in that it is provided with a controller which, according to the type of resin product which is to be fused, reads in advance mechanical or electrical changes for the purpose of identifying the type of product which is to be fused, selects and sets the heat pattern corresponding to the type of resin product which is to be fused, and automatically performs the fusion process.

Preferably, the connector of a controller is provided with a terminal by which to connect it to terminals at either end of an electrical resistance wire which is exposed to the surface or end of the resin product which is to be fused, and a terminal by which to connect it to the part which constitutes the mechanical or electrical change for the purpose of identifying the type allocated to the resin product which is to be fused.

Thus, by means of this further aspect of the invention it is possible to perform the setting (initial setting) of the heat pattern automatically and competently on the basis of the type of resin product which is to be fused, and anyone can handle it and perform the fusion process for resin products correctly.

Also, because the connector of the controller is provided with a terminal by which to connect it to the terminals at either end of an electrical resistance wire which is exposed to the surface or end of the resin product which is to be fused, and a terminal by which to connect it to the part which constitutes the mechanical or electrical change for the purpose of identifying the type allocated to the resin product which is to be fused, it is possible to perform the initial setting without any special operation by connecting the connector of the controller to the resin product which is to be fused.

Conventional electrofusion control devices (referred to below as 'EF controllers') for supplying power to the heating wires of EF joints effect fusion automatically by storing a heating control pattern (referred to below as 'heat pattern') for each type of EF joint and automatically controlling the amounts of power that are supplied to heating wires on the basis of the heat patterns corresponding to EF joint types.

Since the heating wires of different manufacturers have different physical properties, an EF controller can only be used for the EF joints of a specific manufacturer, and so it is necessary for pipe-layer operatives to have ready a set of EF controllers for the EF joints of different manufacturers, which is extremely uneconomical.

It is the object of this fifth aspect of the present invention to provide an EF joint automatic fusion control method which can deal with the EF joints of any manufacturer.

According to a fifth aspect of the present invention, there is provided an electrofusion joint automatic fusion control method wherein:

- (1) in response to a fusion work start signal, detection of the surrounding temperature and measurement of the value of the resistance of the heating wire of an electrofusion joint at the surrounding temperature are effected and set power is supplied to said heating wire,
- (2) when the power reaches a set value, the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the specific heat of resin is calculated by PID computation,
- (3) having reference to the degree of resistance variation and the specific heat calculated in (2), the power is raised stepwise, and in each step the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the degree of specific heat variation is calculated, and
- (4) when the degree of specific heat variation calculated in (3) goes below a certain constant, raising of the power is stopped, on-off control in constant time intervals is effected, and when the specific heat goes below a certain constant the supply of power is cut.

According to the fifth aspect of the invention there is also provided an electrofusion joint automatic fusion control method wherein:

- (1) in response to a fusion work start signal, detection of the surrounding temperature and measurement of the value of the resistance of the heating wire of an electrofusion joint at the surrounding temperature are effected and set power is supplied to said heating wire,

(2) when the power reaches a set value the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the specific heat of resin is calculated by PID computation,

(3) having reference to the degree of resistance variation and the specific heat calculated in (2), the power is raised stepwise, and in each step the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the degree of specific heat variation is calculated, and

(4) when the degree of specific heat variation calculated in (3) goes below a certain constant, raising of the power is stopped, on-off control in constant time intervals is effected, and after elapse of a time calculated on the basis of the specific heat calculated in step (3) the supply of power is stopped.

Since, according to an EF joint automatic fusion control method of this, fifth, aspect of the invention, in the course of control, judgements are made on the type of EF joint and the physical properties of the heating wire and while this is being done the amount of power (temperature field) that is optimum for heating and melting the resin is sought and confirmed, the invention is one that makes it possible for fusion of all EF joints to be effected properly, regardless of the EF joint types or manufacturers.

In the prior art, electrical fusion can take place even if the end of the pipe is not completely fitted into the socket. There is, therefore, a risk that separation may occur after joining has been carried out.

Therefore, according to a sixth aspect of the invention there is provided a method of fusing resin products characterised in that a first resin product and a second resin product are placed in the joining position, the connectors of a controller are connected to a pair of terminal pins which are exposed on the surface of the first resin product, the current supplied to an electrically resistant wire which is inset into the joining surfaces of the first resin product and the second resin product and connected at its

ends to the terminal pins, is controlled by the controller; a switch part which switches the current on and off, being formed in the intermediate part of the electrically resistant wire and the switch being held closed by second resin product only when the first resin product and the second resin product are placed in a specified joining position, thus making electrical fusion operations possible.

Thus, it is impossible to carry out electrical fusion operations unless the first resin product and the second resin product are in the specified joining position and this makes it possible to prevent joining failure in a way which has not been possible.

Electrical fusion is generally used to join junctions of resin pipes, when an electric current is passed through an electrically resistant wire which is previously wound spirally on the inner surface of the socket of the joint into which the spigot is inserted, and the pipe and joint are thus heated and fused. In the prior art, fusion was confirmed by fitting an inspection hole to the socket of the joint and melting of the resin confirmed through this inspection hole.

However, this known method of confirming fusion involves problems such as the fact that molten resin flows out of the inspection hole, forming a cavity between pipe and joint and, once it has flowed out, the resin hardens to form burr.

The purpose of this aspect of the present invention is to propose a method of confirming fusion of resin products such as pipes and joints without the use of an inspection hole, which will prevent join failure of resin products due to incomplete fusion and also to propose a method of confirming fusion of resin products which does not necessitate any surface after-treatment of the resin products after joining.

Therefore, according to a seventh aspect of the invention there is provided a method of confirming fusion of resin products characterised in that, in a method of molten

adhesion of resin products in which a first resin product and a second resin product are set for joining, a controller connector is connected to terminal pins projecting from the surface of the first resin product, the current supplied to an electrically resistant wire, which is inset into the joining surfaces of the first resin product and the second resin product and is connected at its ends to the above-mentioned terminal pins, is controlled by the said controller, and the first resin product and the second resin product are fused; a resin product type identification means is used to identify the type of first resin product when work begins and to set a corresponding heat pattern, when the connector is connected to the above-mentioned terminal pins.

Preferably, a sensor arm projects from the connector and fits into a cavity located in a resin product, the depth of which cavity varies according to the type of resin product, and the type of resin product is identified on the basis of the length of travel of the sensor arm.

A temperature identification device may be used to detect the surface temperature of the first resin product using a temperature sensor at the tip of the above-mentioned sensor arm when it contacts the base of the cavity and this finding may be used to correct the heat pattern on the basis of the temperature of the first resin product at the beginning of work.

By such an arrangement it is thus possible to detect simultaneously the expansion and temperature of the resin when melted. When this method of confirming fusion is used, as the expansion and temperature of the resin are detected at the time of fusion, it is possible to confirm the fusion of the resin products without an inspection hole being fitted and the existing sensors are used to detect the expansion and temperature of the resin, without any special sensor being fitted. Furthermore, since both the expansion and temperature of the resin are detected, it is possible to detect fusion of resin products without involving any additional cost.

According to the seventh aspect of the invention there is also provided a method of confirming fusion of resin products characterised in that, in a method of fusion of resin products in which a first resin product and a second resin product are set for joining, a controller connector is connected to terminal pins projecting from the surface of the first resin product, the current supplied to an electrically resistant wire, which is inset into the joining surfaces of the first resin product and second resin product and has its ends connected to the above-mentioned terminal pins, is controlled by the above-mentioned controller, and the first resin product and second resin product are thus fused; a clamp tool is used with clamp parts which hold the first resin product and second resin product and thus fix the first resin product and second resin product in joining position, the clamping action of the above-mentioned clamp part being released by expansion pressure during melting.

When this method of confirming fusion is used, the clamp part of the clamp tool which clamps the resin products together before work starts is automatically released by resin expansion pressure during fusion, and it is thus possible to confirm fusion of the resin parts without the provision of an inspection hole and also to confirm fusion of the resin parts simply by the mechanical operation of a clamp part.

According to the seventh aspect of the invention there is also provided a method of confirming fusion of resin products characterised in that, in a method of fusion of resin products in which a first resin product and a second resin product are set for joining, a controller connector is connected to terminal pins projecting from the surface of the first resin product, the current supplied to an electrically resistant wire, which is inset into the joining surfaces of the first resin product and the second resin product and has its ends connected to the above-mentioned terminal pins, is controlled by the above-mentioned controller, and the first resin product and the second resin product are thus fused, the current value and voltage value of the circuit through which this current is

passed to the above-mentioned electrically resistant wire is detected, these current value and voltage value being varied in the same ratio and it being detected when the resistance of the circuit remains constant for at least a specified time.

The control value of the controller is detected when this method of confirming fusion is used and it is thus possible to confirm fusion of the resin parts without the provision of an inspection hole and, as the electrical changes which accompany fusion of the resin are found directly, it is possible to confirm fusion of the resin parts with certainty.

Conventional electrofusion jointing techniques are not compatible with metal pipe fittings and components.

The eighth aspect of the invention, therefore, sets out to provide means for enabling electrofused components to be used in conjunction with metal components.

To this end, according to an eighth aspect of the invention there is provided a pipe fitting comprising a first axial end portion comprising means for engagement with a metal pipe component and a second axial end portion provided with a heat element, which generates heat upon application of an electric current thereto, for electrofusion with a plastics pipe component; the first and second axial end portions being joined together.

Thus an embodiment of the eighth aspect of the invention enables electrofused components to be connected to metal components.

In conventional electrofusion welding arrangements, a spigot and socket arrangement is required for connecting components. It is accordingly often difficult to achieve the jointing of larger diameter pipes and slip-lining.

The ninth aspect of the invention, therefore, sets out to provide an arrangement which does not require a separate socket. The invention also sets out to provide an arrangement which facilitates the jointing of large diameter pipes and slip-lining.

