

[54] **HEATING SYSTEM FOR ASPHALT EQUIPMENT**

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[51] Int. Cl. **H05b 3/82**, F24h 1/10

[58] Field of Search 219/280-282, 302, 219/306, 308-310, 312, 320, 321, 325-327, 332, 338, 341, 485, 486, 487, 496; 126/343.5 R, 343.5 A, 351, 360

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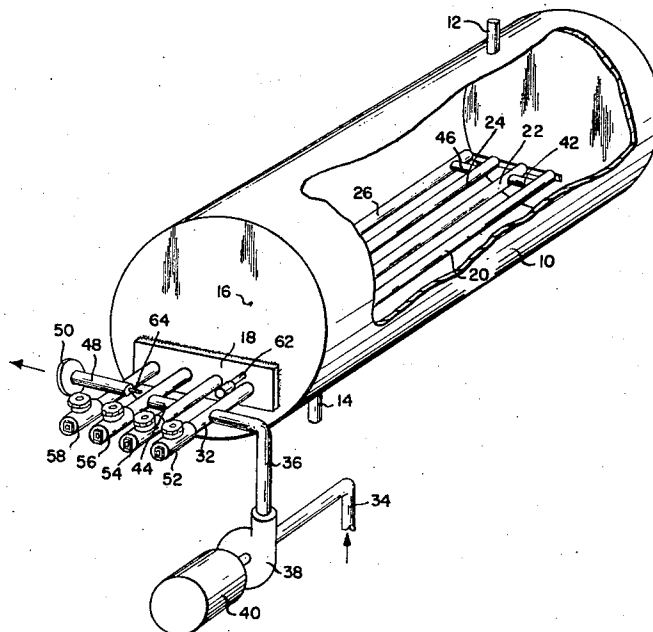
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[57] **ABSTRACT**

A controlled heating system, in which heat-transfer oil, which is circulated through jacketed heating means installed in an asphalt tank, effects the production of a high heat input when oil is flowing, and a low heat input when oil is not flowing. "There are three electrical embodiments disclosed, one involving a plurality of electrically resistive elements all of which are connected to a source of electrical current when heat transfer fluid is flowing with at least one of the elements being disconnected when heat transfer fluid is not flowing; a second in which three electrically resistive elements are connected to a source of current in a Y-configuration when heat transfer fluid is not flowing and in a 'delta' configuration when heat transfer fluid is flowing; and a third in which three electrically resistive elements are connected in a Y-configuration, all of the elements being energized for high capacity operation while only two elements are energized to effect heating at a lower rate. A fourth embodiment involves a gas-fired heating system."

17 Claims, 8 Drawing Figures



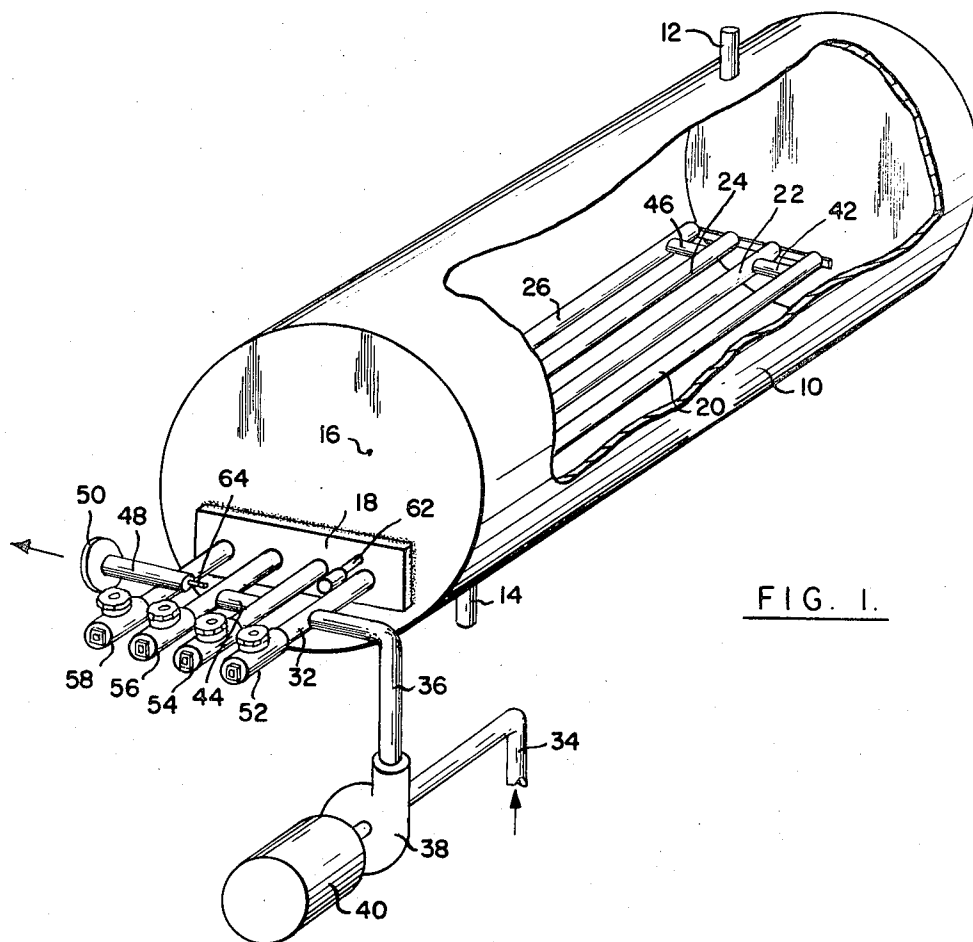


FIG. 1.

