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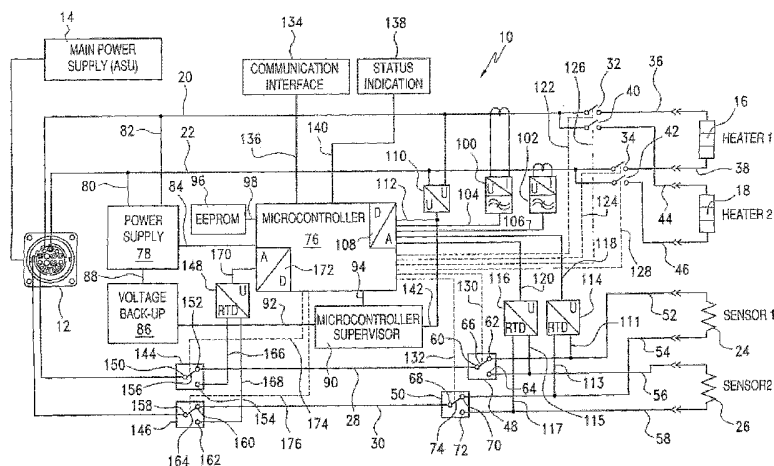
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(54) Title: CONTROL CIRCUITS FOR HOT MELT ADHESIVE HEATER CIRCUITS AND APPLICATOR HEADS



(57) Abstract: An electronic control circuit, for use in connection a hot melt adhesive dispensing system having a relatively large applicator head, has a plurality of heater circuits and a plurality of temperature sensors disposed upon different regions of the relatively large applicator head, wherein the electronic control circuitry can effectively interface between the plurality of heater circuits and the plurality of temperature sensors, and the adhesive supply unit (ASU) hose and head connector, so as to control individual ones of the plurality of heater circuits and thereby ensure that all of the heater circuits will maintain the same temperature setting throughout all regions of the applicator head. A second electronic control circuit enables the temperature sensors to effectively be eliminated due to the fact that the temperature value of each heater circuit can be calculated from resistance and temperature coefficient values characteristic of the heater circuit, wherein the electronic control circuitry can again interface between the heater circuit and the adhesive supply unit (ASU) temperature controller.

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CONTROL CIRCUITS FOR HOT MELT ADHESIVE HEATER  
CIRCUITS AND APPLICATOR HEADS

CROSS REFERENCE TO RELATED PATENT APPLICATIONS

This patent application is a Continuation-in-Part of  
5 United States Patent Application entitled **REDUNDANT CONTROL**  
**CIRCUIT FOR HOT MELT ADHESIVE HOSE ASSEMBLY HEATER CIRCUITS**  
**AND TEMPERATURE SENSORS**, which was filed on May 6, 2005 and  
which has been assigned Serial Number 11/123,028.

FIELD OF THE INVENTION

10 The present invention relates generally to hot melt  
adhesive dispensing systems, and more particularly to a new  
and improved redundant control circuit which effectively has  
redundant components inherently incorporated therein, such  
as, for example, redundant hot melt adhesive heater circuits,  
15 and redundant hot melt adhesive temperature sensors, whereby  
should a failure occur within one of the hot melt adhesive  
heater circuits, or within one of the hot melt adhesive temp-  
erature sensors, switch mechanisms may be suitably actuated  
so as to effectively withdraw the failed hot melt adhesive

heater circuit, or the failed hot melt adhesive temperature sensor, from its operative or functional disposition within the electrical circuitry, and to substantially simultaneously insert the backup or redundant hot melt adhesive heater circuit, or the backup or redundant hot melt adhesive temperature sensor, into the redundant control circuitry whereby the hot melt adhesive hose assembly does not need to be replaced immediately but can be subsequently replaced in accordance with, for example, normal scheduled maintenance procedures, the hot melt adhesive dispensing production line does not need to be shut down for repairs whereby extensive downtime to replace the failed hot melt adhesive hose assembly is effectively able to be avoided, and the hot melt adhesive dispensing production line can continue to operate without any production downtime.

In addition, in connection with, for example, hot melt adhesive dispensing systems employing a relatively large applicator head wherein a plurality of hot melt adhesive heater circuits and a plurality of hot melt adhesive temperature sensors are disposed upon different regions of the relatively large applicator head, the redundant control circuitry can effectively interface between the plurality of hot melt adhesive heater circuits and the plurality of hot melt adhesive temperature sensors, and the adhesive supply unit (ASU) hose and head connector so as to control individual ones of the plurality of hot melt adhesive heater circuits and thereby ensure that all of the hot melt adhesive heater circuits will maintain the same temperature setting throughout all regions of the applicator head. Still further, in accordance with an alternative mode of operation, the hot melt adhesive

system temperature sensors may effectively be eliminated due to the fact that the temperature value of each hot melt adhesive heater circuit or wire can be calculated by means of the redundant control circuitry from temperature coefficient and resistance values characteristic of the hot melt adhesive heater circuit or wire whereby the redundant control circuitry can again serve as an interface between the hot melt adhesive heater circuits or wires and the adhesive supply unit (ASU) temperature controller, transmit the calculated temperature values back to the adhesive supply unit (ASU) temperature controller, and, in turn, transmit appropriate signals from the adhesive supply unit (ASU) temperature controller back to any one of the plurality of hot melt adhesive heater circuits or wires so as to control the temperatures thereof.

## 15 BACKGROUND OF THE INVENTION

In connection with hot melt adhesive dispensing systems, failures can generally occur within two different categories, that is, mechanical failures due to wear, or electrical failures due to electrical malfunctions. More particularly, in connection with the different types of electrical failures that can be experienced, electrical failures can occur, for example, either within the heater circuit which is used to maintain the hot melt adhesive material, which is flowing through the hot melt adhesive hose assembly, at a predetermined temperature level, or within the temperature sensor which is operatively or thermally associated with the hot melt adhesive hose assembly in order to effectively de-

tect the temperature level of the hot melt adhesive material,  
which is flowing through the hot melt adhesive hose assembly,  
and to appropriately control the heater circuit so as to ef-  
fectively ensure that the desired temperature level of the  
5 hot melt adhesive material, which is flowing through the hot  
melt adhesive hose assembly, is in fact maintained. Mainte-  
nance of the proper or desired temperature level of the hot  
melt adhesive material is of course critical in order to en-  
sure that the hot melt adhesive material will be properly  
10 dispensed, and provide the desired adhesive properties, once  
the hot melt adhesive material is in fact deposited onto a  
particular substrate. In either case, that is, whether a  
failure is experienced in connection with the heater circuit,  
or in connection with the temperature sensor, such failures  
15 typically cause the hot melt adhesive dispensing production  
line to be shut down for extended periods of time, in order  
to implement the repair or replacement of the failed compon-  
ents, whereby valuable production time is lost.

In addition, the temperature zones defined within,  
20 or encountered in connection with, standard hot melt adhesive  
application equipment are effectively organized in pairs com-  
prising the hot melt adhesive supply hose and the hot melt  
adhesive applicator head. If a particular one of the hot melt  
adhesive applicator heads is relatively large, then it usual-  
25 ly comprises a plurality of cartridge heaters or heater cir-  
cuits, connected in parallel, but only a single temperature  
sensor which is usually located at a relatively central regi-  
on of the applicator head so as to sense, in effect, an aver-  
age or median temperature reading for the applicator head.  
30 Accordingly, based upon such an average or median temperature

reading sensed by means of the single temperature sensor, suitable electrical power is sent to each cartridge heater or heater circuit by means of the adhesive supply unit (ASU) temperature controller. However, due to tolerances and unbalanced heat distribution factors or characteristics, the actual temperatures at the different locations can differ significantly which can, of course, ultimately lead to performance problems comprising, for example, improperly heated hot melt adhesive material which will, of course, in turn, lead to improperly or incompletely bonded products.

Ideally, therefore, it would be desirable to distribute and adjust the electrical power being supplied from the adhesive supply unit (ASU) temperature controller to each one of the plurality of cartridge heaters or heater circuits in such a manner that all of the cartridge heaters or heater circuits would maintain the same predetermined or set temperature level. One possible solution to this dilemma would be to install additional temperature sensors within the applicator head and let the adhesive supply unit (ASU) temperature controller control each zone independently with a common temperature set point. However, this solution has several operational problems, disadvantages, and drawbacks. For example, each cartridge heater or heater circuit, and its respective temperature sensor, would require its own temperature zone upon the adhesive supply unit (ASU) temperature controller, however the number of zones available upon the adhesive supply unit (ASU) temperature controller are limited. Secondly, each temperature zone would require a separate cable and connector, which would entail or require an extensive amount of electrical connections, routing, and the like. Thirdly,

even though the temperature set point for all of the cartridge heaters or heater circuits, and their respective temperature sensors, would be the same, each temperature zone would have to be individually programmed.