According to the ninth aspect of the invention, there is provided a length of pipe comprising an insulated heating element in an end portion thereof, the end portion being adapted for direct connection to an end portion of a different length of pipe by means of electrofusion using the heating element.

By such an arrangement a separate socket is not required.

According to a ninth aspect of the invention there is also provided a spigot or socket for use in the formation of an electrofusion joint, with the said spigot or socket comprising an insulated heating element buried in the body of a wall portion thereof.

By such arrangements the jointing of large diameter pipes and slip-lining is greatly facilitated.

Electrical fusion is generally used to join junctions of resin pipes, when an electric current is passed through an electrically resistant wire which is previously wound spirally on the inner surface of the socket of the joint into which the joint is inserted, and the pipe and joint thus heated and fused. In the prior art, fusion was confirmed by fitting an inspection hole to the socket of the joint and melting of the resin confirmed through this inspection hole.

However, this known method of confirming fusion involves problems such as the fact that molten resin flows out of the inspection hole, forming a cavity between pipe and joint and, once it has flowed out, the resin hardens to form burr.

The purpose of this aspect of the present invention is to propose a method of confirming fusion of resin products such as pipes and joints without the use of an inspection hole, which will prevent joint failure of resin products due to incomplete fusion and also to propose a method of confirming fusion of resin products which does not necessitate any surface after-treatment of the resin products after joining.

According to a tenth aspect of the present invention there is provided a heating element for use in electrofusion coupling pipe components, comprising a heating element including nickel or an alloy of nickel; wherein the heating element is adapted for use as a temperature sensor.

Nickel has a higher resistivity coefficient, this means that the resistance of the nickel or nickel-based wire changes significantly with temperature, with the effect that the fitting has in effect a built-in thermocouple to measure directly in the weld zone. This means that the welding process can accurately be measured with none of the above described adverse effects. Furthermore, although nickel is more expensive, it has superior corrosion protection properties and nickel is also better than copper in applications of low voltage, high current and also gives better (shorter) heat times than copper on large fittings where a long soak time is usually needed.

Embodiments of the various aspects of the invention will be described, by way of example, and with reference to the accompanying drawings, in which:-

Figure 1 shows a heat pattern graph relating to first and second aspects of the invention;

Figure 2 is a schematic view of electrofusion apparatus in accordance with first and second aspects of the invention;

Figure 3 is a schematic section of a controller in accordance with first and second aspects of the invention;

Figure 4 is a section of a joint according to first and second aspects of the invention;

Figure 5 is a schematic section of a connector in accordance with first and second aspects of the invention;

Figure 6 is a diagram of an electrofusion control circuit in accordance with first and second aspects of the invention;

Figure 7 is a control flow chart relating to first and second aspects of the invention;

Figure 8 is a fusion control flow chart relating to first and second aspects of the invention;

Figure 9 is a control circuit diagram relating to third and fourth aspects of the invention;

Figure 10 is view of an electrofusion device in accordance with third and fourth aspects of the invention;

Figure 11 is a cross-section of a joint in accordance with third and fourth aspects of the invention;

Figure 12 is a plan view of a connection between a heating element and controller in accordance with third and fourth aspects of the invention;

Figure 13 is a diagram of a heat pattern relating to third and fourth aspects of the invention;

Figures 14 to 16 are operational flowcharts relating to third and fourth aspects of the invention;

Figure 17 shows a variation of the arrangement of Figure 12;

Figure 18 shows a fusion control curve relating to a fifth aspect of the invention;

Figure 19 shows an electrofusion joint and controller in accordance with a fifth aspect of the invention;

Figure 20 shows a cross-section of an electrofusion joint reception part relating to a fifth aspect of the invention;

Figure 21 shows a cross-section of an electrofusion controller's connector in accordance with a fifth aspect of the invention;

Figure 22 is a cross-section of a joint relating to a sixth aspect of the invention;

Figure 23 is a schematic view of electrofusion apparatus relating to a sixth aspect of the invention;

Figure 24 is a schematic view of a controller's connection in accordance with a sixth aspect of the invention;

Figure 25 is a schematic view of an apparatus relating to a seventh aspect of the invention;

Figure 26 is a cross-section through a socket relating to a seventh aspect of the invention;

Figure 27 is a schematic view of a controller connection relating to a seventh aspect of the invention;

Figure 28 is a view of a clamping arrangement in accordance with a seventh aspect of the invention;

Figure 29 is a further view of the clamp of Figure 28;

Figure 30 is a control circuit diagram according to a seventh aspect of the invention;

Figure 31 is a heat pattern curve relating to a seventh aspect of the invention;

Figures 32 to 34 are operational flowcharts relating to the seventh aspect of the invention;

Figure 35 is an enlarged sectional view of part of the clamp arrangement of Figures 28 and 29;

Figure 36 is a view of a transition fitting in accordance with an eighth aspect of the invention; and

Figure 37 is a partial cross-sectional view of a socket wall incorporating a coil in accordance with a ninth aspect of the invention.

First and second aspects of the invention - see Figures 1 to 8

Below are detailed explanations of embodiments of first and second aspects of this invention based on Figures 1 to 8. Figure 1 is a heat pattern chart, while Figure 2 is an explanation of electrofusion fastening operation. Symbol 1 in Figure 2 is the controller for electrofusion fastening. The start button 3, stop button 4 and liquid crystal indicator 5 are arranged on the main case 2. The electric power cord 7 set up on the end of the plug 6 connecting to the electric power and the control cord 9 set up on the end of the connector 8 connecting to the side of the thermoplastic resin spigot both extend from main case 2.

As shown in Figure 3, the main case 2 is formed from a square box-shaped hermetically sealed structure consisting of a square framed side plate 10, a top plate 11 that covers the top of side plate 10 and a bottom plate 12 that covers the bottom of side plate 10. This prevents the intrusion of water inside the main case 2 which contain the various kinds of electrical and electronic parts and distributing boards on which they are mounted. The bottom plate 12 is made from metal material like aluminium which is outstanding in heat radiation, there is a solid body of numerous heat radiating blades 13 under the bottom plate 12, and the bottom plate 12 is a heat radiating plate so that temperature increase is prevented inside the main case 2 and the electrical and electronic parts are protected from heat. Also, it is constructed in such a way that a bracket 15 is set up that firmly connects the electronic control element 14 which reaches a high temperature during operation to the bottom plate 12 with the result that high temperature increases are prevented.

Also, symbol 16 in Figure 2 is a thermoplastic resin joint, and symbol 17 is a thermoplastic resin pipe of the same material as joint 16.

As shown in Figure 4, a heat generating body 20 formed into a sleeve shape with electrical resistance wires 19 folded in two rolled into a screw shape along the cylinder is buried beforehand into the inner circumference surface of each socket 18 of the joints 16 where the pipe 17 spigots are inserted, and terminal pins 21 fitted at both ends of the electrical resistance wires 19 are fixed to come out from the ends of each socket 18.

The electrical resistance wires 19 are made of simple electric resistant wire like nickel with an insulation covering of the same thermoplastic resin material as with the joint 16.

Between the terminal pins 21,21 at the end of each socket 18, a hollow 22 is formed whose depth differs according to the quality, shape and size of the joint 16.

As shown in Figure 5, fixed terminals 23,23 in which terminal pins 21,21 come in to make connection are buried into the connecting end of the connector 8, and moveable terminal 25, which is a sensor arm stuck into the end section sticks, into the hollow 22 between fixed terminals 23,23.

Inside the connector 8, a potentiometer grade sensor 26 is set up, and a normal rack gear 28 is formed round the grade sensor 26 pinion 27 in the moveable terminal 25 of the connector part 8. When there is a connection between each terminal pin 21,21 of the socket 18 and each fixed terminal 23,23 of the connector 8, there is a simultaneous connection of the connector 8 moveable terminal 25 in the hollow 22 of the socket 18, and the detection by the grade sensor 26 of the moveable terminal's 25 quality of movement in and out allows for a decision to be made on the grade of the joint 15.

The moveable terminal 25 is fixed in the standard location of the grade sensor 26 by the spring 29 that presses the moveable terminal 25 in a protruding direction and the

stopper 31 that connects to the fixed bracket 30 of the grade sensor 26 and controls the amount of protrusion of the moveable terminal 25.

The moveable terminal 25 is formed into a tube axis shape and a tube axis shaped sensor case 32 is inserted and fitted to reciprocate at will on the inside of the moveable terminal 25. A heat sensor 33 is fixed to the end of the sensor case 32 and the end of the heat sensor 33 at the end of the moveable terminal 25 is exposed, and when the moveable terminal 25 is connected into the hollow 22, the end of the heat sensor 33 makes contact with the bottom of the hollow 22, with the result that the temperature (external temperature) of the joint 16 at the time the electrofusion fastening operation begins can be detected.

In addition, the control cord 9 with the connector 8 fixed at the end is attached to the CPU 34 where the electric power cord attached to the fixed terminals 23,23 and the grade signal transmission cord attached to the grade sensor 26 and the heat signal transmission cord attached to the heat sensor 33 are fitted in the controller 1.

As shown in Figure 6, a CPU 34 formed with a microcomputer is fixed up in the controller 1, and connected to the CPU 34 is a start button 3 and stop button 4 and a grade sensor 26 and a heat sensor 33 and a heat generating body 20 and indicator 5 and a memory 35 that records the heat pattern. It is set up so that, based on the heat pattern, the electric current is supplied to the heat generating body and the pipe 17 spigot is fastened through electrofusion to the socket 18 of the joint 16.

