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(58) Field of search
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INT CL⁴ **H05B**
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(54) **Tubular electric heater**

(57) A heating apparatus has a flexible heat tube (12) including a copper outer tube (40) containing a hairpinned heating element formed of a spiral of ultrafine resistance wire (43) wound on a flexible fiberglass core (42) and contained in a silicon rubber sheath (41). The heat tube (12) is sealably introduced into a housing (11) and the heating element is connected in series with control devices including a thermostat (18), a thermal switch (24) and a thermal cutoff (23). The thermal switch (24) intermittently switches the power supply ON and OFF to maintain the surface temperature of the tube below a selected limit where it emerges from the housing (11), fig 1, while the thermal cutoff (23) permanently breaks the supply of power in the event of short circuits across the hairpinned element or ground faults. The heat tube construction employing ultrafine resistance wire (43) prevents cascading i.e. a short circuit which travels along the tube.

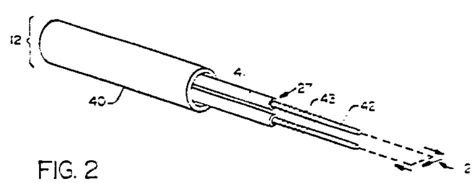


FIG. 2

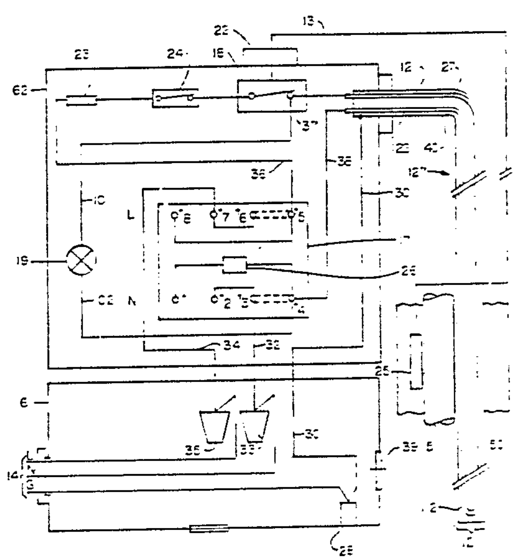


FIG 3

GB 2 224 189 A

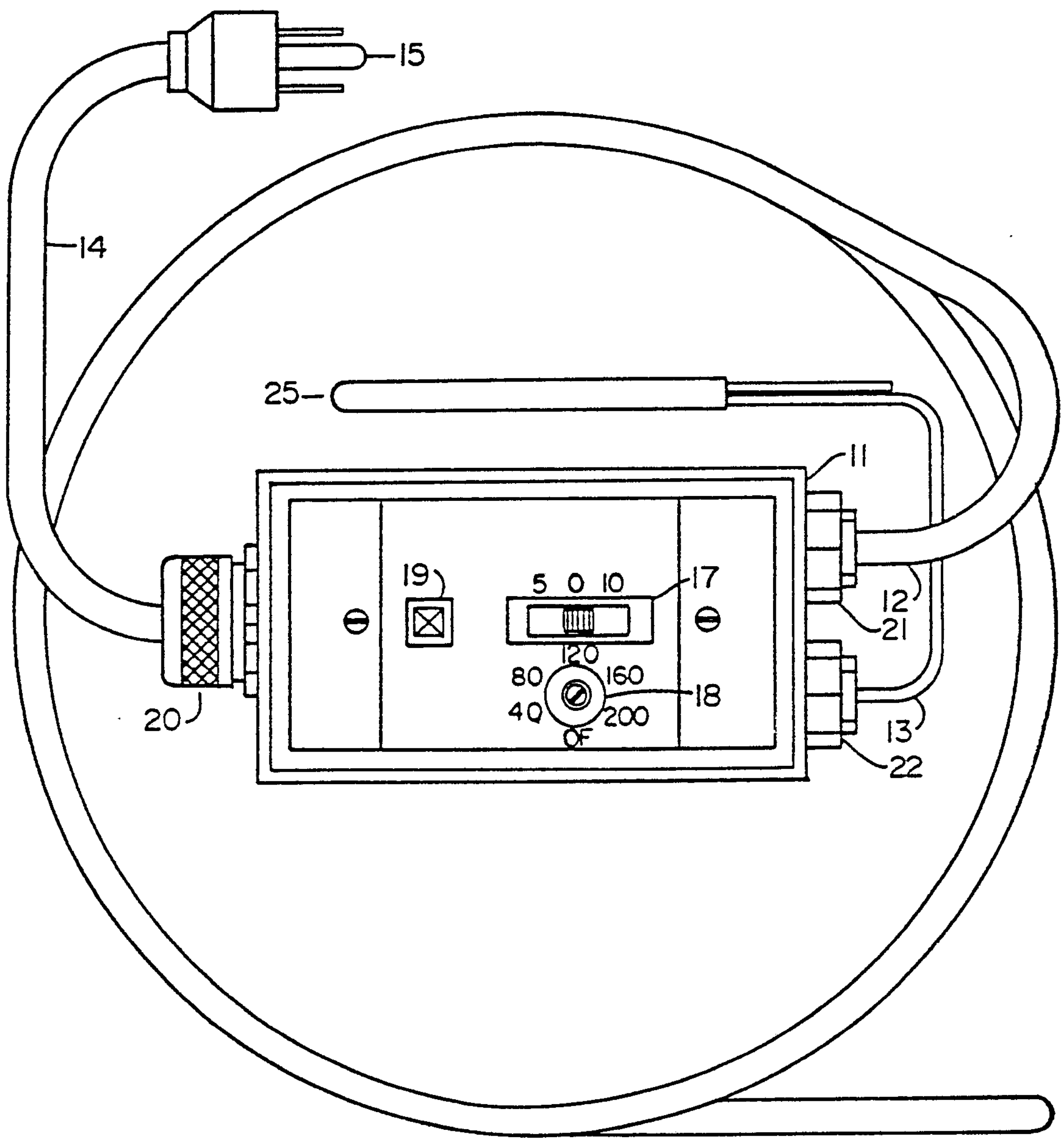
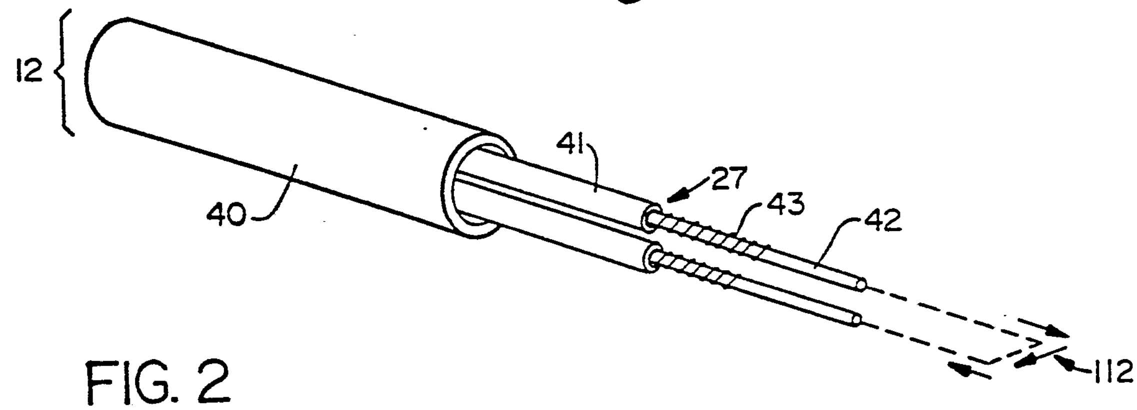
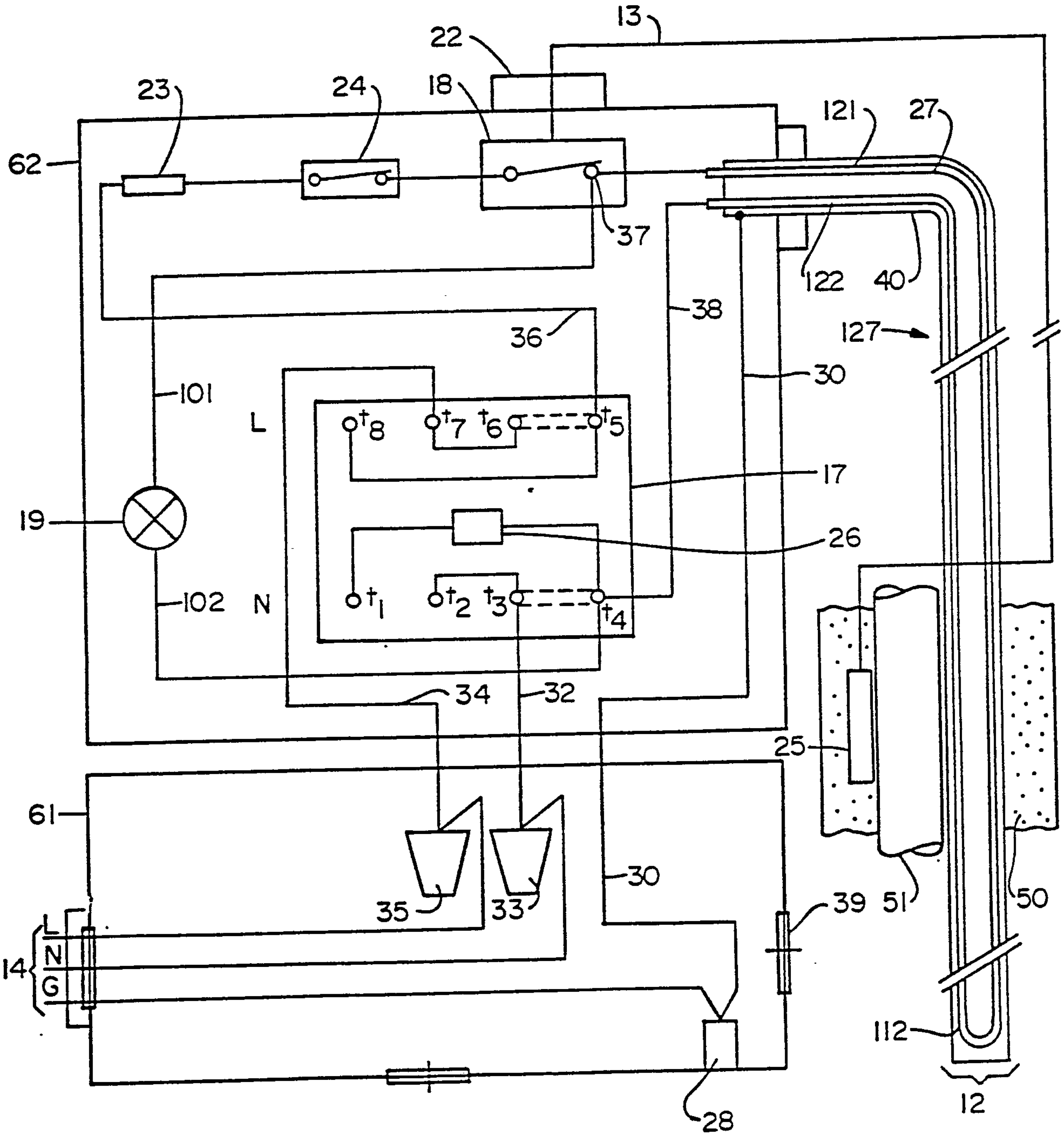