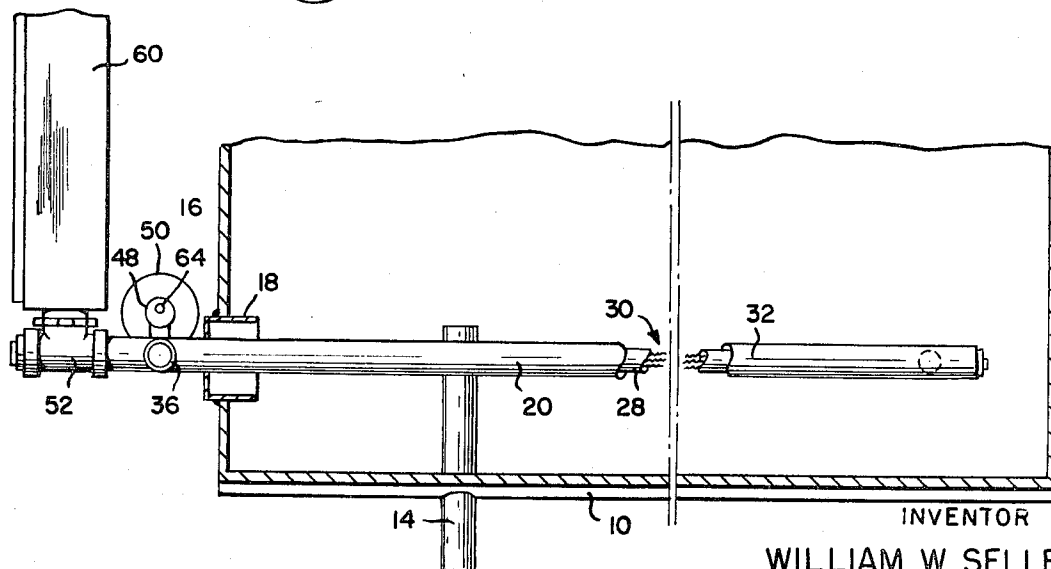


FIG. 2.

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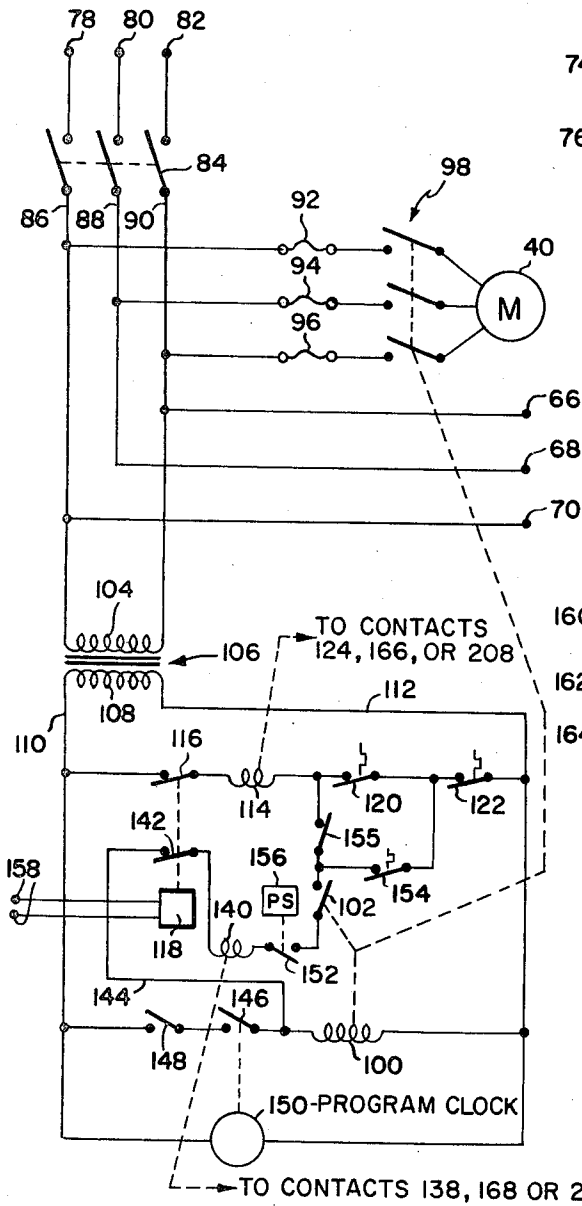


FIG. 3.

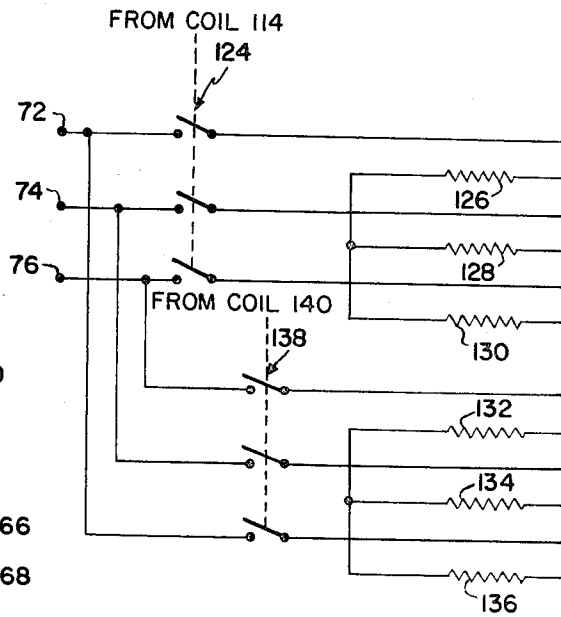


FIG. 4.