Incidentally, the heat pattern is recorded in the memory 35 for each grade of the joint 16 and, as clearly shown in the heat pattern diagram in Figure 1, the heat pattern shows a connection between the electric current value (A) flowing in the electrical resistance wire 19 of the heat generating body 20 and time. The electric current begins to flow from the beginning of the electrofusion fastening operation and the electric

current value (A) is raised to the first fixed electric current value (A1), and the first fixed electric current value (A1) maintains the first time (S1). Then the electric current value (A) is raised to the second fixed electric current value (A2), and the second fixed electric current value (A2) maintains the second time (S2). Next the electric current value (A) is raised to the fifth fixed electric current value (A5) which is the maximum electric current value, and the fifth fixed electric current value (A5) maintains the third time (S3). Next the electric current value (A) is lowered to the third electric current value (A3), and the third fixed electric current value (A3) maintains the fourth time (S4). After the fourth time (S4) has passed, the electric current supply is cut.

The fourth electric current value (S4) is the electric current value that heats the thermoplastic resin which is the material of the insulation covering for the joint 16 and the pipe 17 and the electric resistance wire 19 to its fusion temperature. The first to the third fixed electric current values (A1), (A2), (A3) are fixed lower than the fourth fixed electric current value (A4), while the fifth fixed electric current value (A5) is fixed higher than the fourth fixed electric current value (A4), fixed up like $A1 < A2 < A3 < A4 < A5$. The period from the beginning of the electrofusion fastening operation until the second fixed period (S2) has passed is the drying process. The amount of heat generated from the heat generating body 20 in this drying process evaporates the water adhering to the inner circumference surface of the socket 18 of the joint 6 and the external circumference surface of the spigot of the pipe 17 and dries the resin surface to be electrofused. The period from after the drying process has finished until the third fixed period (S3) has passed is the fusion process. The amount of heat generated from the heat generating body 20 in this fusion process fuses the insulation covering of the inner circumference surface of socket 18 of the joint 16 and the external circumference surface of the spigot of the pipe 17 and the electric resistance wire 19. The period from after the fusion process has finished until the fourth fixed period (S4) has passed is the fastening process. The amount of heat

generated from the heat generating body 20 in this fusion process gradually fixed the fused resin in a stable condition.

As shown in Figure 2, the controller 1 is brought to the place where the pipes are arranged, and the plug 6 on the end of the electric power cord 7 is connected to the generator or some other electric power source set up in the place where the pipes are arranged. After connections have been made between the terminal pins 21,21 at the end of the socket 18 of the joint 16 in which the pipe 17 spigot has been inserted, and the fixed terminals 23,23 of the connector 8 at the end of the control cord 9 of the controller 1 in the hollow 22, and the moveable terminals 25, the controller 1 start button 3 is turned on, with the result that automatic control begins whereby the socket 18 of the joint 16 and the pipe 17 spigot are automatically fused. As shown in the heat pattern diagram of Figure 1 and the flowchart of Figure 7, when the start button 3 is turned on the grade sensor 26 and the heat sensor 33 output values are read in and, based on the grade sensor's 26 output values, the joint's 16 grade is judged. Heat pattern selection setting control (initial setting) in which the heat pattern corresponding to that grade is read from the memory 35 is carried out. Afterwards, drying control and fusion control and fastening control are carried out where the electric current flowing into the heat generating body 20 is controlled based on the selected set heat pattern, and the electrofusion fastening is completed.

As shown in the flowchart of Figure 8, with fusion control, when the heat sensor 33 output value (t_a) is within the fixed range (for example, 10-30° centigrade), the electric current flowing to the heat generating body 20 based on the initially set heat pattern is controlled. However, when the external air temperature of the site of operation is high, the resin temperature quickly rises, and when it is low, the rise in resin temperature slows down. Therefore, the heat pattern is adjusted so that when the heat sensor 33 output value (t_a) is higher than the fixed range, the third fixed period (S3) of the heat pattern is made correspondingly short, and when it is lower, the third fixed

period (s3) of the heat pattern is made correspondingly long. After that, the electric current flowing to the heat generating body 20 is controlled based on the heat pattern after adjustment.

When the pipe 17 spigot does not insert properly into the socket 18 of the joint 16, the amount of heat transmitted from the heat generating body 20 to the resin is reduced, the temperature of the heat generating body 20 quickly rises, and the electrical resistance also increases with the rise in temperature. On the other hand, when it is properly inserted, the amount of heat transmitted from the heat generating body 20 to the resin increases, and the temperature increase of the heat generating body 20 slows down. Due to these special characteristics, use is made of the fact that there are changes in the time it takes for the electric current value flowing in the heat generating body 20 to rise in order to carry out investigations of poor insertions of the pipe 17. When the period it takes from the beginning of fusion control for the electric current value (Ax) flowing in the heat generating body 20 to rise to the fixed electric current value (A0) fixed lower than the fourth fixed electric current value (A4) of the heat pattern remains within the fixed time (S0), the pipe 17 is considered correctly inserted, the electric current supply is continued to the heat generating body 20 and the electrofusion fastening operation is carried out. On the other hand, when the time it takes to rise exceeds the fixed time (S0), the pipe 17 is not considered correctly inserted, the electric current supply is discontinued to the heat generating body 20, there is an indication of poor insertion of the pipe 17 on the indicator 5, and the electrofusion fastening operation is discontinued before the resin is fused, preventing the fusion and fastening of the pipe 17 to the joint 16 in a poor insertion condition.

As clearly shown from the above practical examples, by supplying an electric current to the heat generating body 20 set up on the inner circumference surface of the socket 18 of a joint 16 made from thermoplastic resin, and by using the electrofusion fastening apparatus that fuses the spigot of a thermoplastic pipe 17 to the above mentioned joint

16 socket 18, when the time it takes the electric current value (A_x) flowing into the heat generating body 20 to rise to the fixed electric current value (A_0) exceeds the fixed time (S_0), measures are taken to detect poor insertions of the pipe 17 judged to have the pipe spigot incorrectly inserted into the joint 16 socket 18, and the electric current supply to the heat generating body 20 is discontinued while the poor pipe 17 insertion is being detected according to the detection measures. Since poor insertions of pipe 17 that cannot be judged visually are correctly detected, and the fusion and fastening operation is discontinued while the detection is made, conventional fusion and fastening failure due to poor insertions of pipe 17 disappear, and correct fusion and fastening is normally carried out.

As is also clearly shown from the above practical examples, by supplying an electric current to the heat generating body 20 set up on the inner circumference surface of the socket 18 of a joint 16 made from thermoplastic resin, and by using the electrofusion fastening apparatus that fuses the spigot of a thermoplastic pipe 17 to the above mentioned joint 16 socket 18, a drying process is carried out in which thermoplastic resin is heated by the above mentioned heat generating body 20 to below its fusion temperature, before the fusion process in which thermoplastic resin is heated by the above mentioned heat generating body 20 to above its fusion temperature. Even if water adheres to the pipe 17 spigot or the joint 16 socket 18, since the fusion process is carried out after the water is evaporated and the fusion section is completely dried, the previous problems of damage to electrofusion fastening apparatus and heat generating bodies due to water and poor bonding strength are avoided, and the effect is that a proper fusion can normally be carried out.

Third and fourth aspects of the invention - see Figures 9 to 17

There follows a detailed description of embodiments of third and fourth aspects of the present invention with the aid of Figures 9 to 17 of the drawings. Figure 9 is a plan of

the control circuit and Figure 10 shows the external appearance of the whole of the electrofusion device. In the drawings 101 is the body of the electrofusion device. It is provided on the upper surface of the casing 102 of the body with handles 103, 104 left and right for the purpose of carrying it. On the surface of the operating panel 105 on one side of the casing 102 are buttons 106, 107, for commencing and terminating the fusion process, buttons 108 for use in setting the heat pattern, a digital display which shows the state of the fusion process and the heat pattern set and input, and a speaker 110 whereby various audible warnings are generated. A power cable 112 with a Plug 111 for connection to a 100-volt commercial power supply on the end of it, an earth cable 114 with a metal rod 113 on the end of it for inserting into the ground or elsewhere, and a connecting cable 116 with a connector 115 on the end of it for connecting to the terminal of the product which is to be fused also lead from the aforesaid casing 102 of the body of the device.

In the drawings, 117 and 118 are a joint and a pipe which are made of the same thermoplastic resin and which are to be fused and joined.

As is shown in Figures 11 and 12, on the inner circumference of each of the sockets 119 of the aforesaid joint 117 there has been embedded in advance by secondary moulding a heat element 121 formed into a sleeve by winding in a spiral shape the electrical resistance wire 120 which has an insulating coating. At the same time, there are on the ends of each socket 119 of the aforesaid joint 117 small holes 119a for the purpose of exposing the terminals 122, 123 of the electrical resistance wire 120 on their inner circumference and for verifying fusion.

The material, length, thickness and electrical resistance of the electrical resistance wire 120 are selected at will according to the material, shape and size, i.e. the type, of the joint 117.

On the end of each socket 119 of the aforesaid joint 117 between the aforesaid terminals 122, 123 there is a concave section 124 which differs in depth according to the material, shape and size, i.e. the type, of the joint 117.

From the connecting end of the aforesaid connector 115 protrude the fixed terminals 125, 126 to be inserted into and connected to the aforesaid terminals 122, 123. From between these fixed terminals 125, 126 protrudes a moveable terminal 127 which is inserted into the aforesaid concave section 124.

Within the aforesaid connector 115 is a potentiometer 128 which acts a type sensor. On the moveable terminal 127 within the connector 115 there is a rack which engages with the pinion gear 129 of the potentiometer 128. This is configured in such a way that when the terminals 125, 126 of the connector 115 are inserted into and connected to the terminals 122, 123 of the joint 117, the moveable terminal 127 of the connector 115 is inserted simultaneously into the concave section 124 of the joint 117 so that the amount by which the moveable terminal 127 moves in and out is detected by the potentiometer 128 and thus the material, shape and size, i.e. the type, of the joint 117 is identified.

The position of the aforesaid moveable terminal 127 in relation to the potentiometer 128 is determined by means of a spring 131 which presses in the direction in which the moveable terminal 127 protrudes, and a stopper 133 which comes into contact with the bracket 132 of the potentiometer 128 and regulates the movement of the moveable terminal 127.