5           Continuing still further, and in accordance with a potentially alternative mode of operation, it is desirable to effectively eliminate the need for the plurality of temperature sensors so as to render the hot melt adhesive application equipment more economical to produce. It is known that  
10 each heater circuit or wire has an inherent or predetermined electrical temperature coefficient, and that there is also a predetermined or known relationship between the temperature of a wire and its electrical resistance. Accordingly, if the resistance of the heater circuit or wire can be determined,  
15 then the temperature of the heater circuit or wire can be determined whereby the temperature sensors could effectively be eliminated.

A need therefore exists in the art for a new and improved redundant control circuit, for use in conjunction  
20 with a hot melt adhesive hose assembly, wherein redundant electrical components could effectively be incorporated such that if a failure occurs within a particular electrical component, the failed electrical component could effectively be removed from its operative or functional disposition within  
25 the electrical circuitry, and the other electrical component could effectively be operatively or functionally incorporated into the electrical circuitry. In this manner, the hot melt adhesive dispensing production line would not need to be shut down for extended periods of time, in order to implement the

replacement of the failed hot melt adhesive hose assembly, whereby valuable production time would not be lost. In addition, a need also exists in the art for a new and improved electronic control circuit, for use in connection with hot melt adhesive application equipment, and in particular, in conjunction with a relatively large application head comprising a plurality of cartridge heaters or heater circuits, wherein a plurality of temperature sensors may respectively be used in conjunction with the plurality of cartridge heaters or heater circuits whereby the number of zones upon the adhesive supply unit (ASU) temperature controller need not be increased and yet all of the plurality of cartridge heaters or heater circuits can be individually and independently controlled. Still further, a need exists in the art for a new and improved electronic control circuit, for use in connection with hot melt adhesive application equipment, wherein the use of temperature sensors can effectively be eliminated, and yet the temperature of each one of a plurality of cartridge heaters or heater circuits can nevertheless be determined such that the adhesive supply unit (ASU) temperature controller can individually and independently control the cartridge heaters or heater circuits.

#### SUMMARY OF THE INVENTION

The foregoing and other objectives are achieved in accordance with the teachings and principles of the present invention through the provision of a new and improved redundant control circuit which comprises a pair of heater cir-

cuits which are adapted to be wrapped around the external peripheral surface of a hot melt adhesive hose assembly core, and a pair of temperature sensors which are also adapted to be disposed in contact with the external peripheral surface of the hose core. A first one of the heater circuits would initially be electrically connected to the hot melt adhesive hose assembly electrical circuitry, and in a similar manner, a first one of the temperature sensors would likewise be electrically connected to the hot melt adhesive hose assembly electrical circuitry. Subsequently, should a failure occur within the first one of the heater circuits, then an electrical switch mechanism would be activated so as to effectively remove the first, failed heater circuit from the hot melt adhesive hose assembly electrical circuitry, and substantially simultaneously, electrically connect the second one of the heater circuits to the hot melt adhesive hose assembly electrical circuitry. Similar switching procedures would also be implemented in connection with the pair of temperature sensors should a failure occur within a first one of the temperature sensors initially incorporated within the hot melt adhesive hose assembly electrical circuitry.

In addition, in connection with, for example, a first alternative embodiment of the present invention, wherein a hot melt adhesive dispensing system employs a relatively large applicator head which has a plurality of hot melt adhesive heater circuits and a plurality of hot melt adhesive temperature sensors disposed upon different regions of the relatively large applicator head, the electronic control circuitry can effectively interface between the plurality of hot melt adhesive heater circuits and the plurality of hot melt

adhesive temperature sensors, and the adhesive supply unit (ASU) hose and head connector, so as to control individual ones of the plurality of hot melt adhesive heater circuits and thereby ensure that all of the hot melt adhesive heater  
5 circuits will maintain the same temperature setting throughout all regions of the applicator head. Still further, in accordance with a second alternative mode of operation, the hot melt adhesive system temperature sensors may effectively be eliminated due to the fact that the temperature value of  
10 each hot melt adhesive heater circuit or wire can be calculated by means of the electronic control circuitry from temperature coefficient and resistance values characteristic of the hot melt adhesive heater circuit or wire whereby the electronic control circuitry can again serve as an interface  
15 between the hot melt adhesive heater circuits or wires and the adhesive supply unit (ASU) temperature controller by transmitting the calculated temperature values back to the adhesive supply unit (ASU) temperature controller whereby, in turn, the adhesive supply unit (ASU) temperature control-  
20 ler can transmit appropriate signals to any one of the plurality of hot melt adhesive heater circuits or wires so as to control the temperatures thereof.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Various other features and attendant advantages of  
25 the present invention will be more fully appreciated from the following detailed description when considered in connection with the accompanying drawings in which like reference char-

acters designate like or corresponding parts throughout the several views, and wherein:

**FIGURE 1** is an electronic circuit diagram schematically illustrating the new and improved redundant control circuit, operatively associated with a hot melt adhesive hose assembly, developed in accordance with the principles and teachings of the present invention, and showing the cooperative parts thereof, wherein a pair of redundant heater circuits and a pair of redundant temperature sensors, along with a first pair of switching mechanisms operatively connected to the pair of redundant heater circuits, and a second pair of switching mechanisms operatively connected to the pair of redundant temperature sensors, are operatively incorporated within the new and improved redundant control circuit such that should a failure occur within a first one of the pair of redundant heater circuits, then the first pair of switching mechanisms will be activated so as to effectively remove the first, failed heater circuit from the hot melt adhesive hose assembly electrical circuitry, and substantially simultaneously, electrically connect the second one of the pair of redundant heater circuits to the hot melt adhesive hose assembly electrical circuitry, while in a similar manner, should a failure occur within a first one of the pair of redundant temperature sensors, the second pair of switching mechanisms will be activated so as to effectively remove the first, failed temperature sensor from the hot melt adhesive hose assembly electrical circuitry, and substantially simultaneously, electrically connect the second one of the pair of redundant temperature sensors to the hot melt adhesive hose assembly electrical circuitry;

**FIGURE 2** is a schematic electronic circuit diagram illustrating a first alternative embodiment of a new and improved electronic control circuit, developed in accordance with the principles and teachings of the present invention and showing the cooperative parts thereof, wherein the electronic control circuit is operatively associated with a plurality of heater circuits and a plurality of temperature sensors which are arranged within a plurality of sub-zones, and a switching mechanism respectively connects the plurality of heater circuits to the adhesive supply unit (ASU) electrical connector, and wherein the electronic control circuitry effectively serves as an interface between the plurality of heater circuits and the plurality of temperature sensors, and the adhesive supply unit (ASU) electrical connector, whereby temperature sensor signals are routed from the temperature sensors to the adhesive supply unit (ASU) temperature controller, and temperature control signals are routed from the adhesive supply unit (ASU) temperature controller to the individual heater circuits, through means of the microcontroller within the electronic control circuit, as necessary; and

**FIGURE 3** is a schematic electronic circuit diagram illustrating a second alternative embodiment of a new and improved electronic control circuit, developed in accordance with the principles and teachings of the present invention and showing the cooperative parts thereof, wherein the electronic control circuit is operatively associated with at least one heater circuit is disclosed, and wherein further, the resistance value within the heater circuit wire may be determined from current and voltage readings, the resistance value may then be converted into a temperature value by means

of a lookup table stored within the **EEPROM** of the electronic control circuit, and the temperature value may then be transmitted to the adhesive supply unit (ASU) temperature controller which will then directly control the heater circuit as  
5 necessary, whereby the necessity for using a temperature sensor in conjunction with the heater circuit has been obviated.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and more particularly to **FIGURE 1** thereof, the new and improved redundant  
10 control circuit, which has been developed in accordance with the principles and teachings of the present invention, which shows the cooperative parts thereof, and which is adapted to be operatively associated with a hot melt adhesive hose assembly, such as, for example, that disclosed within the noted  
15 copending United States Patent Application entitled **HOT MELT ADHESIVE HOSE ASSEMBLY HAVING REDUNDANT COMPONENTS**, which was filed on May 6, 2005, and which has been assigned Serial Number 11/123,053, is disclosed and is generally indicated by the reference character 10. As is well known in the hot melt  
20 adhesive material dispensing art, hot melt adhesive material is normally supplied to a hot melt adhesive hose assembly, not shown, from a hot melt adhesive supply unit, also not shown, in a heated state, and a heater circuit or heater assembly is conventionally operatively associated with the hot  
25 melt adhesive hose assembly in order to maintain the hot melt adhesive material at a predetermined temperature level, while the same is being conducted through the hot melt adhesive

hose assembly, such that the hot melt adhesive material will have or exhibit the proper viscosity properties when the hot melt adhesive material is dispensed from the applicator end of the hot melt adhesive hose assembly. In addition, a temperature sensor is likewise conventionally operatively associated with the hot melt adhesive hose assembly so as to effectively detect or sense the temperature level of the hot melt adhesive material being conducted through the hot melt adhesive hose assembly, and to accordingly or appropriately control the energization of the heater circuit or heater assembly, so as to again ensure the fact that the hot melt adhesive material is being heated to, and maintained at, the proper temperature level while the same is being conducted through the hot melt adhesive hose assembly, such that the hot melt adhesive material will have or exhibit the proper viscosity properties when the hot melt adhesive material is dispensed from the applicator end of the hot melt adhesive hose assembly.