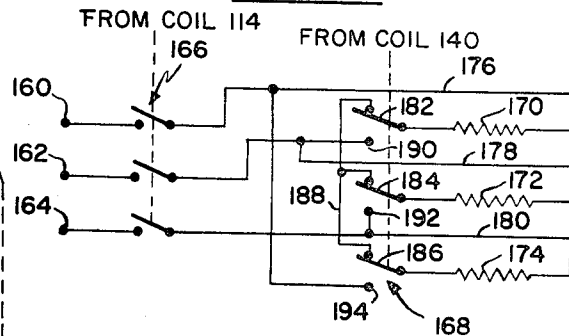


FIG. 5.

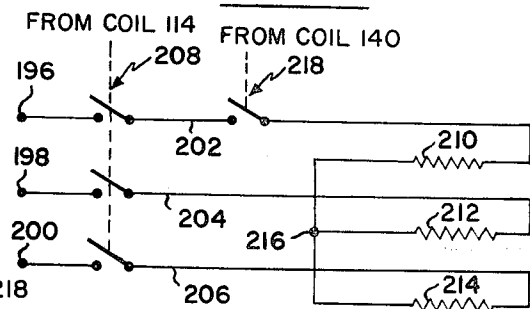


FIG. 6.

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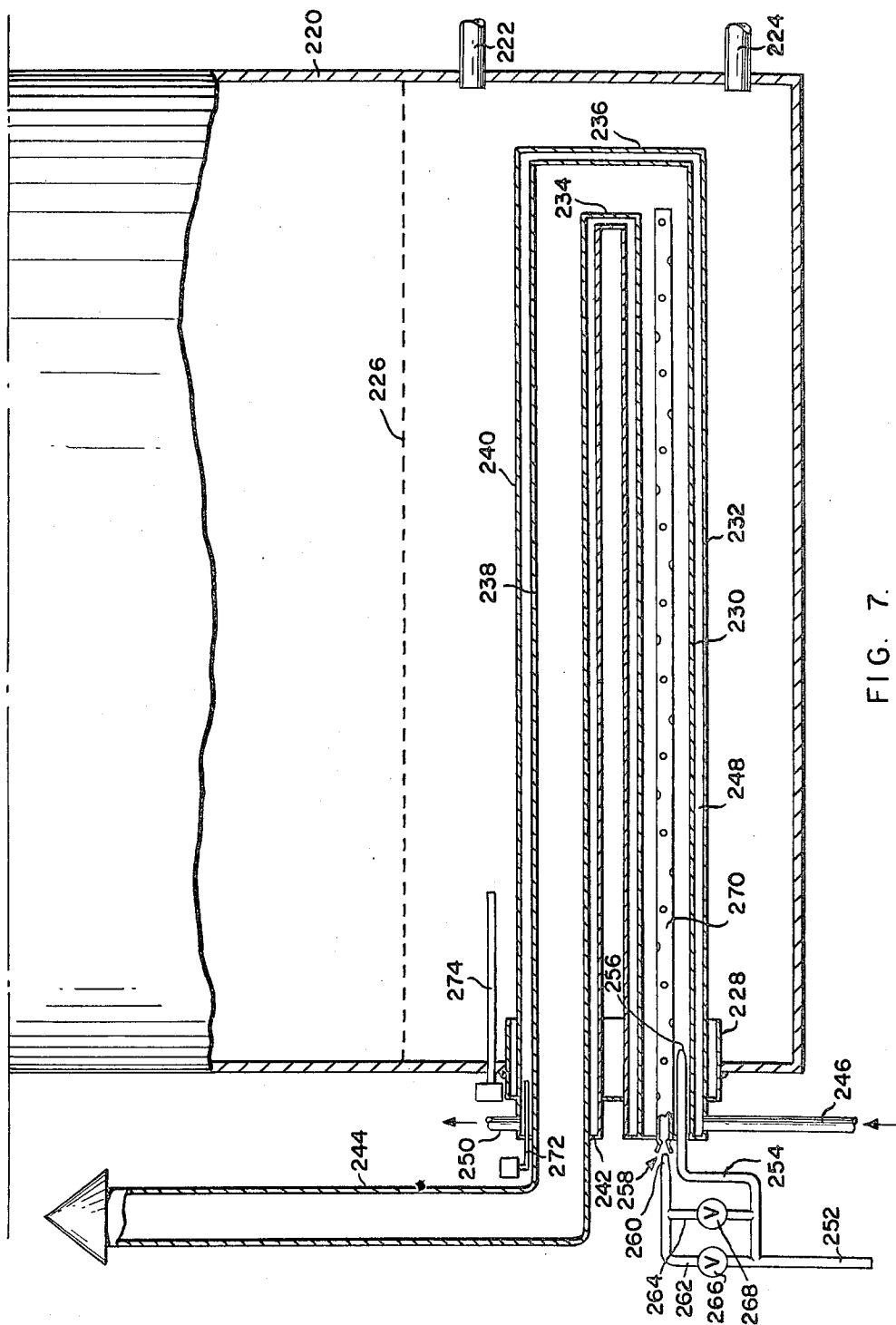
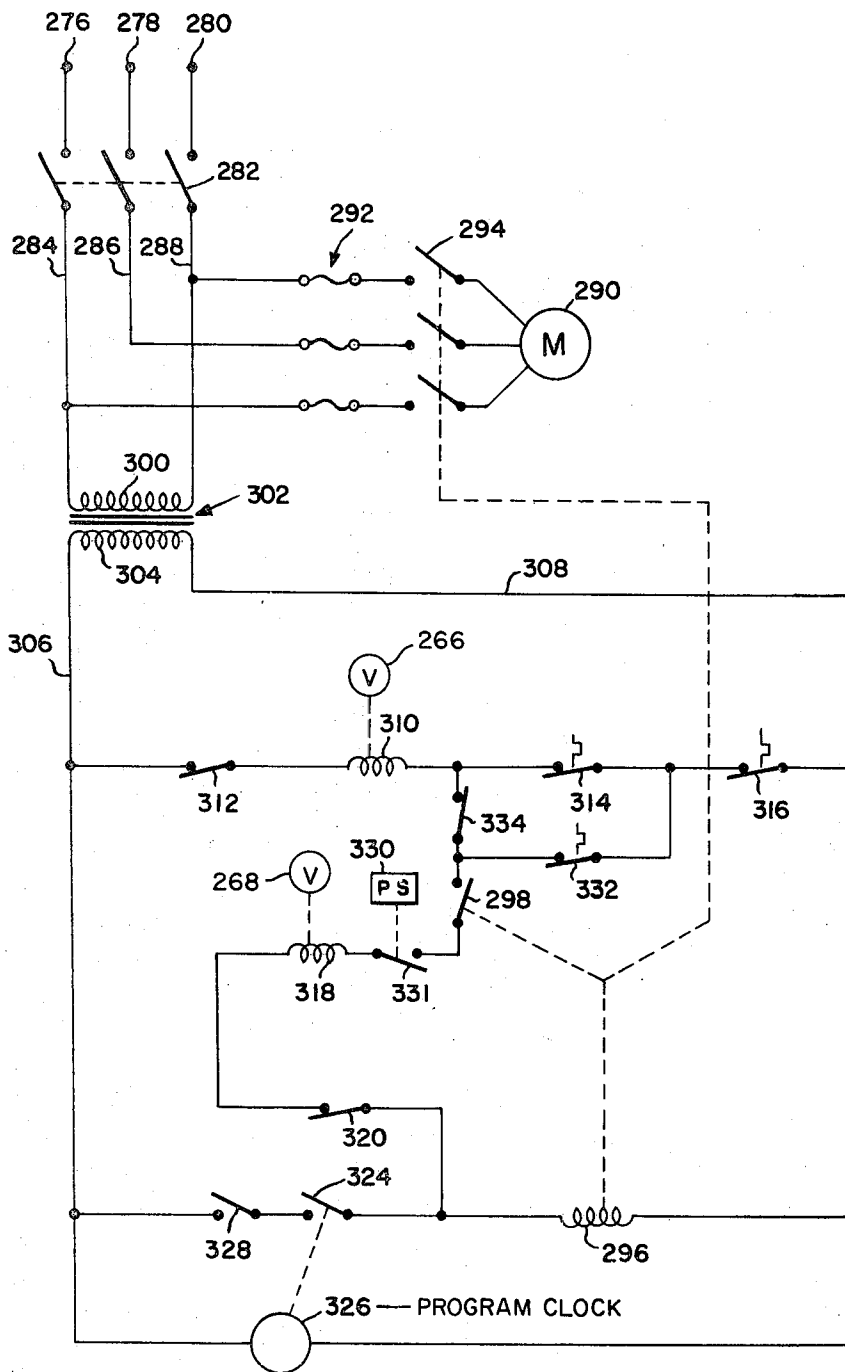