The aforesaid connector 115 is provided with an in-built temperature sensor 134, which is configured in such a way that the detection surface 135 of the temperature sensor 134 faces outward through a hole 136 in the connector so that the aforesaid

temperature sensor 134 can detect the outside air temperature in the immediate vicinity of the joint.

The connecting cable on the end of which the aforesaid connector 115 is attached serves to connect to the aforesaid body 101 of the device the power cable 137 which connects to the aforesaid terminals 125, 126, the connecting cable 138 which connects to the potentiometer 128, and the connecting cable 139 which connects to the aforesaid temperature sensor 134.

As is shown in Figure 9, the aforesaid body 101 of the device is provided with a controller 140 consisting of a microcomputer which is configured in such a way that the aforesaid buttons 106, 107 for the purpose of commencing and terminating the fusion process, the device 141 for setting the heat pattern with the buttons 108, the aforesaid display 109, the voice-synthesising circuit 142 of the aforesaid speaker 110, the aforesaid potentiometer 128, the aforesaid temperature sensor 134 and the memory 143 for storing heat patterns are connected to the aforesaid controller 140, while at the same time the heat element 121 of the joint 117 is connected to the said controller 140 by way of the aforesaid connector 115, the type of the joint 117 is identified in accordance with the output of the potentiometer 128, the heat pattern corresponding to the type of the said joint 117 is selected and set, the amount of heat (work) of the heat element 121 is controlled in accordance with the said heat pattern, and the process of fusing the joint 117 and the pipe 118 is performed.

The aforesaid memory 143 stores the heat patterns for each type of joint 117. As will be apparent from the heat pattern chart in Figure 13, the said heat pattern determines the value of the electrical current (A) to be fed to the heat element 121, and the time (t). The current begins to be fed when the fusion process starts. When set current value 1 (A1) is reached, this value is maintained for time 1 (t1). When time 1 (t1) has elapsed, the current (A) is lowered by a specified amount for time 4 (t4). When set

current value 2 (A2) is reached, this value is maintained for time 2 (t2). When time 2 (t2) has elapsed, the current value becomes 0.

This is configured in such a way that the resin of the joint 117 and the pipe 118 is melted by means of the amount of heat generated in the heat element 121 by the aforesaid set current value 1 (A1), and the molten resin set by means of the amount of heat generated in the heat element 121 by set current value 2 (A2), thus joining the joint 117 and the pipe 118.

Where the space (L) between the joint 117 and the pipe 118 is large, the amount of heat conveyed to the resin is small, the temperature of the heat element 121 rises rapidly, and as it does so, the electrical resistance increases. Where, on the other hand, the aforesaid space (L) is small, the rise in temperature of the heat element 121 is slower. The device is configured in such a way that use is made of this phenomenon in order to detect the space (L) between the joint (17) and the pipe (18) by means of the difference in start-up time (t3) from commencement of the fusion process to attainment of set current value 1 (A1) and to amend the aforesaid heat pattern.

Similarly, where the outside air temperature in the place where the fusion process is being performed is high, the temperature of the resin rises rapidly; where it is low, it rises more slowly. The device is configured in such a way that the heat pattern is amended also on the basis of the output of the outside air temperature sensor 134.

The present embodiment is configured in the manner outlined above. The body 101 of the electrofusion device is carried to the place where the fusion process is to be performed. The plug 111 at the end of the power cable 112 of the aforesaid body 101 of the device is connected to the power supply provided in the place where the fusion process is to be performed, the metal rod 113 at the end of the earth cable 114 is inserted into the ground, and the aforesaid body 101 of the device is set ready for the

fusion process to begin. The end of the pipe 118 is inserted into the socket 119 of the joint 117, the fixed terminals 125, 126 and the moveable terminal 127 of the connector 115 at the end of the connecting cord 116 of the body 101 of the device are inserted into the terminals 122, 123 and the concave section 124 on the end of the socket 119 of the joint 117 into which has been inserted the end of the pipe 118. When the button 106 for commencing the fusion process is switched on, the process begins automatically. As the flowchart in Figure 14 shows, when the button 106 for commencing the fusion process is switched on, the device first reads the output value of the potentiometer, identifies the material, shape and size, i.e. the type of the joint 116, reads from the memory 143 the heat pattern corresponding to that type, and automatically performs the initial setting for the fusion process. The current then begins to be fed to the heat element 121. When set current value 1 (A_1) is reached, the device reads the output value of the temperature sensor 134, calculates the space (L), computes the appropriate amount of heat (work), and in accordance with this amends the heat pattern which it selected and set at the time of the initial setting. When the time (t_1) of the amended heat pattern has elapsed, the current value (A) is lowered by a specified amount for time (t_4). When that has elapsed and set current value 2 (A_2) is reached, the lowering of the current value (A) is stopped. Then, after time (t_2) has elapsed, the current value (A) becomes 0, thus completing the fusion process.

As the flowchart in Figure 16 shows, it is also possible to use the buttons 108 for use in setting the heat pattern in order to read in the output values of the type selector 141. In this case, if a corresponding pattern is stored in the memory 143, that pattern is read out and the fusion process commences; if there is no corresponding pattern stored in the memory 143, that pattern is read out and the fusion process commences; if there is no corresponding pattern stored in the memory 143, the operator is notified of its inability to commence the process.

In the above embodiment, a mechanical change in the shape of the concave section 124 was effected to the end of the socket 119 of the joint 117, and the potentiometer 128 converted the depth of that concave section 124 into an electrical signal by means of which the controller automatically identified the material, shape and size, i.e. the type, of the joint.

However, as Figure 17 shows, it is also possible to use secondary moulding to embed in advance inside the sockets 119 of the joint 117 a resistive element 144 with an electrical resistance value which differs according to the materials, shape and size, i.e. the type, of the said joint 117. One end of this resistive element 144 is then connected to the electrical resistance wire 120 of the heat element 121, and the terminal 145 which connects to the other end of the aforesaid resistive element 144 is exposed on the end of the socket 119 of the joint 117 between the terminals 122, 123 for the heat element 121. A fixed terminal 146, which is inserted into and connected to the aforesaid terminal 145 between the terminals 125, 126 for the heat element 121 on the connecting end of the connector 115 of the controller 140, is allowed to protrude, and the terminals 125, 126, 146 on the connector 115 side are simultaneously inserted into and connected to the terminals 122, 123, 145 on the joint 117 side. Thus, by inputting into the controller 140 the electrical resistance value of the resistive element 144 of the joint 117, the controller 140 can be made to identify the material, shape and size, i.e. the type of, the joint 117 by means of electrical changes allocated to the joint 117.

As will be clear from the above embodiment, because this electrofusion device for resin products wherein the resin of a joint is fused by supplying power to a heat element attached to the resin product to which it is to be fused is provided with a controller which controls the amount of heat of the aforesaid heat element in accordance with heat patterns whereby the power level rises at commencement of the fusion process until it reaches set power level 1, which is maintained for the duration of time 1 before being lowered by a specified amount for the duration of time 4, after which it reaches

set power level 2 and is maintained there for the duration of time 2 before the fusion process terminates, it is possible to fuse the resins of resin products correctly.

Because it detects the space between the resin products which are to be fused by the time needed to reach set power level 1 from commencement of the fusion process, it is possible to detect the space between the resin products which are to be fused correctly and without need for any special means.

Because the connector of the controller whereby it is connected to the resin product which is to be fused is provided with a temperature sensor which detects the outside air temperature, it is possible to detect correctly the outside temperature in the immediate vicinity of the resin products which are to be fused.

Because it amends heat patterns on the basis of the space between resin products which are to be fused and of the outside air temperature, it is possible to obtain the correct amount of heat which corresponds to differences in the measurements of the resin products which are to be fused and to the environment of the place where the fusion process is performed.

Because by means of set power level 1 it brings the temperature of the resin product which is to be fused to one which is above the melting point of the resin but below the point at which it deteriorates or is damaged, it is possible to prevent deterioration in or damage to the resin caused by over-heating the resin products which are to be fused.

As will be also clear from the above embodiment, the present invention provides an electrofusion device for resin products wherein the resin of a joint is fused by supplying power to a heat element attached to the resin product to which it is to be fused, being provided with a controller which according to the type of resin product which is to be fused reads in advance the mechanical or electrical changes for the purpose of

identifying the type allocated to the product which is to be fused, selects and sets the heat pattern corresponding to the resin product which is to be fused, and performs the fusion process automatically, thus making it possible to perform the setting (initial setting) of the heat pattern automatically and competently on the basis of the type of resin product which is to be fused, thereby allowing anyone to handle it and perform the fusion process for resin products correctly.

Also, because the connector of the controller is provided with a terminal by which to connect it to the terminals at either end of an electrical resistance wire which is exposed to the surface or end of the resin product which is to be fused and a terminal by which to connect it to the part which constitutes the mechanical or electrical change for the purpose of identifying the type allocated to the resin product which is to be fused, it is possible to perform the initial setting without any special operation by connecting the connector of the controller to the resin product which is to be fused.

Fifth aspect of the invention - see Figures 18 to 21

An example of practice in accordance with the fifth aspect of the invention will now be described in detail with reference to Figures 18 to 21 of the drawings. Figure 18 is a plot of a control curve in EF joint automatic fusion control, and Fig. 19 shows one example of an EF joint and an EF controller. In the drawings 201 is a T-type EF joint in which a pair of connector pins 204 projects from the end surface of each one of reception ports 203 that can be connected to the end portion of a pipe 202 made of thermoplastic resin. 205 in the drawings indicates an EF controller which carries a CPU for automatic fusion control and is provided with a control cord 207 which has at its end a connector 206 that can be connected to connector pins 204, a power supply cord 209 that has at its end a power supply plug 208 that can be connected to a power supply, a start switch 210, a stop switch 211 and a display 212.