FIG. 1



12
41
27
43
42
40
112

FIG. 2



13
22
23
24
18
121
27
62
37
122
40
36
38
127
101
30
L
t_8
t_7
t_6
t_5
17
19
26
102
N
t_1
t_2
t_3
t_4
34
32
25
61
35
33
30
39
51
50
L
N
14
G
112
28
12

FIG. 3

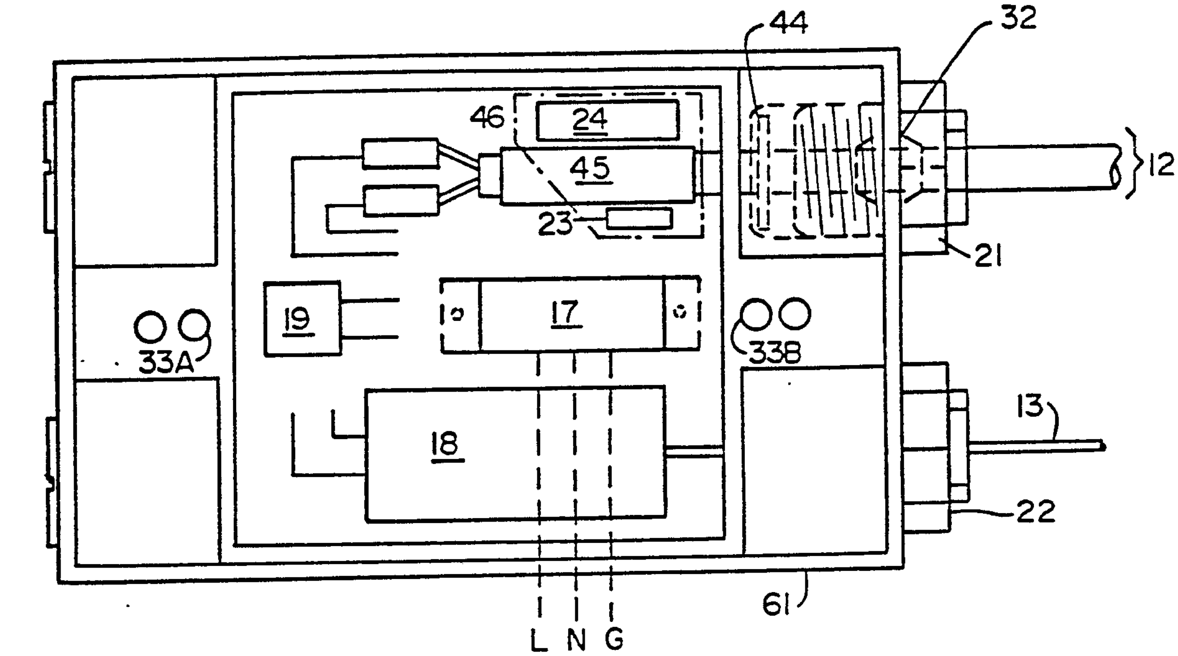

44
32
46
24
45
12
23
21
19
17
33A
338
13
18
22
61
L N G

FIG. 4

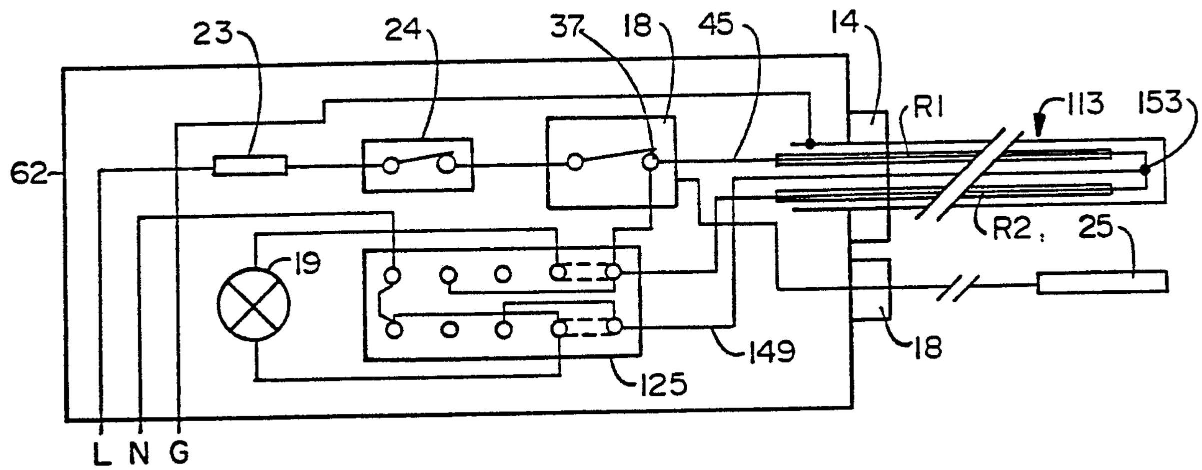

23
24
37
18
45
14
R1
113
153
62
19
R2
25
149
18
125
L N G

FIG. 5

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HEAT TRACING TUBULAR HEATER

This invention relates to an electrical heating apparatus, and more particularly to an improved heat tube apparatus for heat tracing of piping, vessels, tanks and other mechanical constructions to maintain them or their contents at a desired temperature. A primary use of such heat tubing is to prevent freezing of water in domestic, commercial and industrial applications and to maintain the temperature of liquids that would cool if not heat traced.

Electrical heating apparatus required for heat tracing must be sufficiently flexible to follow the routing of piping to which it is attached. Such flexibility allows the heaters to be serpentined (looped) back in the same plane, at a suitable bending radius, to form a heating array for the surface heating of other mechanical constructions such as vessels and tanks.

Heat tracing apparatus is defined by IEEE.515 (1983) as "Electrical Resistance" type to differentiate it from induction and dielectric types. The electrical resistance type is also referred to as "Electric Surface Heating" type or "ESH type." Other terminology used to refer to heat tracing apparatus includes "Heating Cable" and "Heating Cable Sets," the latter being further defined by the prefix "Series" or "Parallel."

An unofficial but widely used term for heating cable is "heat tape," a designation which arises from the flattish profile of most series and parallel heating cables. "Heating Cable," "Heating Cable Set" and "Heating Cable Unit" are the most commonly found designations within the industry.

The term "Series," as it is used to refer to heating cable sets, typically denotes a heating cable that uses electrical resistance wire or a resistance strip to form a heat producing circuit. In such series cable sets, the current travels down one leg of the cable set and returns up the other.

The term "Parallel," as it is used to refer to heating cable sets, typically denotes a heating cable that has a pair of longitudinally extending, low resistance, conductive parallel buswires or bus strips. Resistive paths for current flow are formed transversely across the two low resistance buswires or bus strips. A finite resistance path may be formed by a fine insulated nickel-chrome resistance wire spiralled around the length of the double buswire (bus strip) and attached to alternate buswires (bus strips) at spaced intervals, e.g., of 1-ft to 3-ft lengths, to form a zig-zag along the length of the cable. Such cable is known as "constant wattage" inasmuch as the power (watts per foot or meter) does not vary (decreases) as the temperature of the resistance wire or strip increases. It is also known as a "zonal" type of heating cable inasmuch as the heating cable may be cut on site to the required length, the zonal length being a discrete heating unit in itself. In a zonal approach, the final result is a number of discrete zonal lengths connected in parallel with one another.