FIG. 7.

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HEATING SYSTEM FOR ASPHALT EQUIPMENT

BACKGROUND OF THE INVENTION

This invention relates to heating systems, and particularly to a heating system of the kind used for maintaining asphalt contained in a storage tank in a heated condition.

In bituminous concrete plants, various components, other than storage tanks, are present, and require heating. For example, mixing tower components, piping pumps and pugmills must be maintained at relatively high temperatures for proper operation. Furthermore, these components are liable to freeze at shut down, and have to be heated in order to be put back into operation. It has been conventional practice to utilize a circulating heat-transfer fluid, usually oil, for the purpose of heating these various plant components. The oil is commonly circulated through one or more of the storage tanks in a plant in order to take advantage of the heat provided by the storage tank heaters and stored in the asphalt contained in the tanks.

In general, the heat-transfer oil is circulated through the storage tanks in conduits which are in contact with the stored asphalt, but which are spaced from the heating elements. With such an arrangement, it is difficult to attain rapid heating of the auxiliary components of the plant. In order to solve this problem, I have provided, instead of ordinary conduits, jacketed auxiliary heating elements in addition to the heating elements which are normally used to heat the asphalt in a storage tank. The heat-transfer oil is circulated through the jackets of the auxiliary heaters so that it carries off not only the heat conducted through the asphalt from the main heaters, but also the heat conducted directly from the auxiliary heaters. The system just mentioned is fully disclosed in my co-pending application, Ser. No. 539,348, filed Apr. 1, 1966, now U.S. Pat. No. 3,622,748, granted Nov. 23, 1971.

Heretofore, no successful attempt has been made to utilize the main heaters of a storage tank for direct heating of heat-transfer oil by providing them with jackets. While oil would be heated rapidly in such a system, and rapid heating of the auxiliary components would be effected, such a system would be potentially wasteful of heat if oil were circulated continuously. On the other hand, if circulation were stopped periodically when the auxiliary components reached the required temperatures, the heating elements, which would be in close proximity with the oil-carrying jackets, would be liable to overheat the oil.