Covered wire in which a strand is covered with the same material as the material (thermoplastic resin) by which the EF joint 201 is formed is used as a heating wire 213 that is embedded in the inner peripheral surface of each reception port 203 of the EF joint 201, as shown in Fig. 20. In Figure 20 it can be seen that the heating wire 213 is embedded in the form of a coil in the inner peripheral surface of each reception port 203, in a double-folded state so that both its ends project from the end surface of the reception port 203, and its two ends are connected to connector pins 204.

Plug-in openings 214 for EF joint 201 connector pins 204 are provided in the end surface of the connector 206 of the EF controller 205, and a sensor case 215 extends out from between the plug-in openings 214. The sensor case 215 is constantly urged in the outwardly projecting direction by a spring 216, and its maximum projection amount is restricted by a stopper 217. A thermistor 218 is mounted at the tip end of the sensor case 215 by screwing into an axial hole of the sensor case 215 a hollow threaded shaft 219 which has the thermistor 218 mounted at its tip end, and the arrangement is made such that, when the connector 206 is connected, the tip end of the sensor case 215 comes into contact with the end surface of the reception port 203 of the EF joint 201 and the temperature of the EF joint 201 (the surrounding temperature) is detected.

Automatic fusion control of the EF joint 201 by the EF controller 205 is started by on-actuation of the start button 210 when the power supply plug of the EF controller 205 is connected to a power supply and the connector 206 of the EF controller 205 is connected to the connector pins 204 of the reception port 203 of the EF joint 201 into which the pipe 202 has been inserted as illustrated in Fig. 19.

As is clear from Fig. 18, on supply of a fusion operation start signal to the CPU as the result of on-actuation of the start button 210, first, the surrounding temperature (initial temperature T1) is detected by reading the output value of the thermistor 218, the

resistance value of the heating wire 213 at this initial temperature T1 is determined and set power is supplied to the heating wire 213 (step 1).

When the power reaches a set value, the degree of resistance variation is calculated, on-off control at set constant time intervals is effected, and the resin's specific heat is calculated by PID computation. In this case, the resin's specific heat and the temperature coefficient of the resistance of the heating wire 213 can be forecast to a certain extent. In the example, there is 3-times repetition of on-off action, and it is seen that the temperature of the heating wire 13 repeatedly rises and falls between T2 and T3 (it goes beyond T2 and T3 because there is a response lag). The set value at which on-off control is started, ie, the heating wire 213 temperature T2, is set at a temperature that is quite a bit lower than the resin's melting temperature (step 2).

Having reference to the specific heat and degree of resistance variation calculated in step 2, the power is increased in steps, and in each step, the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the degree of specific heat variation is calculated. In this case, it is possible to judge whether the initially forecast temperature dependence of the resistance of the heating wire 213 and the resin's specific heat are reasonable, and if they are not they can be adjusted, the temperature coefficient of the heating wire 213 resistance (its resistance characteristic) and the resin's specific heat can be confirmed and the optimum temperature field for melting the resin can be determined. In the example, the power is raised in 4 steps, and there is 1-time on-off control in each step, and it is seen that after the temperature of the heating wire 213 has risen from T2 to T4 it falls temporarily to T5, after it has risen again from T4 to T6 it falls temporarily to T7, after it has risen again from T6 to T8 it falls temporarily to T9, and after it has risen again from T8 to T10 it falls temporarily to T11 and then returns to T10, and it is further seen that the optimum temperature field is found through the confirmation made in the 4th step. There are cases in which this confirmation operation ends in the 1st step and cases in

which there are increases up to step 5 or step 6, and it is preferable to limit the number of steps to, eg, 10 and to stop the supply of power and give an alarm in the 10th step. Thanks to the fact that the power is raised in a stepwise manner as described above, heating of the heating wire 213 to a temperature which causes heat deterioration of the resin is prevented (step 3).

When the degree of specific heat variation calculated in step 3 goes below a constant, raising of the power is stopped and on-off control in constant time intervals is effected, and when the specific heat goes below a constant, the supply of power is stopped. In the example, when, as the result of raising of the power in the 4th step, the temperature of the heating wire 213 reaches the optimum temperature T_{10} , the degree of specific heat variation goes below a constant, raising of the power is stopped and on-off control is effected, so performing a parallel temperature operation which maintains the temperature of the heating wire 213 at the optimum temperature T_{10} . As a result of this parallel temperature operation, the amplitude of variation of the power each time on-off control is effected becomes smaller as the resin temperature approaches the temperature of the heating wire 213, ie, the specific heat becomes less, and then, when the resin is heated to the heating wire 213 temperature T_{10} , the specific heat becomes approximately "0", ie, the resin melts, and so when the resin has melted and advanced sufficiently, the supply of power is stopped and the fusion operation is concluded (step 4).

The arrangement may also be that the duration of the parallel temperature operation up to when the power is cut off is calculated on the basis of the specific heat calculated in step 3 and the power is cut off on elapse of the calculated period of time after the start of the parallel temperature operation.

Since the control method described above can be applied to the EF joints of any manufacturer, it is preferable to form EF controller 205 connectors 206 that can be

connected to the EF joint connector pins of different manufacturers. For example, it is preferable to provide 2 connectors 206 that can be respectively connected to different connector pins. Also, in cases where connection is difficult if a thermistor constituting a temperature sensor is provided in the connector, the arrangement may be that a temperature sensor that detects the outside air temperature is provided on the EF controller 205 housing and the outside air temperature is taken as the initial temperature.

Since, as described above, this aspect of the invention makes it possible for judgements on the type of resin and the physical properties of heating wire to be made during control and, while this is done, to search for and find the optimum amount of power (temperature field) for heating and melting resin, it makes it possible to effect fusion of all EF joints properly, regardless of the EF joint types or manufacturers.

Further, whereas conventionally resistors possessing resistance values in correspondence to EF joint types are embedded as well as heating wires in EF joints and EF joint types are distinguished by reading the resistance values of these resistors, in the invention these are not necessary and so the cost of EF joints can be lower and the structure of EF controller connectors can be simplified.

Further, whereas in the past gaps between pipes and EF joints have constituted considerable disturbance in control and have caused the production of fusion faults, fusion bonding is detected through specific heat and so gaps do not constitute disturbance and fusion faults can be eliminated.

Sixth aspect of the invention - see Figures 22 to 24

Below, a sixth aspect of the present invention is described in more detail through examples based on Figures 22 to 24. Figure 22 is a partial and enlarged sectional view

of resin product 301 and Figure 23 is an explanatory diagram of electrical fusion operations. In the figures 301 is a controller; 302 are right and left handles fitted to the top surface of the rectangular box-shaped main case to facilitate moving it; 303 is an operating panel on the front surface of the main case on which are buttons 304 and 305 to start and stop electrical fusion operations, multiple buttons 306 ... to set heat patterns, digital display 307 which visually displays the fusion operations status and the heat patterns etc which are set and input, and speaker 308 which generates a range of warning and advisory noises. Power cable 310, at the end of which is plug 309 which connects to a commercial 100V AC power source, earth cable 312 at the end of which is a metal rod 311 which is inserted into the ground etc, and connection cable 314 at the end of which is connector 313 which connects to the resin product all extend from the main case of controller 301.

Also in the figures, 315 and 316 are a joint (resin product 1) and a pipe (resin product 2) which are thermoplastic resin products of the same material (e.g. polyethylene resin) which are joined by having their contiguous surfaces melted and fused.

As Figures 22 and 23 show, the heating element, formed from double-folded electrically resistant wire 318 in a spiral sleeve on the inner circumferential surface of sockets 315a of joint 315, is inset into the surface by an insert forming process and the contact surfaces of power male terminals 320 and 321 contact the ends of electrically resistant wire 318 on the end surfaces of the sockets 315a of joint 315.

Electrically resistant wire 318 is formed from electrically resistant wire material such as nickel covered by a thermoplastic resin (preferably the same as the joint) and the material, length and thickness of electrically resistant wire 318 can be selected to be appropriate for the material, shape and size of joint 315.

Also, a condenser 313, the capacitance of which differs according to the material, shape and size of the joint is previously inset in the sockets 315a of joint 315 and one end of this condenser 322 is connected to one end of electrically resistant wire 318 and the end contact surface of type signal output male terminal 323, which is connected to the other end of condenser 322, is exposed between female power terminals 320 and 321 at the end surfaces of sockets 315a of joint 315.

On the other hand, male terminals 324, 325 and 326 project from the connected end surface of connector 313 and are fixed so as to allow insertion and connection with female terminals 320, 321 and 323 simultaneously. Type signal input male terminal 326 between male power terminals 324 and 325 is formed into a tubular shape and tubular temperature sensor case 327 is fitted inside male terminal 326 so as to slide freely; and at the tip of temperature sensor case 327, thermistor 328, which is a temperature sensor is attached. Temperature sensor case 327 is held under pressure towards the tip of the male terminal 326 by spring 329 and the tip of thermistor 328 is held projecting, and free to move in and out, from the tip of female terminal 326; male terminals 324, 325 and 326 and thermistor 328 are all connected to controller 301.

Switch part 330, which switches the electric current off and on, is formed at an intermediate part of electrically resistant wire 318 which forms the heating element. This switch part 330 interrupts one end of the heating element 319 located at the innermost part of socket 315a of joint 315, that is at the bent end of the electrically resistant wire 318. The resin covering of electrically resistant wire 318 is removed at the cut end and the electrical resistant wire exposed; one end of the electrical resistant wire which is connected to the power male terminal 320 at the other end and one end of the electrical resistant wire which is connected to the female power terminal 321 at the other end, are exposed during non-contact status (with the switch off) at the innermost part of the external circumference side of socket 315a of joint 315. Only when the end of pipe 316 is inserted correctly as far as the innermost part of socket

315a of joint 315 is the other end of the electrically resistant wire kept in contact at the outer circumferential surface of the end of pipe 316; if the end of pipe 316 is not inserted correctly as far as the innermost part of socket 315a of joint 315, no heating is emitted from heating element 319.