As has been noted hereinbefore, electrical failures can occur within hot melt adhesive material dispensing systems either within, for example, the heater circuit or heater assembly which is used to maintain the hot melt adhesive material, which is flowing through the hot melt adhesive hose assembly, at a predetermined temperature level, or within the temperature sensor which is operatively or thermally associated with the hot melt adhesive hose assembly in order to effectively detect the temperature level of the hot melt adhesive material, which is flowing through the hot melt adhesive hose assembly, and to appropriately control the energization of the heater circuit or heater assembly so as to effectively

ensure that the desired temperature level of the hot melt adhesive material, which is flowing through the hot melt adhesive hose assembly, is in fact maintained. Maintenance of the proper or desired temperature level of the hot melt adhesive material is of course critical in order to ensure that the hot melt adhesive material will be properly dispensed, and will provide the desired adhesive properties, once the hot melt adhesive material is in fact deposited onto a particular substrate. In either case, that is, whether a failure is experienced in connection with the heater circuit or heater assembly, or in connection with the temperature sensor, such failures typically cause the hot melt adhesive dispensing production line to be shut down for extended periods of time, in order to implement the replacement of the hot melt adhesive hose assembly, whereby valuable production time is lost.

It has therefore been determined that it would be desirable to effectively incorporate redundant heater circuits or heater assemblies, as well as redundant temperature sensors, into the hot melt adhesive hose assembly, and to provide a new and improved redundant control circuit for effectively controlling the activation or energization of the redundant heater circuits or heater assemblies, as well as the redundant temperature sensors, such that if a failure occurs within a particular one of the heater circuits or heater assemblies, or within a particular one of the temperature sensors, the failed heater circuit or heater assembly, or the failed temperature sensor, could readily and immediately be effectively removed from its operative or functional disposition within the electrical circuitry, and the other corresponding heater circuit or heater assembly, or temperature

sensor, could readily and immediately be operatively or functionally incorporated into the electrical circuitry. In this manner, the hot melt adhesive dispensing production line would not need to be shut down for extended periods of time, in order to implement the replacement of the failed hot melt adhesive hose assembly, whereby valuable production time would not be lost.

More particularly, then, it is seen that the new and improved redundant control circuit 10, for achieving the aforementioned desirable results, comprises an electrical connector 12 which is adapted to receive electrical power from a suitable main power supply 14 which is operatively associated with an adhesive supply unit (ASU), not shown, a pair of heater circuits or heater assemblies 16,18 which are electrically connected to the electrical connector 12 by means of a first pair of primary power lines 20,22, and a pair of temperature sensors 24,26 which are electrically connected to the electrical connector 12 by means of a second pair of primary power lines 28,30. It is noted that while each one of the temperature sensors 24,26 may comprise, and has been designated in the **SOLE FIGURE** as a resistance temperature detector (RTD), each temperature sensor 24,26 may alternatively comprise a thermistor, or a thermocouple. It is further seen that the opposite ends of the first heater circuit or heater assembly 16 are electrically connected to the first pair of primary power lines 20,22 by means of a first pair of switch mechanisms 32,34 and a first pair of auxiliary connection lines 36,38, while the opposite ends of the second heater circuit or heater assembly 18 are electrically connected to the first pair of primary power lines 20,22 by means of a

second pair of switch mechanisms 40,42 and a second pair of auxiliary connection lines 44,46. Accordingly, it can readily be appreciated that when, for example, the first pair of switch mechanisms 32,34, operatively associated with the first heater circuit or first heater assembly 16, are both disposed at their **CLOSED** positions, while the second pair of switch mechanisms 40,42, operatively associated with the second heater circuit or second heater assembly 18, are both disposed at their **OPEN** positions, the first heater circuit or first heater assembly 16 will be electrically connected into the overall redundant control circuit 10 and will be electrically connected to the electrical connector 12 so as to receive electrical power therefrom in order to heat the hot melt adhesive hose assembly, not shown. Conversely, when, for example, the second pair of switch mechanisms 40,42, operatively associated with the second heater circuit or second heater assembly 18, are both disposed at their **CLOSED** positions, while the first pair of switch mechanisms 32,34 operatively associated with the first heater circuit or first heater assembly 16, are both disposed at their **OPEN** positions, the second heater circuit or second heater assembly 18 will be electrically connected into the overall redundant control circuit 10 and will be electrically connected to the electrical connector 12 so as to receive electrical power therefrom in order to heat the hot melt adhesive hose assembly, not shown.

Continuing further, it is similarly seen that the opposite ends of the first temperature sensor 24 are electrically connected to the second pair of primary power lines 28,30 by means of a third pair of single-throw, double-pole

switch mechanisms 48,50 and a third pair of auxiliary connection lines 52,54, while the opposite ends of the second temperature sensor 26 are electrically connected to the second pair of primary power lines 28,30 by means of the third pair of single-throw, double-pole switch mechanisms 48,50 and a fourth pair of auxiliary connection lines 56,58. It is more particularly seen that the first single-throw, double-pole switch mechanism 48, of the third pair of single-throw, double-pole switch mechanisms 48,50, actually comprises a common terminal 60, a pair of alternatively selectable terminals 62, 64, and a switch member 66, while in a similar manner, the second single-throw, double-pole switch mechanism 50, of the third pair of single-throw, double-pole switch mechanisms 48,50, actually comprises a common terminal 68, a pair of alternatively selectable terminals 70,72, and a switch member 74.

Accordingly, as was the case with the first and second heater circuits or first and second heater assemblies 16,18, when, for example, the third pair of switch mechanisms 48,50 are both disposed at their **UPPER CLOSED** positions at which the switch members 66,74 are disposed in contact with and electrically connected to the upper selectable terminals 62, 70, while simultaneously the switch members 66,74 are disposed in **OPEN** states with respect to the lower selectable terminals 64,72, then the first temperature sensor 24 will be electrically connected into the overall redundant control circuit 10 and will be electrically connected to the electrical connector 12 so as to receive electrical power therefrom in order to monitor the temperature level of the hot melt adhesive hose assembly, not shown, so as to, in turn, effect-

ively control the one of the first or second heater circuits, or first or second heater assemblies, 16,18 that is currently electrically connected into the overall circuit 10. Conversely, when, for example, the third pair of switch mechanisms  
5 48,50 are both disposed at their **LOWER CLOSED** positions at which the switch members 66,74 are disposed in contact with and electrically connected to the lower selectable terminals 64,72, while simultaneously the switch members 66,74 are disposed in **OPEN** states with respect to the upper selectable  
10 terminals 62,70, then the second temperature sensor 26 will be electrically connected into the overall redundant control circuit 10 and will be electrically connected to the electrical connector 12 so as to receive electrical power therefrom in order to monitor the temperature level of the hot melt adhesive hose assembly, not shown, so as to, in turn, effectively control the one of the first or second heater circuits,  
15 or first or second heater assemblies, 16,18 that is currently electrically connected into the overall redundant control circuit 10.

20 The redundant control circuit 10 is seen to further comprise a microcontroller 76 which is supplied with electrical power from a secondary power supply unit 78, and it is seen that the secondary power supply unit 78 is electrically connected to the primary power lines 20,22 through means of  
25 secondary power lines 80,82, and still further, the secondary power supply unit 78 is electrically connected to the microcontroller 76 through means of a tertiary power line 84. A voltage backup unit 86 is electrically connected to the secondary power supply unit 78 by means of an electrical connection  
30 line 88, and the voltage backup unit 86 is also elec-

trically connected to a microcontroller supervisor unit 90 by means of an electrical connection line 92 while the microcontroller supervisor unit 90 is, in turn, electrically connected to the microcontroller 76 by means of an electrical connection line 94. Still further, an **EEPROM** type memory unit 96 is electrically connected to the microcontroller 76 by means of an electrical connection line 98, and it is noted that the functions and operations of these various electrical components, that is, for example, the microcontroller 76, the voltage backup unit 86, the microcontroller supervisor unit 90, and the **EEPROM** type memory unit 96 will be discussed and explained shortly hereafter.