SUMMARY OF THE INVENTION

In accordance with this invention, the main heating elements of a storage tank are provided with jackets, and are used for direct heating of the heat-transfer oil. A control system avoids the problems of waste of heat and overheating by providing a high heat input when oil circulation is taking place and providing a low heat input when oil is not circulating. In addition, the control system is responsive to the temperatures of the asphalt and the heat-transfer oil, and maintains them at the desired temperatures.

The invention will be described as applied to a heating system for a storage tank containing asphalt to be supplied to a bituminous concrete plant and involving a heat-transfer system circulating heat-transfer oil to

other components or equipment of the asphalt system, such as plant jacket components, piping, pumps, other storage tanks, etc. It will be apparent, however, that the invention is more generally applicable to heating systems for storage tanks containing materials other than asphalt, such as for example, storage tanks for various chemicals, caustics and similar materials. Heat-transfer fluids other than oil may be involved. Several embodiments of the invention will be described, including a gas-fired heating system, and three different electrical heating systems.

The principal object of this invention is to provide a simple means of heating a stored material in which the heating elements which heat the stored material are also used for heating auxiliary components through a heat-transfer fluid.

One very advantageous feature of the invention is that the heating system can be constructed from optimum size components much smaller than the components necessary for a comparable capacity system which does not employ circulating heat-transfer fluid. This advantage is achieved because much higher densities (heat levels) are permitted in an arrangement with a circulating heat transfer fluid than in an arrangement without such circulation.

Another feature of the invention is that in the event the liquid in storage in the tank is completely removed, the system can be operated with circulation at maximum capacity with substantially all of the heat going directly into the heat transfer fluid, and is not dependent on the fluid in storage to transfer a portion of the heat to the heat transfer fluid.

A further object is to provide a heating system for heating a stored fluid and auxiliary components which is economical in operation in that waste of heat is minimized, but which is capable of effecting rapid heating of the auxiliary components of the system. Other objects will be apparent from the following description read in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially cut-away perspective view of an asphalt storage tank having jacketed electrical heating elements in accordance with the invention;

FIG. 2 is a vertical section of the tank shown in FIG. 1, also showing the exterior of a box containing the electrical control system;

FIG. 3 is a schematic diagram of a part of the electrical control circuitry for the electrical heating elements which is common to the several different disclosed embodiments of the electrical heating system;

FIG. 4 is a schematic diagram of part of the electrical circuit which may be interconnected with the circuitry in FIG. 3;

FIG. 5 is a schematic diagram of an alternative part of an electrical circuit which may be interconnected with the circuitry in FIG. 3;

FIG. 6 is a schematic diagram of a still further alternative electrical circuit which may be interconnected with the circuitry in FIG. 3;

FIG. 7 is a partially cut-away elevation of a storage tank in the form of a vertical cylinder having a gas-fired, jacketed heating element; and

FIG. 8 is a schematic diagram of the control circuit for the gas-fired heating element of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows an asphalt storage tank 10 in the form of a horizontal cylinder having an inlet opening 12 for the introduction of asphalt and an outlet opening 14 at the bottom for removal of asphalt. Conventional valves and pumping means may be provided in conjunction with openings 12 and 14 for the delivery and removal of asphalt.

FIG. 2 shows end 16 of the tank in section, and shows a weld box 18 welded in place in a rectangular opening in end 16. The function of the weld box 18 is to accommodate curvature in the wall of the tank in which the opening is formed. Although it does not appear in the drawings, end 16 might well be outwardly convex or have some other non-flat configuration.

Extending through weld box 18 and into the interior of the tank are four members 20, 22, 24 and 26. Each of these members consists of a jacketed electrical heating element. As shown in FIG. 2, element 20 comprises an internal electrical heating element 28 containing a plurality of heating coils indicated at 30. Surrounding element 28 is a jacket 32, which is spaced from the outer surface of heating element 28 to provide a passage about heating element 28 for the flow of heat-transfer fluid.

The jackets of members 20, 22, 24 and 26 are interconnected with each other in such a way as to provide a continuous path for the flow of heat-transfer fluid so that it traverses the length of the tank four times before delivery to the auxiliary components which are heated by it. Heat-transfer fluid enters pipe 34, and is pumped through pipe 36 by pump 38, which is driven by electrical motor 40. From pipe 36, the fluid enters jacket 32 of member 20. The fluid flows through the jacket to the opposite end of member 20, and flows into the jacket of member 22 through passage 42. The fluid then flows through the length of the jacket of member 22, and through passage 44 to the jacket of member 24. After passing through the length of the jacket of member 24, the fluid enters the jacket of member 26 through passage 46, and finally flows outwardly through outlet 48. Outlet 48 is provided with a flange 50 for connection for piping leading to auxiliary components of the plant.

Electrical connections to the heating coils in the heating elements are made through fittings 52, 54, 56 and 58. A box containing the electrical circuitry is shown, in part, in FIG. 2 at 60.

A thermostat 62 (FIG. 1) extends into the asphalt in the space between members 20 and 22. Thermostat 62 has a set of contacts which open when a predetermined maximum temperature is reached in the asphalt. A second thermostat 64 extends into outlet 48 to sense the temperature of the oil in the outlet. Thermostat 64 is preferably a double-stage thermostat having two sets of contacts. The first set of contacts is set to open when the temperature of the heat-transfer fluid reaches the optimum temperature for heating auxiliary components. The second set of contacts in thermostat 64 is an overtemperature switch and is set to open at a predetermined maximum temperature which is in excess of the temperature which effects opening of the first switch. Of course, two separate single-stage thermostats may be used instead of the double-stage thermostat.