The term "Parallel" is also applied to a heating cable of the "self-limiting" or "self-regulating" type which employs parallel copper buswires between which is extruded a special conductive compound which acts as the resistive heating element. This conductive compound offers an increasing resistance to current as it heats up. Hence, more heat is produced at lower temperatures and less at high temperatures. The advantage of this design is that it does not normally allow a predetermined design temperature to be exceeded, thus an upper limit temperature controller or thermostat is not essential. Since the heating circuit comprises an infinite number of parallel paths across the heating cable, each finite part of the cable's length supplies the heat required for that exact location. Due to the fact that its length may be chosen at will, like the constant wattage heating cable, it is widely used for heat tracing and is commonly cut to length from a reel on site or in a supply house.

For decades, heat tracing has been accomplished using a series heating cable which comprises two resistance wire spirals within a copper or high temperature alloy tubing. The tubing is packed with a compressed magnesium oxide insulation to form a tubular heater of immense strength and resistance to impact and other site dangers. The magnesium oxide is referred to as "mineral insulation," and the mineral insulated heating cable is referenced as "MI." MI heating cable is used in ordinary and hazardous applications and is used almost exclusively in hazardous locations because the compressed magnesium oxide within the solid wall tubing does not allow exploding fluids and vapors under continuous pressure to travel through it.

Since magnesium oxide is hygroscopic, site preparation of the seals and cold leads is rarely done. Instead, factory-terminated heating sets are supplied after the lengths have been determined on site, which leads to aggravating construction delays. For this reason, in the past 20 years there has been a large increase in the use of site-terminated, off-the-reel heating cables, mainly of the self-regulated type and, more recently, of the constant wattage type.

In the interest of avoiding site terminations, heating cables, mainly of the series circuitry variety, have been made available from sources such as hardware stores and electrical supply houses in finished form, complete with cold lead and plug for immediate connection to a 120 volt (V) receptacle. Such heating cables are available in about 10 different lengths ranging from 3 ft to 100 ft, in the 5-7W/ft range, with or without an integral thermostat. Thermostats used with such apparatus are either pipe-sensing and thus attached to the pipe or ambient (air temperature) sensing and thus typically arranged to hang in the air.