A sheet spring contact piece is used to allow the switch part 303 to switch with certainty and it is simple to fit a groove in the inner circumferential surface of socket 315a of joint 315 in order to control the position of the contact piece.

Thus controller 301 is taken to the site of fusion operations, plug 309 at the end of power cable 310 is connected to the power source fitted in the site of fusion operations and metal rod 311 at the end of earth cable 312 is inserted into the ground of the site of fusion operations and controller 301 set to enable fusion operations. The end of pipe 316 is inserted into socket 315a of joint 315 and set. Joint 315 and pipe 316 are kept in contact position by a clamp tool (not shown). Male terminals 324, 325 and 326 of connector 313 at the end of the connecting cable 314 of controller 301 are inserted into female terminals 320, 321 and 323 on the end surface of the socket 315a of joint 315 into which the end of pipe 316 has been inserted and the fusion operation start button is pushed to ON and the fusion operations automatically started. Thus, when the fusion operation start button is pushed to ON, current flows along electrically resistant wire 318 and the type identification signal and temperature signal are read from joint 315. The heat pattern i.e. the quantity and time of the heat given out by heating element 319 is set to correspond with the type of resin product on the basis of these signals. The current to electrically resistant wire 318 is controlled on the basis of this heat pattern and the resin on the outer circumferential surface of pipe 316 and the inner circumferential surface of socket 315a of joint 315 are melted by the heat generated by heating element 319 and they become fused.

In these fusion operations, if the end of pipe 316 is not set in a position which is properly inserted as far as the innermost part of socket 315a of joint 315, switch part 330 of electrically resistant wire 318 is in open state and it is thus impossible for current to flow along electrically resistant wire 318 and impossible for fusion to be carried out. Only if the end of pipe 316 is set in a position which is properly inserted as far as the innermost part of socket 315a of joint 315, is switch part 330 of electrically resistant wire 318 set to closed, making it possible for current to flow along electrically resistant wire 318 and for fusion to be carried out.

As is clear from the above examples, in the sixth aspect of the present invention, resin product 1 315 and resin product 316 are set in a joining position, connector 313 of controller 301 is connected to twin terminal pins 320 and 321 which are exposed on the surface of resin product 1 315. Current which flows along electrically resistant wire 318, which is inset in the contact surfaces of resin product 1 315 and resin product 2 316 and the ends of which are connected to terminal pins 320 and 321, is controlled by controller 301. Resin product 1 315 and resin product 2 316 are thus fused. In the method according to the invention, switch 303, which switches the current OFF and ON is formed in an intermediate position in electrically resistant wire 318 and only when resin product 1 315 and resin product 2 316 are set correctly in the joining position is it possible for fusion operations to be carried out. This thus has the marked effect of being capable of preventing joining failures in a way which has not been seen in the prior art.

Seventh aspect of the invention - see Figures 25 to 35

First a method of detecting fusion of resin products according to the seventh aspect of the invention is described in detail on the basis of figures 25 to 35.

Figure 25 is a descriptive figure of the method of detecting fusion according to the invention. In this figure, 401 is a controller; 402 are right and left handles used for moving the device and fitted on the upper surface of the main rectangular box-shaped case; 404 and 405 are buttons for starting and stopping the fusion operations and 406 are multiple input buttons for setting the heat pattern on operating panel 403, on the front surface of the main case; 407 is a digital display which displays visually the fusion operation status and heat pattern set and input; 408 is a speaker which generates a range of informative and warning noises. There is also power cable 401 at the end of which is plug 409 which is connected to a commercial 100 volt alternating current power supply; an earth cable, at the end of which is a metal rod 411 which is inserted into, for example, the earth; a connection cable 414 at the end of which is a connector 413 connecting it to the resin product. All of these come from the main case of controller 401.

In the figure, 415 and 416 are a joint (resin product 1) and pipe (resin product 2) which are thermoplastic resin products of the same substance (e.g. polyethylene resin) which are to be joined by fusion, and 417 is a clamp tool which fixes joint 415 and pipe 416 in the joining position for fusion to take place.

As shown in Figures 26 and 27, heating element 419 which is electric resistance wire in a spiral sleeve form is previously inset as a formed insert into the inner circumferential surface of socket 415a of the above-mentioned joint 415; and terminals 402 and 421, which are terminal pins connected to the ends of the electrical resistance wire 418, project in parallel on the end surface of socket 415a of above-mentioned joint 415.

The above-mentioned electrical resistance wire 418 is an electrically resistant wire such as nickel wire covered with a thermoplastic resin (preferably the same material as the joint); the material, length, thickness and electrical resistance of the electrically

resistant wire 418 can be selected depending on the material, shape and size of the part.

Concavity 422, the depth of which differs according to the material, shape and size of joint 415 is formed between terminals 420 and 421 on the end surface of sockets 415a of joint 415.

Fixed terminals 423 and 424, into which terminal pins are inserted for connection are inset in the connecting end surface of connector 413 and moveable terminal 425 which is a sensor arm whose tip is inserted into concavity 422 projects from between fixed terminals 423 and 424.

Potentiometer 426, which is a type sensor, is fitted inside connector 413 and rack gear 428 is formed to mesh with pinion gear 427 of potentiometer 426, at mobile terminal 425 inside the connector 413. When terminals 402 and 421 on the side of joint 415 and terminals 423 and 424 on the side of connector 413 are connected, the tip of movable terminal 425 on the side of connector 413 is inserted into concavity 422 on the side of joint 415, the movement of movable terminal 425 is detected by potentiometer 426 and the type of the part, including material, shape and size, is thus identified.

Movable terminal 425 is kept in contact with the attachment bracket 430 of potentiometer 426 by spring 429 which presses in the projection direction of movable terminal 425 and movable terminal 425 is located at the standard position of freely sliding potentiometer 426 by stopper 431 which restrains movement of movable terminal 425 in the projection direction.

Movable terminal 425 is formed in a tubular form and tubular removable temperature sensor case 432 is inserted and fixed inside movable terminal 425. Thermistor 433

which is a temperature sensor, is attached to the tip of temperature sensor case 432 and when the end surface of thermistor 433 is exposed at the end surface of movable terminal 425 and connector 413 connected to joint 415, the end surface of thermistor 433 comes into contact with the bottom surface of concavity 422 and detects the surface temperature (atmospheric temperature) of joint 415 when fusion operations start.

Connecting wire 414 attached to the tip of connector 416 connects the power cable, which connects to terminals 414 and 423, the connecting wire, which connects to potentiometer 426, and connecting wire which connects to thermistor 433, to controller 401.

As shown in Figures 28 and 29, clamp tool 417 has clamp part 1 434 which holds parts other than socket 415a of joint 415 and clamp part 2 435 which holds pipe 416. Both clamp parts 434 and 435 consist of semi-circular clamp arms 436 and 437 which fit onto the part to be held and one clamp arm 436 of clamp part 1 and one clamp arm 436 of clamp part 2 are linked through link arm 438; one end of clamp arm 436 is linked so as to rotate freely with one end of the other clamp arm via fulcrum 439; and attachment bolt 404 attaches the other end of movable clamp arm 437 to the other end of fixed clamp arm 436. Joint 415 and pipe 416 are clamped in the joining position by the respective clamp parts 434 of clam tool 416.

As shown in Figure 30, there is a microcomputer (CPU) 441 of controller 401 and this has buttons 404 and 405 for starting and stopping fusion procedures, heat pattern setting device 442 with buttons 406 ... for input of heat pattern settings, display 407 and audio synthesis circuit 443 of speaker 408. Potentiometer 426 and thermistor 433 and memory 444, which records heat patterns, are connected to CPU 441 and CPU 441 is connected via connector 413 to heating element 419 of joint 415. The type of joint 415 is identified on the basis of the output of potentiometer 426, the heat pattern

is selected and set according to the type of joint 415, the current to electrically resistant wire 418 of heating element 419 is controlled on the basis of this heat pattern and joint 415 and pipe 416 are thus electrically fused.

As shown in Figure 31, as the heat pattern for each type of joint 415 is stored in memory 444, the heat pattern shows a relationship between time (t) and the current (A) flowing through electrical resistant wire 418 of heating element 419. Current flows from the start of fusion operations and when set current 1 (A1) is reached, this set current 1 (A1) is maintained for time 1 (t1). When time 1 (t1) has elapsed, current (A) is lowered by a fixed ratio for time 2. When set current 2 (A2) is reached, this set current 2 (A2) is maintained for time 3 (t3). When time 3 (t3) has elapsed, the current is set to 0.

Thus, the resins at the joining point between joint 415 and pipe 416 is fused by the heat from heating element 419 due to set current 1 (A1), the molten resin is set by the heat from heating element 419 due to set current 2 (A2), and the joint 415 and pipe 416 are thus fused.

If the gap between joint 415 and pipe 416 is large, the quantity of heat transmitted to the resin is small, the temperature of the heating element rises rapidly and the temperature rises results in an increase in electrical resistance. Conversely, if the gap is small, the amount of heat transmitted to the resin is great and the temperature rise of heating element 419 is slow. Exploiting these characteristics, the gap between joint 415 and pipe 416 at the junction can be detected from the elapsed time (t4) taken from the start of fusing operations by current (A) to reach set current (A1) and the heat pattern is corrected using this.

Also, the structure is such that the heat pattern is corrected on the basis of the output of thermistor 433, since when the ambient atmospheric temperature is high at the

beginning of fusion operations, the resin temperature rises rapidly while, conversely, the resin temperature rises slowly when the ambient atmospheric temperature is low.