Continuing further, in accordance with additional features characteristic of the new and improved redundant control circuit 10 developed in accordance with the principles and teachings of the present invention, a first current-voltage transformer or converter 100 is electrically connected to or across the primary power line 20, while a second current-voltage transformer or converter 102 is electrically connected to or across the primary power line 22. The current voltage transformers or converters 100,102 are adapted to respectively detect the current levels within the primary power lines 20,22, which alternatively feed power to the first or second heater circuits, or first or second heater assemblies, 16,18 through means of the switch mechanisms 32,34, and 40, 42, and to convert such current levels to corresponding voltage levels which are then fed into the microcontroller 76 by means of data communication lines 104,106. A first analog-to-digital converter 108 is incorporated within the microcontroller 76, and the data communication lines 104, 106 are

electrically connected to the first analog-to-digital converter 108 whereby the incoming analog voltage levels can be converted, by means of the first analog-to-digital converter 108, into digital voltage values which can then of course be processed by means of the microcontroller 76. In addition, a first voltage detector 110 is electrically connected to, or across, the primary power lines 20,22 so as to detect the voltage level existing between the two primary power lines 20,22, and the detected voltage level is fed into the first analog-to-digital converter 108 of the microcontroller 76 by means of a data communication line 112 such that the incoming analog voltage level can be converted, by means of the first analog-to-digital converter 108, into a digital voltage value which can be processed by means of the microcontroller 76. In a similar manner, second and third temperature sensor-voltage converters 114,116 are respectively electrically connected to, or across, the third and fourth pairs of auxiliary connection lines 52,54, and 56,58, by means of connection lines 111,113 and 115,117, so as to detect or determine the voltage levels existing between the third and fourth pairs of auxiliary connection lines 52,54, and 56,58, and the detected voltage levels are respectively fed into the first analog-to-digital converter 108 of the microcontroller 76 by means of data communication lines 118,120 such that the incoming analog voltage levels can likewise be converted, by means of the first analog-to-digital converter 108, into digital voltage values which can be processed by means of the microcontroller 76.

In connection with the operation of the new and improved redundant control circuit 10 of the present invention,

when the adhesive supply unit, not shown, is activated, the main power supply 14 operatively associated with the adhesive supply unit applies or transmits power to the electrical connector 12 whereby a direct current (DC) voltage will be generated and the microcontroller 76 is booted or activated. The **EEPROM** type memory unit 96 stores various parameters and operational profiles operatively associated with the different components comprising the electronic control circuit 10, such as, for example, the various current, voltage, power values, duty cycles, and the like, generated by, or operatively characteristic of, the heater circuits or heater assemblies 16, 18, and the temperature sensors 24,26, as conveyed to the microcontroller 76 by means of the aforementioned data communication lines 104,106,112,118,120. Accordingly, the microcontroller 76 will retrieve the most current data stored within the **EEPROM** type memory unit 96, and will perform various system checks comprising the current levels, voltage levels, power levels, the duty cycle, and the like.

In addition, the microcontroller 76 will activate particular ones of the switch mechanisms 32,34,40,42,48,50, which are respectively connected to the microcontroller 76 by means of signal lines 122,124,126,128,130,132, such that particular ones of the switch mechanisms 32,34,40,42,48,50 will be moved to their **CLOSED** positions. In this manner, a particular one of the first or second heater circuits or heater assemblies 16,18, as well as a particular one of the first or second temperature sensors 24,26, will effectively be incorporated into the operative system comprising the redundant control circuit 10. It is also noted that the redundant control circuit 10 further comprises a communication interface

134 which is electrically connected to the microcontroller 76 by means of a data communication line 136, and a status indication means 138 which is electrically connected to the microcontroller 76 by means of a data communication line 140.

5 The communication interface 134 may comprise, for example, a computer interface, a display panel, and the like, while the status indication means may comprise, for example, green and red LEDs, indicator lights, and the like.

It is further noted that the voltage backup unit 86  
10 serves several functions, such as, for example, providing energy for a predetermined time period, such as, for example, several seconds, after the adhesive supply unit (ASU) has, for example, initiated a shut-down of the first or second heater circuits, or the first or second heater assemblies,  
15 16,18, in accordance with an end-of-cycle mode of operation wherein the residual energy provided by means of the voltage backup unit 86 can nevertheless maintain the microcontroller supervisor 90 active so as to, for example, shut down the microcontroller in a controlled manner or mode. In a similar  
20 manner, the voltage backup unit 86 can provide energy during those time periods within which the first or second heater circuits, or the first or second heater assemblies, 16,18 are being operated in accordance with low duty cycles. Still further, it is noted that in addition to the voltage detector  
25 110 being electrically connected to the microcontroller 76 by means of data communication line 112, the voltage detector 110 is also electrically connected to the microcontroller supervisor 90 by means of a data communication line 142. Accordingly, if, for example, the voltage detector 110 detects  
30 a significantly low voltage level, or the loss of voltage,

for a predetermined period of time, such as, for example, several seconds, then the voltage back-up unit 86 can provide sufficient power to enable the current operating system parameters to be stored within the **EEPROM** type memory unit 96, and for the microcontroller supervisor 90 to again shut down the microcontroller 76 in a controlled manner or mode. It is lastly noted that at all other times, the microcontroller supervisor 90 serves to monitor the microcontroller 76 in order to determine and verify the fact that the microcontroller 76 is operating properly or within normal parameters.

It is to be noted that during normal hot melt adhesive dispensing operations or procedures, or during normal hot melt adhesive application cycles, if, for example, the switch mechanisms 32,34 have been previously moved to their **CLOSED** positions so as to electrically incorporate or connect the first heater circuit or first heater assembly 16 into the redundant control circuit 10, while the switch mechanisms 40, 42 have been previously moved to their **OPEN** positions so as to electrically disconnect or isolate the second heater circuit or second heater assembly 18 from the redundant control circuit 10, and if subsequently, for example, a heater failure is detected as a result of, for example, a significant change in the heater current as detected by means of the current-voltage transformers or converters 100,102, and as compared to, for example, the normal heater current profile data stored within the **EEPROM** type memory unit 96; then the microcontroller 76 will initiate a switchover of the switch mechanisms, by means of suitable signals transmitted over the signal lines 122,124,126,128, so as to move switch mechanisms 32,34 to their **OPEN** positions whereby the first heater cir-

cuit or first heater assembly 16 will now be electrically disconnected or isolated from the redundant control circuit 10, and substantially simultaneously therewith, to move the switch mechanisms 40,42 to their **CLOSED** positions whereby the  
5 second heater circuit or second heater assembly 18 will now be electrically connected to or incorporated within the redundant control circuit 10. It is also to be noted that a heater failure can manifest itself in the form of a ground fault in connection with, for example, the first heater circuit or first heater assembly 16 if the first heater circuit  
10 or first heater assembly 16 is the heater circuit or heater assembly electrically connected to or incorporated within the redundant control circuit 10. In particular, not only should the heater circuit or heater assembly current values detected  
15 by means of the current-voltage converters or transformers 100,102 effectively be in accordance with the normal heater current profile data stored within the **EEPROM** type memory unit 96, but the detected values should also be the same within both of the primary power lines 20,22. If this is not the  
20 case, the first heater circuit or first heater assembly 16 may have a ground fault. Still yet further, if the current values, detected within both of the primary power lines 20, 22, change suddenly, although the duty cycle remains constant, this may indicate a defective heater circuit or heater  
25 assembly whereby a switchover between the first and second heater circuits or first and second heater assemblies 16,18 would again be warranted.

It is lastly noted, in connection with the operations and connections of the first and second heater circuits  
30 or first and second heater assemblies 16,18 within the redun-

dant control circuit 10, that it may be desirable to simultaneously activate all of the switch mechanisms 32,34,40,42 to their **CLOSED** positions such that both of the first and second heater circuits or first and second heater assemblies 5 16,18 are electrically connected to or incorporated within the electronic control circuit 10 for a predeterminedly short period of time, subsequent to which, one set of the switch mechanisms 32,34,40,42 would again be activated so as to be disposed at their **OPENED** position so as to serve their redundant objective. Activating all of the switch mechanisms 32, 10 34,40,42 to their **CLOSED** positions such that both of the first and second heater circuits or first and second heater assemblies 16,18 are electrically connected to or incorporated within the redundant control circuit 10 enables the system to operate in accordance with a "boost" mode whereby, for 15 example, a rapid heating of the hot melt adhesive hose assembly to the predetermined desired temperature value within a relatively short period of time may be achieved. Alternatively, both of the first and second heater circuits or first and second heater assemblies 16,18 may be electrically connected 20 to or incorporated within the redundant control circuit 10 under low supply voltage conditions, whereas, conversely, if the supply voltage is relatively high, the use of only one of the first and second heater circuits or first and second 25 heater assemblies 16,18 may be necessary.

In connection with the redundant temperature sensors 24,26, it is to be noted that during normal hot melt adhesive dispensing operations or procedures, or during normal hot melt adhesive application cycles, switch members 66,74 30 may be respectively moved, for example, to their illustrated

**CLOSED** positions at which the switch members 66,74 will be respectively electrically connected to terminals 62,70 so as to electrically incorporate or connect the first temperature sensor 24 into the redundant control circuit 10, whereas conversely, the switch members 66,74 will effectively be disposed at their **OPEN** positions with respect to terminals 64,72 so as to effectively electrically disconnect or isolate the second temperature sensor 26 from the redundant control circuit 10. During this time, both temperature sensors 24,26 are continuously monitored by means of the temperature sensor voltage converters 114,116 respectively connected across auxiliary connection lines 52,54, and 56,58, and any time a failure or an abnormality appears to have been detected in connection with one of the temperature sensors 24,26, the temperature sensors 24,26 will effectively be tested further so as to determine or verify which one of the temperature sensors 24,26 is in fact actually defective.