The majority of heating cables ("heat tapes") sold through hardware stores within the United States are factory terminated, series circuitry, nonmetallic braided cables. Such cables typically employ two fine wire resistance spirals spaced apart by a PVC web and insulated from one another and from the environment with polyvinyl chloride (PVC). Some such cables are available with a factory-made end seal and attached molded plug at the power entry end. None of these series circuitry cables have a metallic braid or 3-pin plug, and hence cannot meet U.L. specifications.

For over 30 years, fires have occurred in mobile homes and trailers caused by heat tapes attached to cold water inlet piping under the home catching fire and igniting combustibles. An average of two deaths, several injuries, and millions of dollars worth of damage have occurred per year due to "heat tapes," including self-regulating heating cables, burning like a welding rod back towards the inlet power supply. This phenomenon has been described as "cascading" by U.L.

"Cascading" is a phenomenon exhibited by all prior art heating cables wherein an arcing fault jumps from one position to another along the heating element and, as the resistance of the circuit becomes less, the current increases and the fault intensity becomes more critical. With self-regulating heating cables, water or electrolyte entry into the interstices of the heating cable causes a partial short circuit of the infinite path resistance. The resulting carbonization leads to a cascading condition, which burns along at a rate of one foot every six to seven minutes. For longer cables exceeding 50 feet in length, "leapfrogging" of the arcing condition toward the power supply typically occurs. When the cascading reaches the power entry position, the heating cable can burst into violent flame when the intense arcing emerges from the thermal insulation and contacts oxygen in the air.

It is an object of the present invention to solve the aforementioned problems by providing a heat tracing cable apparatus with means for preventing cascading. According to the preferred embodiment, the means for preventing cascading includes a series-connected resistance type heating element comprising ultrafine spiralled resistance wire, encased in insulating material. Control means are further provided for sensing various fault conditions and providing a series of cutoff safety features.

FIG. 1 is a front pictorial view of the preferred embodiment;

FIG. 2 is a perspective cutaway view of a heat tube according to the preferred embodiment;

FIG. 3 is a circuit schematic of the preferred embodiment;

FIG. 4 is a side sectional view of a portion of the control head of the preferred embodiment; and

FIG. 5 is a circuit schematic of an alternate embodiment.

An external pictorial view of the preferred embodiment is illustrated in FIG. 1. As shown, the preferred embodiment includes a housing 11 from which issues a heat tube assembly 12, a three-conductor electrical cord 14 providing a 120V supply, and a thermostat capillary tube 13. Each of these elements 12, 13, 14 enters the housing 11 through a suitable compression fitting 20, 21, 22, respectively, to provide strain relief. As illustrated, the face of the housing 11 includes an on/off pilot light 19, a W/ft adjustment switch 17, and a thermostat 18 for adjusting the pipe temperature.

FIG. 2 illustrates a cutaway view of the heat tube assembly 12. As shown, the heat tube assembly 12 includes an annealed copper tube 40, containing a hairpinned configuration including a cylindrical silicone rubber sheath 41 containing a cylindrical inner fiberglass core 42 on which is wound a single spiral of resistance wire 43. The spiralled resistance wire 43 has no break at the far end 112, thereby forming a single electrical circuit. In the preferred embodiment, the annealed copper tube 40 is a tube of 5, 10 or 20-ft lengths having a 1/4-inch outside diameter and a 3/16-inch inside diameter. The silicone rubber sheath 41 may be, for example, .085-inch diameter. The spiralled resistance wire 43 is ultrafine, preferably either 33, 34 or 35 AWG (American Wire Gauge).

FIG. 3 is a schematic diagram showing the control circuitry within the housing 11 according to the preferred embodiment. As shown in FIG. 3, the housing 11 is preferably fabricated as two units - a junction box 61 and a control box or control head 62. The control box 62 is preferably dismountable from the junction box 61, for example, by screws.

The control circuitry includes a thermal cutoff 23, a thermal switch 24, a thermostat 18, and the power selection switch 17. The thermal cutoff 23 is attached to the copper heat tube 40 inside the control head 62 to sense the surface temperature of the copper tube 40 and break the 120V power permanently if the temperature of the tube 40 exceeds 100°C, if an over-current condition occurs due to a short circuit across the hairpinned resistance wire spiral 43, or if a ground fault to the copper tube 40 occurs.

The thermal switch 24 is also attached to the copper tube 40 inside the control head 62 and switches the 120V supply on and off to prevent the surface temperature of the tube 40 from exceeding 60°C such that the exposed portion 127 of the heat tube 40, where it emerges from the control head 62 and before it enters the thermal insulation 50 of a pipe 51 or is exposed to weather, does not exceed National Electrical Code requirements for personal safety.

The thermostat 18 includes a 3-ft capillary tube 13 and a 4-inch external sensor 25. When the sensor 25 is attached to the side of an insulated pipe, the thermostat 18 closes to permit current to flow when it senses that the pipe has fallen below the set temperature. The sensor 25 may also be attached to the walls of vessels, hoppers, tanks or other containers requiring heat tracing. The sensor 25 may also be used for ambient sensing for deicing roofs, driveways, walkways, or ramps. The control stem of the thermostat 18 is preferably tamperproof and mounted under the raintight cover of the control head 62.