Part of the electrical circuitry contained in box 60 and controlling the current in the heating coils is illustrated in FIG. 3. The circuitry in FIG. 3 will be interconnected with the circuitry shown in any one of FIGS. 4, 5 and 6.

Assuming, first, that the circuitry in FIGS. 3 and 4 is used, terminals 66, 68 and 70 in FIG. 3 will be connected respectively with terminals 72, 74 and 76 of FIG. 4. Terminals 78, 80 and 82 may be connected to a three-phase supply. A 3-pole, single throw switch 84 is provided to disconnect the current source from lines 86, 88 and 90. The pump drive motor is connected to lines 86, 88 and 90 through fuses 92, 94 and 96, and through contacts 98 of a starter relay. The coil of the starter relay is indicated at 100. Contacts 98 are normally open, and close when coil 100 is energized. An additional normally open contact of the starter relay is indicated at 102.

Lines 86 and 90 are connected to the primary winding 104 of a transformer 106. Secondary 108, which may be adapted to provide a relatively low voltage, is connected to lines 110 and 112. A coil 114 of a first contactor (or relay) is connected to line 110 through normally closed contacts 116 of relay 118.

The opposite end of coil 114 is connected to line 112 through contacts 120 and 122. Contacts 120 are the previously mentioned contacts of thermostat 62, and contacts 122 are the overtemperature contacts of thermostat 64.

The contacts of the first contactor, and which are closed by coil 114 when it is energized, are indicated at 124 in FIG. 4. These contacts, when closed, effect energization of heating coils 126, 128 and 130, which are connected in a Y-configuration.

Coils 126, 128 and 130 are three of six coils in a heating element, the other three coils are indicated at 132, 134 and 136. These coils are also arranged in a Y-configuration and are connected to terminals 72, 74 and 76 through contacts 138 of a second contactor (or relay), the coil of which is shown at 140 in FIG. 3. The coils in the remaining three heating elements are not shown for the sake of simplicity, but are connected to contacts 124 and contacts 138 in the same manner as the coils shown in FIG. 4.

Referring back to FIG. 3, coil 140, the coil of the second contactor, which operates contacts 138 (FIG. 4), is connected through contacts 142 of relay 118 to line 144. Line 144 is connected through contacts 146 and switch 148 to line 110. Contacts 146 are operable by a program clock 150, which is connected to lines 110 and 112. Switch 148 is a manually operable switch. The opposite terminal of coil 140 is connected through normally open contacts 152 and through switch 102, contacts 154 and 122 to line 112. Normally open contacts 152 are operable by a pressure switch 156, which is arranged to sense flow of heat-transfer fluid through outlet 48 and to close contacts 152 when flow takes place. The purpose of the pressure switch is to insure that flow exists before the heater is permitted to operate at high capacity. Switch 155 is a manually operable switch connected in series with contacts 102 of starter coil 100.

The coil of relay 118 is connected to terminals 158, which may be connected to be energized while other electrical equipment in the plant is operating. This

relay acts as an interlock preventing the electrical heaters from operating while other electrical equipment is in use.

The operation of the circuitry constituted by the circuits shown in FIGS. 3 and 4 will now be described. Assuming switch 84 is closed, terminals 158 of relay 118 are unenergized, switch 155 is closed, and switch 148 is closed, and also assuming that all thermostat contacts are closed, the operation is as follows:

Coil 114 of the first contactor will be energized, effecting closure of contacts 124 (FIG. 4) to cause energization of coils 126, 128 and 130 of the heating elements, thus operating the heating elements at partial capacity.

Program clock 150 will be in operation since it is supplied with current from the secondary of transformer 106 through lines 110 and 112. When contacts 146 close, starter coil 100 becomes energized and effects closing of contacts 98 to start motor 40. Contacts 102 also close at this time. Assuming the pump is now properly operating and flow is taking place through the jackets of the heating elements, pressure switch 156 will operate to close contacts 152. Both of coils 114 and 140 will now be energized, and contacts 124 and 138 (FIG. 4) will be closed effecting energization of all of the coils in the heating elements to operate the heaters at high capacity. So long as flow of heat-transfer fluid is taking place, the fluid is not likely to become overheated even while the heating elements are operating at high capacity. However, if an overtemperature condition is sensed by thermostat 64, contacts 122 open, deenergizing both of coils 114 and 140 to deenergize both sets of heating coils. If switch 148 is opened or the program clock 150 is in such a position that contacts 146 are open, the pump motor 40 ceases operating and heat-transfer fluid stops flowing. Under these circumstances, contacts 152, operated by pressure switch 156, are opened and contacts 102 of the starter coil will be opened. Since coil 140 cannot be energized, the heater can operate only at partial capacity. Contacts 120, operated by thermostat 62, control the asphalt temperature by cutting off current through coil 114 when the asphalt temperature reaches an optimum level.

contacts 154 of thermostat 64 come into play only if the system is operated with switch 155 open. If switch 155 is open, the heat transfer fluid temperature is limited by the temperature for which contacts 154 are set. Even while the fluid is flowing, if contacts 154 are open, coil 140 is deenergized and the heater is able to operate only at partial capacity.

It will be noted that the circuitry is such that only when the circulating pump is running (when contacts 102 are closed) can coil 140 be energized to cause high capacity operation.