For example, both temperature sensors should exhibit or generate the same detected voltage values. If an open or short circuit is detected within a particular one of the temperature sensors 24,26, then clearly that particular one of the temperature sensors 24,26 is defective. Accordingly, if, for example, it is determined that temperature sensor 26 is in fact defective, then the switch members 66,74 are maintained at their illustrated positions so as to maintain the temperature sensor 24 electrically connected to, or incorporated within, the redundant control circuit 10, and to concomitantly maintain the temperature sensor 26 electrically disconnected or isolated from the redundant control circuit 10. On the other hand, or conversely, if, for example, it is

determined that the temperature sensor 24 is in fact defective, then signals will be transmitted from the microcontroller 76 to the switch mechanisms 48,50, by means of signal lines 130,132, so as to cause the switch members 66,74 to  
5 switch positions whereby switch member 66 will now be electrically connected to terminal 64 and switch member 74 will be electrically connected to terminal 72. In this manner, temperature sensor 26 will be electrically connected to, or incorporated within, the redundant control circuit 10, and  
10 temperature sensor 24 will be electrically disconnected or isolated from the redundant control circuit 10.

Continuing further, as has been noted hereinbefore, if an abnormality is detected in connection with the operations of the temperature sensors 24,26, then the temperature  
15 sensors 24,26 must be tested in order to determine which one of the temperature sensors 24,26 is in fact operating properly and accurately sensing the temperature level of the hot melt adhesive hose assembly. Various modes or techniques for testing the temperature sensors 24,26 are of course envisioned.  
20 For example, in accordance with a first mode or technique for testing the temperature sensors 24,26, if the current that is detected, by means of the respective one of the current-voltage transformers or converters 100,102 which are operatively associated with the particular one of the first and  
25 second heater circuits or first and second heater assemblies 16,18 which is electrically connected to or incorporated in the redundant control circuit 10, is within a valid range of values, then the temperature level of the hot melt adhesive hose assembly, as sensed by means of each one of the temperature  
30 sensors 24,26, that is, the temperature level of the hot

melt adhesive hose assembly, as sensed by means of both of the temperature sensors 24,26, must attain a predetermined value. If this is not the case, that is, if such a temperature level is not in fact sensed or determined by each one or  
5 both of the temperature sensors 24,26, then either the particular one of the temperature sensors 24,26 which is not in fact sensing the proper temperature level is not properly mounted upon or operatively connected to the hot melt adhesive hose assembly, or the particular one of the temperature  
10 sensors 24,26 which is not in fact sensing the proper temperature level is defective. In accordance with a second mode or technique for testing the temperature sensors 24,26, it is similarly noted that the temperature level of the hot melt adhesive hose assembly, as sensed by means of each one of the  
15 temperature sensors 24,26, that is, the temperature level of the hot melt adhesive hose assembly, as sensed by means of both of the temperature sensors 24,26, must attain predetermined values as a function of the duty cycle. In other words, the temperature levels of the hot melt adhesive hose assembly, as sensed by means of both of the temperature sensors  
20 24,26, is directly proportional to the duty cycle. Accordingly, if the duty cycle is increased, an increased temperature level should be sensed, and correspondingly, if the duty cycle is decreased, a decreased temperature level should be  
25 sensed. If a particular one of the temperature sensors 24,26 is not in fact sensing the proper temperature level, in accordance with the pre-determined variations in the duty cycle, then that particular one of the temperature sensors 24,26 is defective.

30 Continuing further, a last unique feature character-

istic of this embodiment of the present invention will now be described. It is to be appreciated, for example, that sometimes, despite the fact that the two temperature sensors 24, 26 are in fact working properly, and that they are accurately  
5 sensing the temperature level of the hot melt adhesive hose assembly, they do not in fact sense and generate the same temperature values. This may be due, for example, to the fact that the temperature sensors are being utilized in connection with relatively large applicator heads and may be physically  
10 located at substantially different locations within the applicator head.

Therefore, it is desirable, under such conditions, to effectively build or configure a simulated temperature sensor which can effectively generate output values that  
15 comprise averaged values with respect to the temperature values actually sensed and generated by means of the two temperature sensors 24,26. These averaged values generated by means of the simulated temperature sensor will then be utilized to ultimately control the first or second heater circuits, or  
20 first or second heater assemblies, 16,18. Accordingly, in order to in fact achieve this feature or objective, it is noted that the redundant control circuit 10 may comprise an additional pair of single-throw, double-pole switch mechanisms 144,146, which may be similar to the single-throw, double-  
25 pole switch mechanisms 48,50, and a simulated temperature sensor-voltage converter 148 which is utilized in conjunction with the additional pair of single throw, double-pole switch mechanisms 144,146. The simulated temperature sensor-voltage converter 148 is effectively built or configured from suitable  
30 hardware and software incorporated within the microcon-

troller 76 after processing pertinent information derived from the temperature sensor-voltage converters 114,116, and the resulting simulated temperature sensor-voltage converter 148 can be adapted to be interactive with various types of adhesive supply units.

More particularly, it is noted that the additional pair of single throw, double-pole switch mechanisms 144,146, together with the simulated temperature sensor-voltage converter 148, effectively form an optional or alternative sub-circuit which may effectively be electrically connected to or incorporated within the overall redundant control circuit 10, or electrically disconnected from and isolated from the overall redundant control circuit 10. As was the case with the single-throw, double-pole switch mechanisms 48,50, the single-throw, double-pole switch mechanism 144 comprises a common terminal 150, a pair of alternatively selectable terminals 152,154, and a switch member 156, and in a similar manner, the single-throw, double-pole switch mechanism 146 comprises a common terminal 158, a pair of alternatively selectable terminals 160,162, and a switch member 164. Still further, it is seen that auxiliary connection lines 166,168 respectively connect the simulated temperature sensor-voltage converter 148 to the terminals 154,162 of the switch mechanisms 144, 146, and that a data communication line 170 connects the simulated temperature sensor-voltage converter 148 to a second analog-to-digital converter 172 which is incorporated within the microcontroller 76. In addition, it is also seen that signal lines 174,176 respectively interconnect the microcontroller 76 to the switch mechanisms 144,146 so as to cause the switch members 156,164 thereof to achieve switching func-

tions as desired. Accordingly, it can be appreciated still further that when the switch members 156,164 of the switch mechanisms 144,146 are disposed at their illustrated positions, the temperature sensors 24,26 are electrically connected to or incorporated within the redundant control circuit 10 as has been previously described.

On the other hand, when it is desired to effectively electrically connect or incorporate the simulated temperature sensor-voltage converter 148 within the redundant control circuit 10, suitable signals are transmitted from the microcontroller 76 so as to cause the switch members 156,164 to switch over from their illustrated positions, at which the switch members 156,164 are respectively connected to terminals 152,160, to their alternative positions at which the switch members 156,164 will be respectively connected to terminals 154,162. Therefore, the first and second temperature sensors 24,26 are effectively disconnected or isolated from the redundant control circuit 10 such that their generated or sensed temperature output signals are not utilized to control the heater circuits or heater assemblies 16,18, however, their generated or sensed temperature output signals, as transmitted to the microcontroller 76 through means of the temperature sensor-voltage converters 114,116, are nevertheless constantly utilized in conjunction with the simulated temperature sensor-voltage converter 148 and the temperature levels developed by means of the simulated temperature sensor-voltage converter 148 in order to more accurately control the heater circuits or heater assemblies 16, 18. It is lastly to be noted that even when the simulated temperature sensor-voltage converter 148 is being employed,

the redundant control circuit 10 still exhibits redundancy in that both of the temperature sensors 24,26 are being used to generate their temperature level or value outputs, and are being used in conjunction with the simulated temperature sensor-voltage converter 148. In addition, if one of the temperature sensors 24,26 proves to be defective, or fails, the microcontroller 76 will effectively ignore the generated temperature level or value outputs derived from such defective or failed temperature sensor and will utilize the temperature level or value outputs derived from the other temperature sensor. Since the active temperature sensor might be generating temperature level or value outputs which are higher or lower than the averaged temperature level or value outputs generated by both temperature sensors 24,26, the microcontroller 76 may cause the simulated temperature sensor-voltage converter 148 to compensate accordingly based upon the temperature levels or value outputs previously derived from the temperature sensors 24,26 and stored, for example, as profiles within the **EEPROM** type memory unit 96.

20           With reference now being made to **FIGURE 2**, there is disclosed a second embodiment of an electronic control circuit, which has been developed in accordance with the principles and teachings of the present invention and which shows the cooperative parts thereof, wherein the electronic control circuit is being used as an operative interface in connection with a plurality of hot melt adhesive heater circuits and a plurality of hot melt adhesive temperature sensors which have been incorporated within a relatively large applicator head. More particularly, the temperature zones defined within, or  
30 encountered in connection with, standard hot melt adhesive

application equipment are effectively organized in pairs comprising the hot melt adhesive supply hose and the hot melt adhesive applicator head. If a particular one of the hot melt adhesive applicator heads is relatively large, then it usually comprises a plurality of cartridge heaters or heater circuits, connected in parallel, but only a single temperature sensor which is usually located at a relatively central region of the applicator head so as to sense, in effect, an average or median temperature reading for the applicator head.