Thus, controller 401 is taken to the site of fusion operations, plug 411 at the end of power cable 412 is connected to a power source supplied at the site of fusion operations, the metal rod 413 at the end of the earth wire 412 is inserted into the ground at the site of fusion operations and the controller set to be ready for fusion operations. The end of pipe 416 is inserted into socket 415a of joint 415 and set. Joint 415 and pipe 416 are held in the joining position by clamp tool 417. Movable terminal 423 and terminals 423 and 424 of connector 413 at the end of connecting wire 414 of controller 401 are inserted into concavity 422 and terminals 420 and 421 on the end surface of socket 415a of joint 415 into which the end of pipe 416 is inserted. Fusion operations start button 404 is set to ON and fusion operations are automatically started. As shown in the flow charts in Figures 32 and 33, when fusion operations start button 404 is set to ON, the outputs of potentiometer 426 and thermistor 433 are read and the type of joint 416 is identified on the basis of the output of potentiometer 426. The heat pattern corresponding to this type is read from memory 444 and the initial settings for fusion operations are automatically set.

Subsequently, voltage is applied to the ends of electrically resistant wire 418 of heating element 419 and current flows. When current (A) flowing in electrically resistant wire 418 reaches set current 1 (A1), the gap between joint 415 and pipe 416 is calculated from the time (t4) from the start of fusion operations to the establishment of set current 1 (A1). The appropriate heat (work) is calculated on the basis of the output value from the thermistor and the heat pattern initially set is corrected on the basis of this heat (work). After a specific time (t1) has elapsed after this correction has been made, current (A) is lowered by a fixed proportion and set current 2 (A2) is reached. After a time (t2) of current reduction, the decrease of current (A) is stopped and after time (t3) has elapsed, current (A) is set to 0. Fusion operations by controller 401 are

thus completed. Connector 413 may be removed when fusion operations by controller 401 are completed and clamp 417 should be removed after the molten resin has been cooled and hardened at room temperature and joint 415 and pipe 416 have been completely joined.

Three methods of confirming the fusion after electrical fusion of resin parts such as joint 415 and pipe 416 are described in greater detail below.

(First method of confirming fusion of resin parts)

In this method, a type identification means, in which the depth of concavity 422 in joint 415 is measured by potentiometer 426 (type sensor) and movable terminal 425 fitted to connector 413 of controller 401 and the type of joint 415 thus identified, is used to select and set the heat pattern appropriate for joint 415; a temperature identification means is used to detect the temperature (external atmospheric temperature) of joint 415 at the start of fusion operations by thermistor 433, inset at the tip of movable terminal 425, being brought into contact with the bottom of concavity 422. Thus when the resin of socket 415a of joint 415 is heated by heating element 419 and expands, the bottom of concavity 422 near heating element 419 rises and moves movable terminal 425 further away from the position at the start of fusion operations and the movement becomes greater as the resin temperature rises. The thermistor remains constantly in contact with the bottom of concavity 422 during fusion operations.

Therefore, as is clear from the flow chart in Figure 34, it is possible to confirm that the resin of the junction between socket 415a of joint 415 and pipe 416 is completely fused, by the comparison between the output values of potentiometer 426 at the start of fusion operations and before heating and the output values of potentiometer 426 during fusion operations and after heating. Fusion is complete when this comparison

shows that the difference is greater than a set value and when the value output from thermistor 433 is also greater than a set value.

Thus, it is possible to confirm fusion of resin products by detecting the temperature of expansion of resin during fusion.

(Second method of confirming fusion of resin parts)

In this method, as is clear from Figures 25, 28, 29 and 35, clamp tool 417 has clamp part 3 445 which holds socket 415a of joint 415. This clamp part 445 consists of two semi-circular clamp arms 446 and 447 which hold the part. Clamp part 3 445 is formed integrally with the intermediate part of link arm 438 which unites clamp part 1 434 and clamp part 2 435 and one end of clamp arm 447 is linked, so as to rotate freely via fulcrum 448, to one end of clamp arm 446. There is also a locating notch 449 and locating projection 450 which attach the other end of movable clamp arm 447 in a freely detachable manner to the other end of fixed clamp arm 446. The other ends of clamp arms 446 and 447 of clamp part 3 445 are joined by locating notch 449 and locating projection 450 such that the interior diameter is approximately the same as the outer diameter of the socket 415a of joint 415 before fusion operations. Locating projection 450 is removed from locating notch 449 by the expansion pressure of socket 415a of joint 415 and pipe 416 is completely melted. This releases the clamp on socket 415a of joint 415 by clamp part 3 445. It is thus possible to confirm the complete fusion of the resin parts through this automatic clamp release of clamp part 3 445 of clamp tool 417.

(Third method of confirming fusion of resin parts)

In this method the current value and voltage value of the current which flows through electrically resistant wire 418 are detected.

The resistance (R) of the circuit changes as the temperature of the resin increases until the time when it melts. It is clear from tests that temperature changes reduce when the resin is completely melted and the circuit resistance (R) becomes steady for a time (t4).

In this method, as is clear from Figure 31, since it is possible to identify current (A) by varying voltage (V) from the start of fusion operations following the heat pattern curve, when current (A) and voltage (V) are detected and are varied in the same proportion, circuit resistance (R) is steady. It is thus possible to confirm the complete fusion of the resin parts through the fact that this resistance (R) remains steady for a specific period of time.

This phenomenon always occurs when the current decreases for set current 1 (A1) to set current 2 (A2) in the heat pattern. This is the time at which the resin has been heated for a specific period of time and has melted.

As is clear from the above examples, in the present invention, resin product 1 415 and resin product 416 are set in the joining position, connector 413 of controller 401 is connected to terminal pins 420 and 421 projecting from the surface of resin product 1 415. Current is supplied to electrically resistant wire 418, which is buried in the contact surface of resin product 1 415 and resin product 2 416 and the ends of which are connected to terminal pins 420 and 421, controlled by controller 401 and resin product 1 415 and resin product 2 416 are thus electrically fused together. This fusion is confirmed in the following ways. A type identification means is used to identify the type of resin product 1 415 at the beginning of operations and set the appropriate heat pattern: when connector 413 is connected to terminal pins 420 and 421, the sensor arm which projects from connector 413 is fitted into concavity 422, of differing depth, on the surface of resin product 1 415, and the depth of cavity 422 is detected on the basis of the movement of sensor arm 425. A temperature detection means is used to

correct the heat pattern on the basis of the temperature of resin product 1 415 at the start of operations; in this, the surface temperature of resin product 1 415 is detected by temperature sensor 433 fitted at the tip of sensor arm 425 being brought into contact with the bottom of concavity 422. As both the temperature and expansion of the resin at melting are detected simultaneously, the temperature and expansion of the resin when it fuses are detected and it is thus possible to confirm the fusion of the resin without the need, as in the prior art, of an inspection hole. There is also no need for a special sensor for the resin temperature or expansion as these functions are performed by existing sensors 426 and 433. Moreover, as both the temperature and expansion of the resin at melting are detected, it is possible to confirm fusion of the resin products with certainty and without the need for extra cost.

The fusion of resin products may be confirmed by the following method. Resin product 1 415 and resin product 2 416 are set for joining, a controller connector is connected to terminal pins 420 and 421 projecting from the surface of resin product 1 415, the current to the electrical resistance line 418, which is inset into the joining surfaces of resin product 1 415 and resin product 2 416 and with both ends connected to the above mentioned terminal pins 420 and 421, is controlled by controller 401, and resin product 1 415 and resin product 2 416 are thus fused, a clamp part 445 which clamps resin product 1 415 and resin product 2 416 is part of clamp tool 417 which fixes resin product 1 415 and resin product 2 416 in joining position and the clamping of clamp part 445 is released by expansion pressure during melting. Thus it is possible to confirm fusion of resin products without the use of inspection hole and it is also possible to confirm the fusion of the resin products simply by the mechanical operations of clamp tool 417 without the use of controller 401.

Fusion of resin products can also be confirmed by the following method. Resin product 1 415 and resin product 2 416 are set for joining, a controller connector 413 of controller 401 is connected to terminal pins 420 and 421 projecting from the surface

of resin product 1 415, the current to the electrical resistance line, which is inset into the joining surfaces of resin product 1 415 and resin product 2 416 and with its ends connected to terminal pins 420 and 421, is controlled by controller 401, and resin product 1 415 and resin product 2 416 are thus fused. Current (A) and voltage (V) of the circuit through which current is passed to electrically resistant wire 418 are detected, this current (A) and voltage (V) are varied in the same ratio and it is detected whether the resistance (R) of the circuit remains constant for at least a specified time. When this method of confirming the fusion of the resin products is used, the control value of controller 401 is detected and it is thus possible to detect fusion of the resin products without the inspection hole used in the prior art. Also as the electrical changes which accompany the melting of the resin are detected directly, it is possible to confirm the fusion of the resin products with certainty.

Eighth aspect of the invention - see Figure 36

Figure 36 shows a pipe fitting 500 which is intended for use as a transition fitting. The transition fitting 500 enables an electrofused coupling to connect to a metal (particularly brass or steel) pipe component, such as a valve

A plastic axial end 502 of the transition fitting comprises a socket mouth 506 fitted with an electrofusion coil 508. This coil operates in exactly the same fashion as any appropriate one of the above described heating elements. Any appropriate one of the above described control boxes may be employed to control the electrofusion fastening of the socket mouth 506 to a plastics pipe inserted into the socket mouth 506.

The transition fitting also comprises a metal axial end portion 504, which is provided with a cylindrical portion 510 with an outer threaded surface 501. This metal portion is for affixation to an appropriate fitting, such as a valve for example by means of the thread 501. The plastics portion 502 of the transition fitting 500 is moulded onto the

metal portion 504 during manufacture. The plastics portion 502 is provided with radially inwardly directed keying formations 514 on a cylindrical portion 503, which internally receives the metal portion 504. The metal portion 504 is provided with corresponding radially outwardly directed keying formations 512 on a radially outer surface of a cylindrical portion 524 thereof which is received within the cylindrical portion 503 of the plastics portion 502. The metal portion 504 comprises an overhanging annular lip 526 which encloses the axial end of the cylindrical portion 503 of the plastics portion.

The transition fitting 500 also includes an intermediate radially inwardly directed web 501 which defines an intermediate flow path between a metal pipe and a plastics pipe connected by the transition fitting.