The selection switch 17 is a three-position, double pole switch, which provides 5, 0, or 10 W/ft selection of heat intensity in the heat tube assembly 12. FIG. 3 illustrates the situation where the sliding contacts of the switch 17 are in the extreme right-hand position, providing 120V to the hairpinned heating element 27 and the maximum power of 10 W/ft. In the extreme left-hand position of the switch 17, the heating element 27 is placed in series with a 3 amp (A) 120V diode (rectifier) 26, mounted in air and attached across the terminals t_1, t_4 of the switch 17. The diode 26 conducts on the forward cycle only of the 120V AC power supply and practically does not conduct at all on the reverse cycle. Thus, approximately half power (5 W/ft) is obtained when the diode 26 is in the circuit. The pilot light 19 is connected by conductors 101, 102 across the terminals t_4, t_5 of the switch 17.

The heat tube assembly 12 may be, for example, 5, 10 or 20 ft in length, and is preferably sealed at both ends with a silicone elastomer. Alternatively, the complete length of the heat tube assembly 12 may be sealed with the elastomer for hazardous location applications. The far end 112 of the copper heat tube assembly 12 is closed with a raintight set-screw.

Each leg 121, 122 of the heating element 27 is 5 W/ft at 60V, and when 120V is applied to the hairpin heating element 27 via power selection switch 17, a 5-ft heat tube provides 50W, a 10-ft tube provides 100W, and a 20-ft tube provides 200W. When in series with the diode 26, the respective power ratings are 25, 50 and 100 watts.

In FIG. 3, electrical power is provided by the power cord 14 including conductors L ("Line"), N ("Neutral"), G ("Ground"), which enter the junction box 61 via the compression fitting 20. The ground conductor G is connected to the junction box 61 at block 28 and to a 2A 120V ground lead 30. The ground lead 30 is connected to the outer copper tube 40 of the heat tube assembly 12. The copper tube 40 is also grounded to the control head housing 62 via a brass collet (sleeve) 32 (FIG. 4) of the compression fitting 21. The control head housing 61 is grounded to the junction box 62 via two securing screws (not shown) mounted at positions 33A and 33B (FIG. 4).

The incoming N (neutral) conductor is connected to a conductor 32 at a wire nut 33. The conductor 32 is connected to one terminal t_3 of the switch 17. The incoming L (line) conductor is attached to a 120V conductor 34 at a wire nut 35. The conductor 34 provides a power connection to another terminal t_7 of the switch 17. The conductor 36 provides a power connection from terminal t_5 to the output terminal 37 of the thermostat 18 through the controls provided by the thermal cutoff 23, the thermal switch 24, and the thermostat 18. The output terminal 37 of the thermostat 18 is connected to the cold lead of one leg 121 of resistance element 27, while the cold lead of the other leg 122 of resistance element 27 is connected by a conductor 38 to the neutral terminal t_4 of the switch 17.

As indicated, the junction box 62 is preferably screwed to the control head 61. The junction box 62 may be, for example, a 4-1/2-inch x 2-1/2-inch x 2-1/2-inch raintight type for receiving the incoming power via cord 14 or via bus wiring in conduit (not shown). Screwed 1/2-inch NPT (National Pipe Thread) conduit entries 39 are provided at four points in the junction box 62 such that a total of five such entries are available to suit the conduit run and the required orientation of the heat tube 12 where it emerges from the control head 61. Any 1/2-inch NPT entries not required for the conduit run are blocked off and made raintight by sealant-bearing 1/2-inch NPT metal closure plugs. A raintight gasket (not shown) preferably joins the junction box 16 and the control head 11.

FIG. 4 illustrates the mechanical interrelationship of the components in the control head 61. As shown, the heat tube assembly 12 enters through the compression fitting 21 and a support washer 44. An insulating plastic tube 45 suitable for 100°C minimum temperature is placed around the end of the copper tube assembly 12. The thermal cutoff 23 and thermal switch 24 are mounted on the insulating tube 45. Heat shrinkable insulating tubing 46 electrically insulates the live-casing thermal cutoff 23 and the thermal switch 24. Typical thermal cutoffs are manufactured by Micro Devices Product Group of Therm-O-Disc Inc., 1320 S. Main St., Mansfield, OH 44907, USA (Model 4208A1), and thermal switches by Portage Electric Products Inc., 7700 Freedom Ave. NW, North Canton, OH 44720, USA (Model C).

In operation, when the switch 17 is set to either 5 or 10 W/ft, power is supplied to the heat tube assembly 12. The thermostat 18 is set to any position between 40 and 200°F, depending on the application. For example, 40°F might be selected for freeze protection of a water pipe, while 120°F might be selected for temperature maintenance of fuel oil, or even 200°F for temperature maintenance of more viscous substances. The introduction of thermal insulation around the pipe or container allows the heat tube 12 to rise above its exposed surface limitation (controlled via the thermal switch) of 140°F (60°C). The thermal cutoff 23 acts as the final high-limit control of surface temperature of the heat tube 12 and also senses an over-current condition at a fraction of the current setting of the normal branch circuit breaker. Importantly, the thermal cutoff 23 fails to safety. The silicone rubber insulated heating element 27 withstands temperatures exceeding 300°F (150°C). The spiralled ultrafine resistance wire 43 cannot sustain cascading. (Leap-frogging does not occur with series resistance type heating cables/tubular heaters, only the self-regulating types.) Thus a series of safety features is provided.