Now assuming that the circuitry in FIG. 3 is interconnected with the circuitry in FIG. 5 rather than with the circuitry in FIG. 4, terminals 66, 68 and 70 will be connected respectively to terminals 160, 162 and 164. Contacts 166 are now the contacts of coil 114, and are shown in the position which they are in when coil 114 is unenergized. Contacts 168 are the contacts of coil 140 and are likewise shown in the position which they are in when coil 140 is unenergized. Each of the heating elements in this case has three heating coils. The heating

coils of only one element are shown for simplicity, and it will be apparent that the heating coils of the remaining heating elements can be connected in parallel or in series, or in other ways with the heating coils indicated at 170, 172 and 174. Each of the heating coils is connected directly at one end to one of the three contacts 166. These connections are made through lines 176, 178 and 180. The opposite ends of the heating coils are connected to the movable members of contacts 168, each of which contacts is a double-throw contact. One end of coil 170 is connected to movable contact member 182. One end of coil 172 is connected to movable contact member 184, and one end of coil 174 is connected to movable contact member 186. The upper stationary members of the contacts are connected together through line 188. Thus, when the contacts are in the position shown, the coils are connected in a Y-configuration. The lower member 190 of the uppermost set of contacts is connected through the middle contact of contacts 166 to terminal 162. The lower member 192 of the middle set of contacts is connected through the lowermost contacts of the set of contacts 166 to terminal 164. The lower terminal 194 of the lowermost set of contacts is connected through the upper set of contacts 166 to terminal 160. Thus, when contacts 168 are pulled downwardly by the energization of coil 140, heating coils 170, 172 and 174 will be connected in a "Delta" configuration. When heat-transfer fluid is not flowing, coil 140 will be unenergized, and the contacts 168 will be in the position shown. So long as coil 114 is energized, contacts 166 will be closed, and the heating coils will be in a Y-configuration and energized. The dissipated power in the Y-configuration is one-third of the power which is dissipated when the same coils are connected in a Delta.

If the asphalt heats up sufficiently to open contacts 120 of thermostat 62, coil 114 will become unenergized and contacts 166 will open, cutting off all current to the heating coils.

If heat-transfer liquid is flowing, both of coils 114 and 140 will be energized, and the heating coils will be connected in a Delta, dissipating maximum power.

The combined circuitry of FIGS. 3 and 5 operates, in all other respects, in a manner similar to the manner of operation of the combined circuitry of FIGS. 3 and 4.

Instead of the circuitry in FIGS. 4 and 5, the circuits in FIG. 6 can be wired to the control circuitry in FIG. 3 by connecting terminals 196, 198 and 200 respectively to terminals 66, 68 and 80 in FIG. 3. Terminals 196, 198 and 200 are respectively connected to lines 202, 204 and 206 through contacts 208, which are now the contacts operated by coil 114. Heating coils 210, 212 and 214 are connected in a Y-configuration, having a common connection at 216. The opposite ends of the heating coil are respectively connected to lines 202, 204 and 206. A single set of contacts 218 is provided in line 202. Contacts 218 are the contacts of coil 140.

The heating coils of the remaining heating elements are not shown in FIG. 6, but it will be apparent that they may be arranged in Y-configuration and connected to the same points to which the ends of coils 210, 212 and 214 are connected. As a possible alternative, they may be connected individually in parallel with coils 210, 212 and 214.

When coil 114 is energized, but coil 140 is unenergized, contacts 208 will be closed, but contacts 218 will be opened. Current will pass only through coils 212 and 214, effecting heating at a low rate. Only when coil 140 is energized do the coils operate at full capacity.

The heating coil circuits in FIGS. 4, 5 and 6 have one common feature: they effect heating at partial capacity when coil 114 (FIG. 3) is energized while coil 140 is unenergized, and effect heating at full capacity when both coils are energized.

Certain components of the electrical circuit in FIG. 3 are optional. For example, relay 118 and its contacts 116 and 142 may be eliminated. Contacts 152 and the pressure switch 156 may be eliminated. These eliminated contacts should be replaced by short circuits. With the pressure switch contacts eliminated, the circuitry determines the presence or absence of flow in the heat-transfer fluid through the closure of contacts 102 when the pump motor is started.

Since the purpose of contacts 122 is to prevent overheating of the heat-transfer fluid, they may be eliminated if the system is such that the asphalt level will never fall below the level of the heaters.

The program clock 150 and its contacts 146 may, of course, be eliminated by replacing contacts 146 by a short circuit and operating the pump motor starter coil by manipulating switch 148.

The embodiment of the invention which utilizes a gas-fired heating element will now be described with reference to FIGS. 7 and 8.

FIG. 7 shows a tank 220 in the form of a vertical cylinder.

An inlet opening (not shown) is provided, and a pair of outlet openings 222 and 224 are provided in the wall of the tank, the latter being closer to the bottom of the tank. The asphalt level is indicated at 226. A weld box 228 is welded into a slot cut in the vertical wall of the tank. Weld box 228 mounts a tubular member 230 which is provided with a jacket 232. The tubular member 230 extends to a point near the opposite side of the tank from the weld box, and connects with vertical tubular member 234, also jacketed by jacket 236. Vertical member 234 connects with a horizontal tubular member 238, surrounded by jacket 240.

Jacket 240 terminates in a tubular closure 242 sealing jacket 240 to member 238. Member 238 extends into a flue 244.

Heat-transfer fluid is pumped by a pump (not shown) through pipe 246, into space 248 between the jackets and the tubular members which they surround. The heat-transfer fluid passes outwardly through pipe 250 after traversing the diameter of the tank twice. Pipe 250 delivers the fluid to the auxiliary plant components which are to be heated.