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10 Accordingly, based upon such an average or median temperature reading sensed by means of the single temperature sensor, suitable electrical power is sent to each cartridge heater or heater circuit by means of the adhesive supply unit (ASU) temperature controller. However, due to tolerances and unbalanced heat distribution factors or characteristics, the actual temperatures at the different locations can differ significantly which can, of course, ultimately lead to performance problems comprising, for example, improperly heated hot melt adhesive material which will, of course, in turn, lead to im-

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20 properly or incompletely bonded products.

Ideally, therefore, it would be desirable to distribute and adjust the electrical power being supplied from the adhesive supply unit (ASU) temperature controller to each one of the plurality of cartridge heaters or heater circuits

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in such a manner that all of the cartridge heaters or heater circuits would maintain the same predetermined or set temperature level. One possible solution to this dilemma would be to install additional temperature sensors within the applicator head and let the adhesive supply unit (ASU) temperature

30

controller control each zone independently with a common

temperature set point. However, this solution has several operational problems, disadvantages, and drawbacks. For example, each cartridge heater or heater circuit, and its respective temperature sensor, would require its own temperature zone upon the adhesive supply unit (ASU) temperature controller, however the number of zones available upon the adhesive supply unit (ASU) temperature controller are limited. Secondly, each temperature zone would require a separate cable and connector, which would entail or require an extensive amount of electrical connections, routing, and the like. Thirdly, even though the temperature set point for all of the cartridge heaters or heater circuits, and their respective temperature sensors, would be the same, each temperature zone would have to be individually programmed.

Therefore, a new and improved control circuit, constructed in accordance with the principles and teachings of the present invention, has been developed, is disclosed within **FIGURE 2**, and is generally indicated by the reference character 210. It will be appreciated that several of the structural components comprising the new and improved control circuit 210 are similar to some of the structural components comprising the redundant control circuit 10 as disclosed in **FIGURE 1**, and therefore, a detailed description of such components, and the operations thereof, will be omitted herefrom for brevity purposes, however, they have been referenced by means of corresponding reference characters except for the fact that the reference characters are within the 200 and 300 series. In addition, and more particularly, it is seen that the new and improved control circuit 210 comprises a relatively large applicator head, which is generally indicated by

the reference character 288, and that a plurality of heater circuits or assemblies 290,292,294, and a plurality of temperature sensors 296,298,300, are incorporated within the applicator head 288. The applicator head 288 is therefore effectively divided into a plurality of sub-zones wherein each one of the sub-zones comprises one of the heater circuits or assemblies 290,292,294 and one of the temperature sensors 296,298,300. It is also seen that a power switch assembly 302 is incorporated within the control circuit 210, and that the power switch assembly 302 comprises a plurality of switch members 304,306,308.

The switch members 304,306,308 respectively connect each one of the plurality of heater circuits or assemblies 290,292,294 to the primary power line 220 by means of connection lines 310,312,314, and in turn, each one of the plurality of temperature sensors 296,298,300 are respectively electrically connected to the temperature sensor-voltage converter 216 by means of connection lines 316,318,320. The temperature sensor-voltage converter 216 is electrically connected to the microcontroller 276 by means of a data communication line 321, and the microcontroller 276 is electrically connected to the plurality of switch members 304,306,308 by means of respective signal lines 324,326,328. It can therefore be readily appreciated that within each sub-zone of the relatively large applicator head 288, each temperature sensor 296,298,300 will effectively transmit the sensed voltage levels to the microcontroller 276, and in turn, the microcontroller 276 can appropriately control each one of the heater circuits or assemblies 290,292,294 by individually and independently controlling each one of the switch members 304,306,

308 so as to permit electrical power to be independently and individually supplied to each one of the heater circuits or assemblies 290,292,294. In this manner, the predeterminedly desired or set temperature level can be attained and main-  
5 tained so as to thereby ensure that all of the hot melt adhesive heater circuits or assemblies 290,292,294 will attain and maintain the same temperature setting throughout all regions of the applicator head 288. It is lastly noted in connection with the new and improved control circuit 210 that,  
10 in addition to each one of the plurality of heater circuits or assemblies 290,292,294, and in addition to each one of the plurality of temperature sensors 296,298,300 which are utilized within each one of the plurality of sub-zones effectively defined within the applicator head 288, still addition-  
15 al heater circuits or assemblies and temperature sensors, not shown, may be utilized in conjunction with the plurality of illustrated heater circuits or assemblies 290,292,294 and the plurality of illustrated temperature sensors 296,298,300 within each one of the sub-zones so as to effectively achieve  
20 redundancy attributes as has been previously described in connection with the redundancy control circuit 10 as illustrated within **FIGURE 1**.

With reference lastly being made to **FIGURE 3**, there is disclosed a third embodiment of an electronic control circuit,  
25 which has been developed in accordance with the principles and teachings of the present invention, and which shows the cooperative parts thereof, wherein it is desirable to effectively eliminate the need for the plurality of temperature sensors so as to render the hot melt adhesive applica-  
30 tion equipment more economical to produce. It is known that

each heater circuit or wire has an inherent or predetermined electrical temperature coefficient, and that there is also a predetermined or known relationship between the temperature of a wire and its electrical resistance. Accordingly, if the  
5 resistance of the heater circuit or wire can be determined, then the temperature of the heater circuit or wire can effectively be determined by means of the electronic control circuitry from the temperature coefficient and resistance values characteristic of the particular hot melt adhesive  
10 heater circuit or wire. In this manner, the electronic control circuitry can again serve as an interface between the hot melt adhesive heater circuits or wires and the adhesive supply unit (ASU) temperature controller, transmit the calculated temperature values back to the adhesive supply unit  
15 (ASU) temperature controller which can, in turn, transmit appropriate signals back to any one of the plurality of hot melt adhesive heater circuits or wires so as to control the temperatures thereof.

Therefore, a new and improved electronic control  
20 circuit, which has been constructed in accordance with the principles and teachings of the present invention, has been developed, is disclosed within **FIGURE 3**, and is generally indicated by the reference character 410. It will again be appreciated that several of the structural components comprising the new and improved electronic control circuit 410  
25 are similar to some of the structural components comprising the redundant control circuit 10 as disclosed in **FIGURE 1**, and therefore, a detailed description of such components, and the operations thereof, will be omitted herefrom for brevity  
30 purposes, however, they have been referenced by means of cor-

responding reference characters except for the fact that the reference characters are within the 400 and 500 series. More particularly, it is seen that the new and improved electronic control circuit 410 comprises at least one heater circuit or wire 416, which may be located either upon the applicator head or upon the hot melt adhesive hose, a current-voltage transformer or converter 502 for detecting the current along primary power line 420, and a voltage detector 510 for detecting the voltage within primary power line 420. The current and voltage values respectively detected by means of the current-voltage transformer or converter 502 and the voltage detector 510 are respectively transmitted to the microcontroller 476 along data communication lines 506, 512, whereby the resistance value of the heater circuit or wire 416 can be calculated.

The temperature coefficient value characteristic of or unique to the particular heater circuit or wire 416 will have already been preprogrammed into the **EEPROM** type memory unit operatively connected to the microcontroller 476, and by means of a lookup table also incorporated, for example, within the **EEPROM** type memory unit, the temperature of the heater circuit or wire 416 can readily be determined. This temperature value is then transmitted from the microcontroller 476 back to adhesive supply unit (ASU) temperature controller by means of data communication line 570, RTD simulator 548, and power line 428 whereby the adhesive supply unit (ASU) temperature controller can, in turn, transmit appropriate signals directly to the heater circuit or wire 416 in order to appropriately control the energization of the heater circuit or wire 416 so as to attain and maintain the predeterminedly

desired temperature level. As was the case with the electronic control circuit 210 as disclosed within **FIGURE 2**, it is also noted in connection with the new and improved control circuit 410 that, in addition to the heater circuit or wire 416, additional heater circuits or wires, not shown, may be utilized in conjunction with the heater circuit or wire 416 so as to effectively achieve redundancy attributes as has been previously described in connection with the redundancy control circuit 10 as illustrated within **FIGURE 1**.

Thus, it may be seen that in accordance with the principles and teachings of the present invention, there has been disclosed and described a redundant control circuit that comprises a pair of heater circuits or heater assemblies wherein each one of the pair of heater circuits or heater assemblies is adapted to heat a hot melt adhesive hose assembly to a predetermined temperature level, and a pair of temperature sensors wherein each one of the temperature sensors is used to sense the temperature of the hot melt adhesive hose assembly and to control energization of the heater circuits or heater assemblies in order to maintain the desired temperature level. A first one of the heater circuits or heater assemblies would initially be electrically connected to the hot melt adhesive hose assembly electrical circuitry, and in a similar manner, a first one of the temperature sensors would likewise be electrically connected to the hot melt adhesive hose assembly electrical circuitry. Subsequently, should a failure occur within the first one of the heater circuits or heater assemblies, then an electrical switch mechanism would be activated so as to effectively remove the first, failed heater circuit or heater assembly from the hot melt adhesive

hose assembly electrical circuitry, and substantially simultaneously, electrically connect the second one of the heater circuits or heater assemblies to the hot melt adhesive hose assembly electrical circuitry. Similar switching procedures  
5 would also be implemented in connection with the pair of temperature sensors should a failure occur within a first one of the temperature sensors initially incorporated within the hot melt adhesive hose assembly electrical circuitry.