As an example of a fault condition that is protected by the thermal switch 24 and the TCO 23, if the heat tube 12 is crushed by external force within the 3-ft limit of the thermostat sensor 25 (which would then continuously call for heat due to loss of power at its 3-ft position), the overamperage that would flow would produce extra heat and current through the two protective devices and would first limit the rise in temperature via the thermal switch 24 and, second, stop the excess current condition via the TCO 23.

As another example of protection afforded by the control circuitry, and particularly of the thermal switch 24, assume that the heat tube 12 was energized during a very hot summer and located on a drained plastic water pipe. If the contacts of the thermostat 18 were to fail in the closed position and thus continually call for power, then the thermal switch 24 would operate to hold the temperature of the heat tube 12 within safe limits for the empty plastic pipe.

The sensing bulb 25 of the thermostat 18 may be attached to the pipe being heated (or any other workpiece) via duct tape, its position being on the opposite side of the pipe from the heat tube 12 on pipes up to four inches in diameter and distanced three inches away from the heat tube on larger pipe sizes. Thus the true pipe or workpiece temperature will be sensed. This ensures that the higher temperature of the heating device will not prematurely switch off the heat, which can happen if the thermostat 18 is part of the heating device itself. In addition, far greater energy savings are realized than if the controlling thermostat senses only the air temperature as with an ambient thermostat. In this latter case, there is no temperature limitation at all in that the pipe or workpiece temperature will rise to where the losses balance the heat input. Overtemperature conditions on the pipe or workpiece could occur with an ambient thermostat, for example, one left exposed outside the thermal pipe insulation.

In those locations which might have 150 days in any year where it is desired to maintain piping at 40^{o}F for freeze protection purposes, if the heating device is left energized at 100 watts, 150 x 24 x 100W x .001 = 360 kWh are used, and if each unit is $0.10, then the cost is $36.00 per annum versus only $6.00 per annum if the true pipe temperature is sensed.

The preferred embodiment has several additional advantages. The solid wall copper tubing 40 is sealed against moisture at each end and resists mechanical damage to heating elements. The heat tube assembly 12 may pass through wooden walls and floors and is straight run, rather than spiralled. The heat tube assembly 12 may be looped back at the end of its run without danger. The heat tube assembly 12 may also cross between pipe lengths in air and heat trace or freeze-protect more than one pipe. It may be used on full or empty plastic pipe without damage.

The unit according to the preferred embodiment is also easy to maintain. The control box 62 and its inbuilt heat tube assembly 12 with its associated thermostat capillary tube 13 and sensor 25 is easily removed from the piping system because it does not spiral around the pipe and from its associated junction box 61 because of the two-screw attachment. The thermostat 18 is replaceable in the control box 62 via single fixing and two spade terminals. The pilot light 19 is withdrawable from the front of the facia plate inside the control box 62 by simply prizing its two connecting wires 101, 102. The junction box 61, control box 62 and heat tube assembly 12, the three main mechanical parts of a heat tube unit, are preferably entirely raintight and may be used indoors or outdoors. The preferred embodiment enables small bore instrument lines to be heat traced at 5W/ft and larger constructions, such as piping to be heat traced at 10 W/ft.

The unit also economizes power. There is a minimum amount of overshoot or undershoot with thermostatic control of the workpiece. There is also less chance of the pipe's contents being damaged by overheating in the case of temperature-sensitive liquids. The preferred embodiment also reduces inventory requirements, since there are only three choices of heat tube length, and no choice to be made of power (W/ft) when selecting the heating device.

The use of the junction box 61 allows runs of:

(a) 200 ft 10 W/ft (maximum) 120V, single-phase, 1-p 20A breaker.

(b) 400 ft 10 W/ft (maximum) 120/240V, single-phase, 2-p 20A breaker.

(c) 600 ft 10 W/ft (maximum) 120/208V, 3-phase 20A, 3-p breaker.

In such applications, the breaker protects the bus wiring of the branch circuit (10 AWG). The breaker is not called upon to protect the heat tube assemblies 12, which have their own protective devices. Thus, there is no reliance on a remote breaker to provide protection of the heating device.

Junction boxes 61 and the associated conduit or EMT tubing may be separately installed and wired and may be supported from the same piping that is required to be heat traced. At a later date, the control boxes 62 with their heat tube assemblies 12 and associated thermostat capillary tube 13 and sensor 25 may be added and connected. The conduit/tube runs may travel along different piping systems to the far end of the 200/400/600-ft circuit, each heat tube having its own inbuilt power (W/ft) selection).

Due to the preferred use of relatively heavy gauge buswiring (10 AWG), the voltage drop along the tube is low compared with heating cables that carry their own fine gauge buswiring and which are operating at the heating cable rather than the ambient temperature, thus reducing length capability and increasing voltage drop. More heat is available at the far end of the circuit, and there is less chance of insufficient heat at the far end due to voltage drop.

Each heat tube is also readily checked out and replaced if damaged, whereas ultra-long and conventional heating cable circuits have to be completely replaced.