This fitting enables electrofusion at the plastics end 502 and conventional mechanical connection to metal components at the metal end 504, thus providing an interface between electrofused and metal pipe components.

Ninth aspect of the invention - see Figure 37

Figure 37 shows an axial section through a pipe joint in which the heating element is buried in the wall of the piping, rather than in a separate fitting, such as a socket. The joint 602 comprises a first pipe section 604 and a second pipe section 606 which are moulded together by use of an intermediate coil 608. This is achieved by providing a neck region on the first pipe section 604 which provides an axial end region having a narrower diameter than the remainder of the pipe wall section. Pipe section 606 has a radially inner mouth portion of somewhat enlarged inner diameter, to accommodate the neck region of first pipe section 604. As a result, the neck of pipe section 604 can be fitted within the corresponding mouth portion of pipe section 606, with the coil 608 sandwiched in between.

This arrangement is facilitated by the use of an insulated heating element for the coil 608 and enables direct jointing of large diameter pipes and slip-lining, without additional socket components or mouldings.

The arrangement also enables the formulation of a pipe component, such as a socket, with the coil buried, rather than located at a wall surface. In such a case the pipe walls are replaced by e.g. socket walls.

The wire in the heating element may, if desired, be made from nickel or a nickel alloy, such as nichrome. Although nickel is more expensive, it has superior corrosion protection properties and, more importantly, a higher resistivity coefficient. This means that the resistance of the nickel or nickel-based wire changes significantly with temperature, such that the fitting has in effect a built-in thermocouple to measure rectly in the weld zone. This constitutes a tenth aspect of the invention. Nickel is also better than copper in applications of low voltage, high current and also gives better (shorter) heat times than copper on large fittings where long soak time is usually needed.

CLAIMS

1. Electrofusion fastening apparatus in which, by supplying an electric current to a heat generating body set up in proximity to the inner circumference surface of a socket of a joint made from thermoplastic resin, the spigot of a thermoplastic pipe is fused and fastened into the above-mentioned socket; characterised in that when the time it takes the electric current value flowing into the heat generating body to rise to a fixed electric current value exceeds a fixed time, measures are taken to detect poor insertions of the pipe judged to have the pipe spigot incorrectly inserted into the joint socket, and the electric current supply to the heat generating body is discontinued while the poor pipe insertion is being detected according to the detection measures.

2. Electrofusion fastening apparatus in which, by supplying an electric current to a heat generating body set up in proximity to the inner circumference surface of a socket of a joint made from thermoplastic resin, the spigot of a thermoplastic pipe is fused and fastened into the above-mentioned socket; characterised in that the apparatus performs a drying process in which thermoplastic resin is heated by the above-mentioned heat generating body to below its fusion temperature, before a fusion process in which thermoplastic resin is heated by the above-mentioned heat generating body to above its fusion temperature.

3. An electrofusion device for resin products wherein the resin of a joint component is fused by supplying power to a heat element attached to a resin product to which it is to be fused; characterised in that it is provided with a controller which controls the amount of heat applied by the aforesaid heat element in accordance with a heat pattern, whereby the power level rises at commencement of the fusion process until it reaches a first set power level, which is maintained for the duration of a first period of time before being lowered by a specified amount for the duration of a second



period of time, after which it reaches a second set power level and is maintained there for the duration of a third period of time before the fusion process terminates.

4. An electrofusion device for resin products as described in Claim 3 characterised in that it detects a gap between the resin products which are to be fused by the time needed to reach the first set power level from commencement of the fusion process.

5. An electrofusion device for resin products as described in Claim 3 or 4, characterised in that a connector of the controller for connection to a resin product which is to be fused is provided with a temperature sensor which detects an outside air temperature.

6. An electrofusion device for resin products as described in Claim 4 or 5, characterised in that it amends the heat pattern on the basis of a gap between resin products which are to be fused and of the outside air temperature.

7. An electrofusion device for resin products as described in Claim 3 characterised in that, by means of the first set power level, it brings the temperature of the resin product which is to be fused to one which is above the melting point of the resin but below the point at which it deteriorates or is damaged.

8. An electrofusion device for resin products wherein the resin of a joint component is fused by supplying power to a heat element attached to a resin product to which it is to be fused; characterised in that it is provided with a controller which, according to the type of resin product which is to be fused, reads in advance mechanical or electrical changes for the purpose of identifying the type of product which is to be fused, selects and sets the heat pattern corresponding to the type of resin product which is to be fused, and automatically performs the fusion process.



9. An electrofusion device for resin products as described in Claim 8 characterised in that a connector of the controller is provided with a terminal by which to connect it to terminals at either end of an electrical resistance wire which is exposed to the surface or end of the resin product which is to be fused, and a terminal by which to connect it to the part which constitutes the mechanical or electrical change for the purpose of identifying the type allocated to the resin product which is to be fused.

10. An electrofusion joint automatic fusion control method wherein:

(1) in response to a fusion work start signal, detection of the surrounding temperature and measurement of the value of the resistance of the heating wire of an electrofusion joint at the surrounding temperature are effected and set power is supplied to said heating wire,

(2) when the power reaches a set value, the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the specific heat of resin is calculated by PID computation,

(3) having reference to the degree of resistance variation and the specific heat calculated in (2), the power is raised stepwise, and in each step the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the degree of specific heat variation is calculated, and

(4) when the degree of specific heat variation calculated in (3) goes below a certain constant, raising of the power is stopped, on-off control in constant time intervals is effected, and when the specific heat goes below a certain constant the supply of power is cut.

11. An electrofusion joint automatic fusion control method wherein:

(1) in response to a fusion work start signal, detection of the surrounding temperature and measurement of the value of the resistance of the heating wire of an electrofusion joint at the surrounding temperature are effected and set power is supplied to said heating wire,



(2) when the power reaches a set value the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the specific heat of resin is calculated by PID computation,

(3) having reference to the degree of resistance variation and the specific heat calculated in (2), the power is raised stepwise, and in each step the degree of resistance variation is calculated, on-off control in set constant time intervals is effected and the degree of specific heat variation is calculated, and

(4) when the degree of specific heat variation calculated in (3) goes below a certain constant, raising of the power is stopped, on-off control in constant time intervals is effected, and after elapse of a time calculated on the basis of the specific heat calculated in step (3) the supply of power is stopped.

12. A method of fusing resin products characterised in that a first resin product and a second resin product are placed in the joining position, the connectors of a controller are connected to a pair of terminal pins which are exposed on the surface of the first resin product, the current supplied to an electrically resistant wire which is inset into the joining surfaces of the first resin product and the second resin product and connected at its ends to the terminal pins, is controlled by the controller; a switch part which switches the current on and off, being formed in the intermediate part of the electrically resistant wire and the switch being held closed by second resin product only when the first resin product and the second resin product are placed in a specified joining position, thus making electrical fusion operations possible.

13. A method of confirming fusion of resin products characterised in that, in a method of molten adhesion of resin products in which a first resin product and a second resin product are set for joining, a controller connector is connected to terminal pins projecting from the surface of the first resin product, the current supplied to an electrically resistant wire, which is inset into the joining surfaces of the first resin product and the second resin product and is connected at its ends to the above-



mentioned terminal pins, is controlled by the said controller, and the first resin product and the second resin product are fused; a resin product type identification means is used to identify the type of first resin product when work begins and to set a corresponding heat pattern, when the connector is connected to the above-mentioned terminal pins.

14. A method according to Claim 13, wherein a sensor arm projects from the connector and fits into a cavity located in a resin product, the depth of which cavity varies according to the type of resin product, and the type of resin product is identified on the basis of the length of travel of the sensor arm.

15. A method according to Claim 14, wherein a temperature identification device is used to detect the surface temperature of the first resin product using a temperature sensor at the tip of the said sensor arm when it contacts the base of the cavity, and this finding is used to correct the heat pattern on the basis of the temperature of the first resin product at the beginning of work.

16. A method of confirming fusion of resin products characterised in that, in a method of fusion of resin products in which a first resin product and a second resin product are set for joining, a controller connector is connected to terminal pins projecting from the surface of the first resin product, the current supplied to an electrically resistant wire, which is inset into the joining surfaces of the first resin product and second resin product and has its ends connected to the above-mentioned terminal pins, is controlled by the above-mentioned controller, and the first resin product and second resin product are thus fused; a clamp tool is used with clamp parts which hold the first resin product and second resin product and thus fix the first resin product and second resin product in joining position, the clamping action of the above-mentioned clamp part being released by expansion pressure during melting.



17. A method of confirming fusion of resin products characterised in that, in a method of fusion of resin products in which a first resin product and a second resin product are set for joining, a controller connector is connected to terminal pins projecting from the surface of the first resin product; the current supplied to an electrically resistant wire, which is inset into the joining surfaces of the first resin product and the second resin product and has its ends connected to the above-mentioned terminal pins, is controlled by the above-mentioned controller, and the first resin product and the second resin product are thus fused, the current value and voltage value of the circuit through which this current is passed to the above-mentioned electrically resistant wire is detected, these current value and voltage value being varied in the same ratio and it being detected when the resistance of the circuit remains constant for at least a specified time.
18. A pipe fitting comprising a first axial end portion comprising means for engagement with a metal pipe component and a second axial end portion provided with a heat element, which generates heat upon application of an electric current thereto, for electrofusion with a plastics pipe component; the first and second axial end portions being joined together.
19. A length of pipe comprising an insulated heating element in an end portion thereof, the end portion being adapted for direct connection to an end portion of a different length of pipe by means of electrofusion using the heating element.
20. A spigot or socket for use in the formation of an electrofusion joint, with the said spigot or socket comprising an insulated heating element buried in the body of a wall portion thereof.



21. A heating element for use in electrofusion coupling pipe components, comprising a heating element including nickel or an alloy of nickel; wherein the heating element is adapted for use as a temperature sensor.