In addition, wherein the hot melt adhesive dispensing system employs a relatively large applicator head which  
10 has a plurality of hot melt adhesive heater circuits and a plurality of hot melt adhesive temperature sensors disposed upon different regions of the relatively large applicator head, the electronic control circuitry can effectively interface  
15 between the plurality of hot melt adhesive heater circuits and the plurality of hot melt adhesive temperature sensors, and the adhesive supply unit (ASU) hose and head connector, so as to control individual ones of the plurality of hot melt adhesive heater circuits and thereby ensure that all  
20 of the hot melt adhesive heater circuits will attain and maintain the same temperature setting throughout all regions of the applicator head. Still further, the hot melt adhesive system temperature sensors may effectively be eliminated due to the fact that the temperature value of each hot melt adhesive  
25 heater circuit or wire can be calculated by means of the electronic control circuitry from temperature coefficient and resistance values characteristic of the hot melt adhesive heater circuit or wire whereby the electronic control circuitry can again serve as an interface between the hot melt adhesive  
30 heater circuit or wire and the adhesive supply unit

(ASU) temperature controller by transmitting the calculated temperature values back to the adhesive supply unit (ASU) temperature controller which will, in turn, transmit appropriate signals to the heater circuit or wire so as to control  
5 the temperature thereof.

Obviously, many variations and modifications of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the present invention may be  
10 practiced otherwise than as specifically described herein.

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WHAT IS CLAIMED AS NEW AND DESIRED TO BE PROTECTED BY LETTERS  
PATENT OF THE UNITED STATES OF AMERICA, IS:

1. An electronic control circuit for use in connection with  
5 hot melt adhesive dispensing equipment, comprising:  
    an electrical power source;  
    a relatively large applicator head which is effect-  
ively divided into a plurality of zones;  
    a plurality of heater assemblies distributed  
10 throughout said relatively large applicator head such that  
one of said plurality of heater assemblies is disposed within  
each one of said plurality of zones defined within said rela-  
tively large applicator head, wherein each one of said plu-  
rality of heater assemblies is operatively associated with  
15 each one of said plurality of zones defined within said rela-  
tively large applicator head so as to heat the hot melt ad-  
hesive material, being fluidically conducted internally with-  
in each one of said plurality of zones defined within said  
relatively large applicator head, to a predetermined tempera-  
20 ture level;  
    a plurality of temperature sensors distributed  
throughout said relatively large applicator head such that  
one of said plurality of temperature sensors is disposed  
within each one of said plurality of zones defined within  
25 said relatively large applicator head, wherein each one of  
said plurality of temperature sensors is operatively associ-  
ated with each one of said plurality of zones defined within  
said relatively large applicator head so as to effectively  
sense the temperature level of the hot melt adhesive materi-  
30 al being fluidically conducted internally within each one of

said plurality of zones of said relatively large applicator head, and to effectively control the energization of each one of said plurality of heater assemblies disposed within each one of said plurality of zones defined within said relatively large applicator head so as to maintain the temperature level of the hot melt adhesive material, being conducted internally within each one of said plurality of zones defined within said relatively large applicator head, at said predetermined temperature level;

switching means for selectively electrically connecting each one of said plurality of temperature sensors, disposed within each one of said plurality of zones defined within said relatively large applicator head, to said electrical power source; and

means for controlling said switching means, in response to temperature levels respectively sensed by said plurality of temperature sensors, so as to selectively electrically connect particular ones of said plurality of heater assemblies to said electrical power source in order to selectively maintain each one of said plurality of zones of said relatively large applicator head at said predetermined temperature level.

2. The electronic control circuit as set forth in Claim 1, wherein:

said means for controlling said switching means comprises a microcontroller.

3. An electronic control circuit for use in connection with hot melt adhesive dispensing equipment, comprising:

an electrical power source;

an adhesive supply unit (ASU) temperature controller;

a hot melt adhesive component;

a heater assembly operatively associated with said hot melt adhesive component so as to effectively heat the hot melt adhesive material, being fluidically conducted internally within said hot melt adhesive component, to a predetermined temperature level;

a first power line electrically connecting said heater assembly to said electrical power source and said adhesive supply unit (ASU) temperature controller;

means for determining the current level within said first power line;

means for determining the voltage level within said first power line; and

means for determining the temperature level of said heater assembly, from said current and voltage levels determined within said first power line, and for transmitting said determined temperature level to said adhesive supply unit (ASU) temperature controller such that said adhesive supply unit (ASU) temperature controller can control electrical power supplied to said heater assembly by means of said first power line so as to control the energization of said heater assembly in order to effectively heat the hot melt adhesive material, being fluidically conducted internally within the hot melt adhesive component, to said predetermined temperature level.

4. The electronic control circuit as set forth in Claim 3,  
wherein:

        said hot melt adhesive component comprises a hot  
melt adhesive hose assembly.

5

5. The electronic control circuit as set forth in Claim 3,  
wherein:

10           said hot melt adhesive component comprises a hot  
melt adhesive applicator head.

15 6. The electronic control circuit as set forth in Claim 3,  
wherein:

        said means for determining said current level with-  
in said first power line comprises a current-voltage convert-  
er.

20

7. The electronic control circuit as set forth in Claim 3,  
wherein:

25           said means for determining said voltage level with-  
in said first power line comprises a voltage detector.

30 8. The electronic control circuit as set forth in Claim 3,  
wherein:

said means for determining the temperature level of said heater assembly, from said current and voltage levels determined within said first power line, and for transmitting said determined temperature level to said adhesive supply unit (ASU) temperature controller, comprises a microcontroller.

9. The electronic control circuit as set forth in Claim 8,  
10 further comprising:

means within said microcontroller for calculating the resistance value of said heater assembly from said current and voltage levels, and for calculating the temperature value of said heater assembly from said resistance value and  
15 a temperature coefficient value inherently characteristic of said heater assembly.

20 10. The electronic control circuit as set forth in Claim 9,  
further comprising:

an **EEPROM** type memory unit incorporated within said microcontroller, wherein said **EEPROM** type memory unit has a look-up table stored therewithin correlating said resistance  
25 values with temperature values for predetermined temperature coefficient values.

30 11. The electronic control circuit as set forth in Claim 8,  
further comprising:

a second power line electrically connecting said microcontroller to said adhesive supply unit (ASU) temperature controller.

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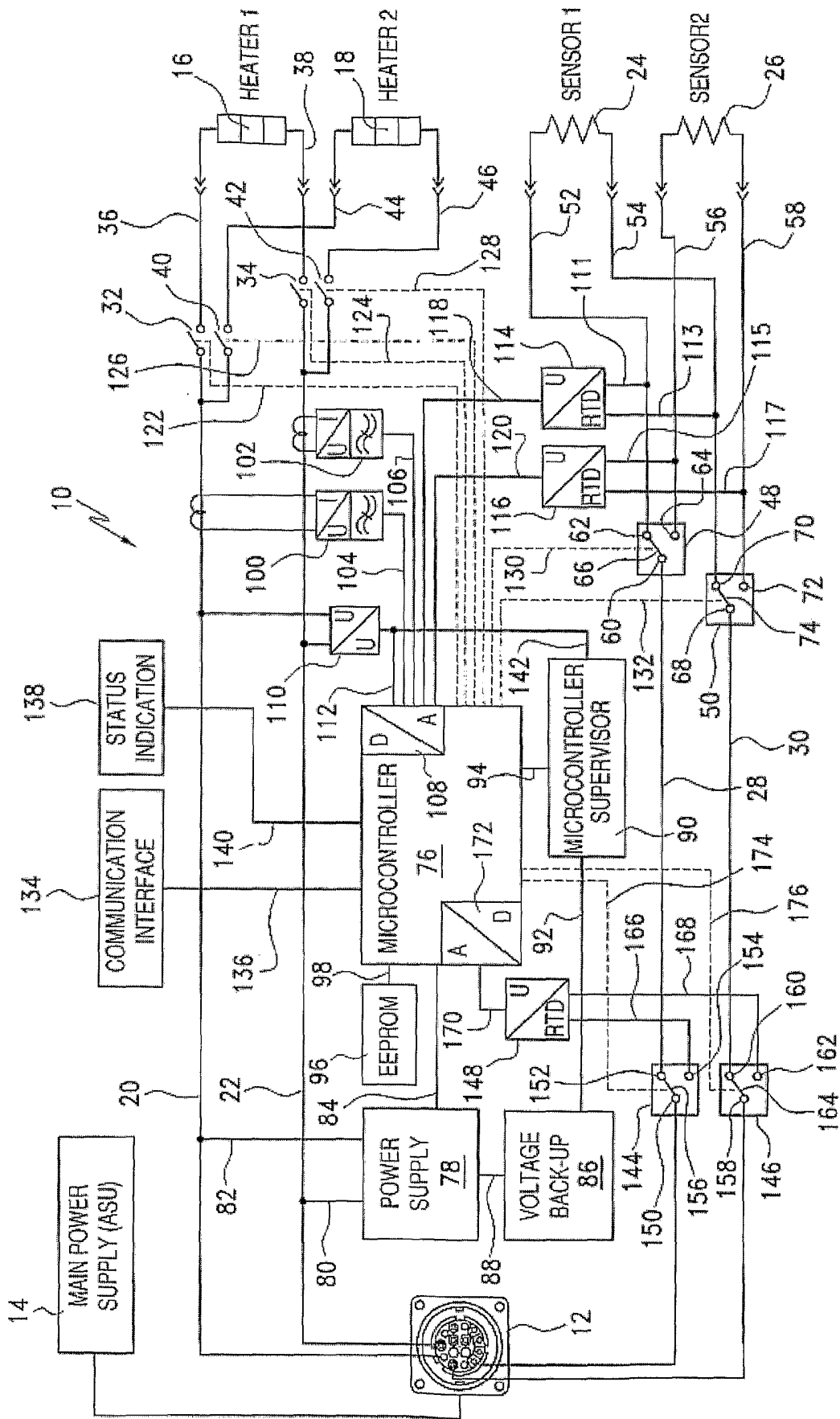