Use of 14 AWG power cord for domestic purposes allows a 15A 120V receptacle to power up to 140 ft of heat tubes from a single outlet, the junction box 61 allowing buswiring to be run to the successive heat tube units. The availability of junction boxes 61 encourages the installer to avoid the use of extension cables, which are not safe to use for permanent electrical installations.

FIG. 5 illustrates an alternate embodiment wherein the selection switch is a four-position, double pole switch 125, which provides 2-1/2, 0, 5 or 10 W/ft selection of the heat intensity in a heat tube 113. FIG. 2 illustrates the situation where the sliding contacts of the switch 125 are in the extreme right-hand position, providing 120V to two resistive elements R_1, R_2 and the maximum power of 5 W/ft per element, 10 W/ft total. In the extreme left-hand position of the switch 125, both of the resistance elements R_1, R_2 of the heat tube 113 are in series with no neutral connection made. Thus, only 60V is applied to each 120V element, resulting in one-quarter of the power or 1-1/8W/ft per element R_1, R_2. In the second position of the switch 125, no electrical power is available for either of the elements R_1, R_2. In the third position to the right, only one of the two 5 W/ft elements receives power, resulting in a 5W output. The pilot light 19 is connected to glow when the thermostat 18 closes. The user of the equipment may thus know that power is available in the control box 62 and that the control equipment is functioning.

As shown, the copper heat tube 113 includes first and second resistance elements R_1, R_2. A center tap insulated copper return conductor 149 is connected to a center tap connection 153 and to the switch 125. This circuitry provides a twin element circuit suitable for three-way switching by the switch 125, including an "off" position. The resistance elements R_1, R_2 are again wound of ultrafine resistance wire to prevent cascading, according to the principles of the invention illustrated, for example, in FIG. 2.

CLAIMS

1. A heating device for generating heat from an electrical power supply, comprising:

a heat conductive tube;

heat generation means within said tube including electrical resistance means for generating heat in response to supplied power, said electrical resistance means including means for preventing cascading; and

a heat control means for mechanically receiving said heat conductive tube and controlling power supplied to said heat generation means from said power supply.

2. The heating device of Claim 1, wherein said heat generation means comprises:

an outer insulating sheath;

an inner insulating means located within said outer sheath; and

an ultrafine resistance wire spiralled on said inner insulating means between said inner insulating means and said outer insulating sheath.

3. The heating device of Claim 2 wherein said outer insulating sheath comprises silicone rubber.

4. The heating device of Claim 3 wherein said inner insulating means comprises a flexible fiberglass core.

5. The heating device of Claim 2 wherein said heat generation means further includes a metal tube containing said outer insulating sheath, inner insulating means and spiralled resistance wire.

6. The heating device of Claim 5 wherein said spiralled resistance wire is 33, 34 or 35 AWG.

7. The heating device of Claim 6 wherein said heat control means includes thermal cutoff means for sensing the surface temperature of said tube and permanently breaking the supply of power to said resistance wire.

8. The heating device of Claim 7 wherein said heat control means is contained in a housing having means for introducing said tube into said housing and wherein said heat control means further includes thermal switch means for intermittently switching the power supply on and off to prevent the surface temperature of the tube from exceeding a selected temperature where it emerges from the housing.

9. The heating device of Claim 4 wherein said heat control means further includes thermostat means for controlling power supply to maintain said tube at a selected operating temperature.

10. The heating device of Claim 5 wherein said heat control means is energized by conductor means and contained in a control box, and further including a junction box attachable to said control box for receiving said conductor means and housing a connection between said power supply and said conductor means.

11. The heating device of Claim 1 wherein said heat generating means includes a spiral of resistance wire of a thickness selected to resist cascading.

12. The heating device of Claim 11 wherein said resistance wire is spiralled around an insulator in a hairpinned configuration.

13. The heating device of Claim 12 wherein said heat control means includes a four-position switch and said hairpin configuration contains a center tap conductor connected to said four-position switch.

14. The heating device of Claim 12 wherein said heat control means further includes a switch means for switching the wattage supplied to said heating element between a plurality of values.

15. A heating device for generating heat from an electrical power supply, comprising:

a bendable, heat conductive tube containing a hairpin-shaped heating element, said heating element including a cylindrical outer insulating sheath, an inner insulating core lying within said outer sheath, and an ultrafine resistance wire connected to said power supply and spiralled on said inner insulating core between said inner insulating core and said outer insulating sheath;

a housing having means for sealably receiving said heat conductive tube;

a thermal cutoff means mounted in said housing for sensing the surface temperature of said heat conductive tube and permanently breaking the supply of power to said resistance wire;

a thermal switch means mounted in said housing for intermittently switching the power supply on and off to prevent the surface temperature of said heat conductive tube from exceeding a selected temperature where it emerges from the housing; and

thermostat means for controlling power supply to said heating element to maintain said tube at a selected operating temperature, said thermal cutoff means, thermal switch means, and thermostat means being connected in series with each other for establishing a breakable serial conductive path between said power supply and said heating element.

16. The heating device of Claim 15 wherein said housing includes an opening and further including a junction box having an opening and means for sealably connecting the opening of said junction box to the opening of said housing for forming a passageway therebetween.

17. A heating device substantially as hereinbefore described, with reference to the accompanying drawings.

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