FIG. 1

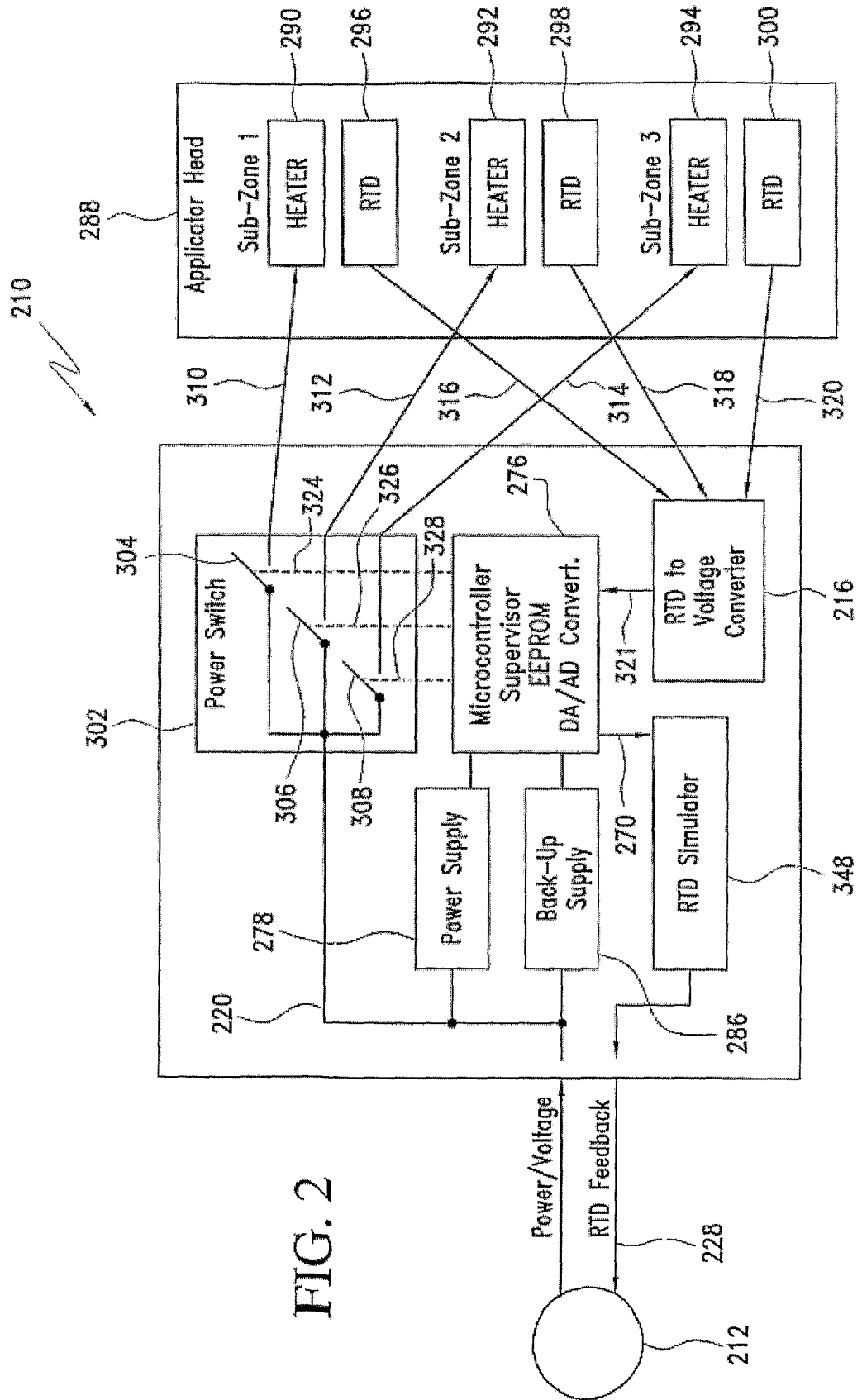


FIG. 2

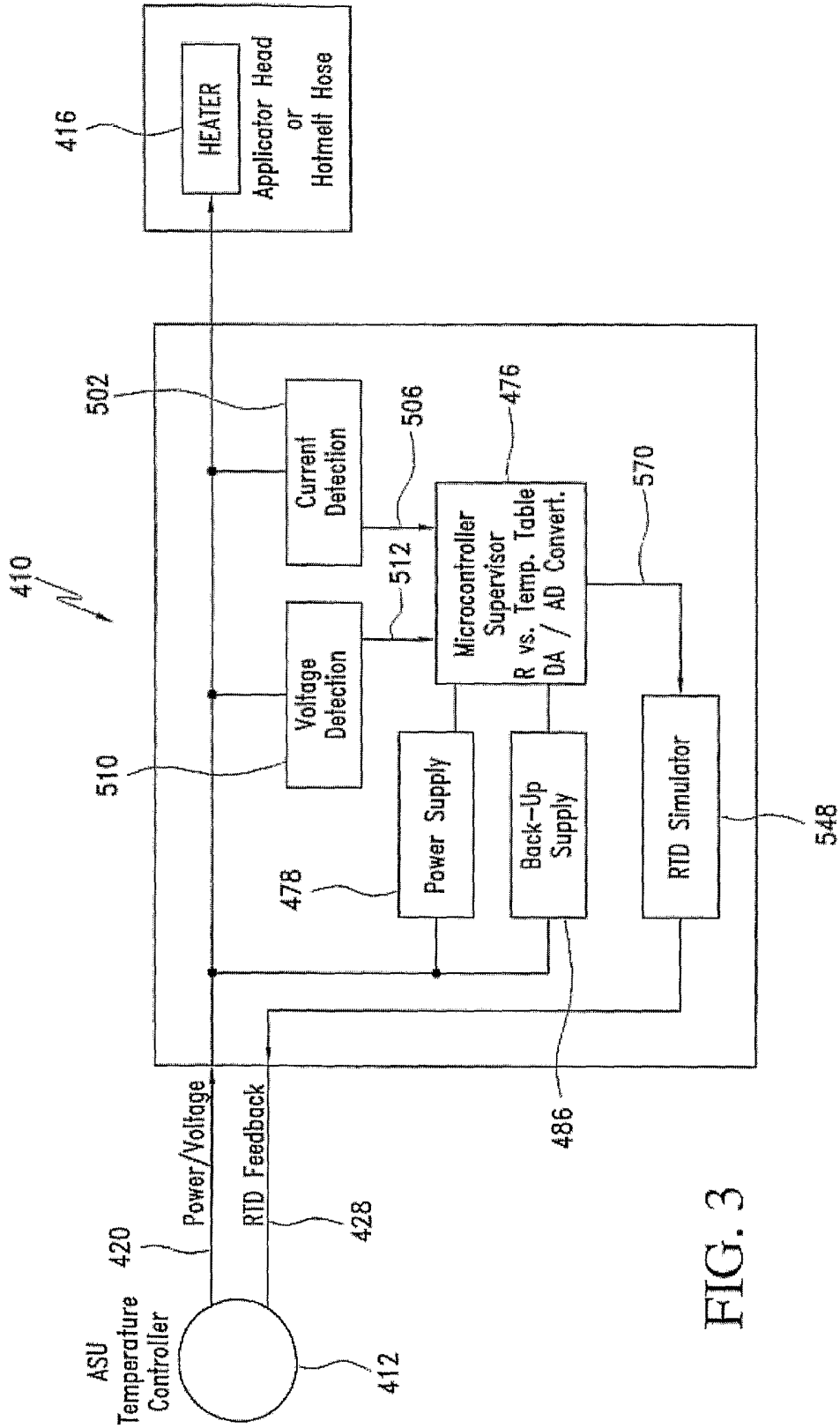


FIG. 3