Combustible gas is delivered through pipe 252, and through pipe 254 to a pilot burner 256. An air-gas mixing device 258 includes a nozzle 260 which is connected to supply pipe 252 through a pair of lines 262 and 264. Each of these lines is provided with one of a pair of solenoid-operated valves 266 and 268, each of which is closed except when its solenoid is energized. These valves control the volume of gas delivered to nozzle 260. The air-gas mixing device is connected to an elongated tube 270 which extends throughout most of the length of tubular member 230. This tube is per-

forated throughout its length, and acts as a burner. The heat which it provides is conducted to the asphalt in the tank through the heat-transfer liquid in space 248. The heat from the exhaust gas within tubular member 238 is also conducted, through the heat-transfer fluid to the asphalt. Thermostat 272 extends through closure 242, and senses the temperature of the heat-transfer fluid near the connection to outlet pipe 250. This thermostat, like thermostat 64 (FIG. 1) is a two-stage thermostat having two set of contacts, the first being set to open at the desired fluid temperature, and the second being set to open at a predetermined high temperature limit.

Thermostat 274 is arranged to sense the temperature of the asphalt within the tank. It has a single set of contacts.

The control circuit for operating valves 266 and 268 is shown in FIG. 8. Terminals 276, 278 and 280 are connected to a three-phase supply. Switch 282 connects the supply to lines 284, 286 and 288. Motor 290 is the motor which drives the pump (not shown) which pumps heat-transfer fluid through the jacket of the heating element in FIG. 7. Motor 290 is connected to lines 284, 286 and 288 through fuses 292 and normally open contacts 294 of a starter coil 296. Coil 296 has an additional normally open set of contacts 298.

Lines 284 and 288 are connected to the primary winding 300 of transformer 302. Secondary winding 304, which may be a low voltage winding, is connected to lines 306 and 308.

Coil 310, which is the solenoid for operating valve 266, is connected at one end to line 306 through manually operable switch 312. The other end is connected to line 308 through contacts 314 of thermostat 274 and contacts 316, the high temperature limit contacts of thermostat 272.

Coil 318 is the solenoid which operates valve 268. One of its ends is connected to line 306 through manually operable switch 320, contacts 324 of program clock 326, and manually operable switch 328. Program clock 326 is continuously connected to lines 306 and 308. Its contacts 324 are connected to control energization of starter coil 296 as well as energization of coil 318.

The opposite end of coil 318 is connected to line 308 through contacts 331 of pressure switch 330, contacts 332 of thermostat 272 and contacts 316 of thermostat 272.

Pressure switch 330 is arranged to sense the flow of heat-transfer fluid, and to close contacts 331 when flow is taking place. Contacts 332 of thermostat 272 open when the heat-transfer fluid reaches the desired temperature.

A manually operable switch 334 and contacts 298 of starter coil 296 are connected in series to provide an additional path for energization of coil 318 through contacts 331, 298, 334, 314 and 316. Energization of coil 318 through this path depends on whether or not manually operable switch 334 is closed.

In operation, assuming all manually operable switches (312, 320, 334 and 328) are closed, coil 310 will be energized, effecting opening of valve 266 until one or both sets of thermostat contacts 314 and 316 open. Valve 266 permits a limited amount of gas to flow into the heater, and heating now takes place only at partial capacity.

When program clock 326 reaches a condition calling for flow of heat-transfer liquid, contacts 324 will close, effecting energization of starter coil 296, starting the pump motor 290. As soon as a flowing condition of the heat-transfer fluid is sensed by pressure switch 330, contacts 331 close, and coil 318 is energized as well as coil 310. Both of valves 226 and 268 will now be open allowing gas to flow into the heater at a high rate, effecting heating at full capacity. It will be noted that the oil temperature can rise above the temperature effecting opening of thermostat contacts 332, since current will continue to pass through coil 318 through the path provided by contacts 331, 298, 334, 314, and 316. If the high temperature limit is reached, however, contacts 316 will open, cutting off current to both of the valve solenoids and effecting a shut-down of the heater.

If manually operable switch 334 is open, coil 318 can be energized through a path including thermostat contacts 332. Thus, current in coil 318 will be cut off, and valve 268 will be closed whenever the temperature of the heat-transfer fluid becomes high enough to open contacts 332.

It will be noted that only when the circulating pump is running (when contacts 298 are closed) can coil 318 be energized to cause high capacity operation.

Switches 312 and 320 are merely provided for convenient cutting off of current in either of the solenoids.

The configuration of the gas-fired heating system shown in FIG. 7 can be modified. In larger installations, for example, several burners may be provided. The jacketed tube which conducts exhaust gas to the flue may be arranged to traverse the storage tank several times.

Various components of the circuit in FIG. 8 can be eliminated. For example, switches 312 and 320 can be replaced by short circuits, and the pressure switch and its contacts 328 can be eliminated by replacing contacts 328 with a short circuit. Switch 334 can be replaced by a permanent short circuit as can contacts 324. The program clock 326 can be eliminated. Contacts 316 of thermostat 272 can be replaced by a short circuit if assurance is provided that asphalt will not flow out of opening 224 (FIG. 7) to such an extent that the asphalt level will fall below the top of jacket 240 of the heater.

I claim:

1. Apparatus for heating a fluid in a storage tank and a circulating heat transfer fluid comprising a storage tank, at least one heater adapted to be mounted at least partly within the interior of the storage tank, said heater being constructed and arranged to be operated to produce heat at a low level and to produce heat at a level higher than said low heat producing level, means providing a passage within said storage tank and in close proximity to and in heat exchange with said heater throughout at least part of its length, for conducting a flowing stream of heat-transfer fluid through the interior of said storage tank, and means responsive to the flowing or non-flowing condition of the heat-transfer fluid for effecting operation of said heater at said low heating level when heat-transfer fluid is not flowing and at said higher level when said heat-transfer fluid is flowing.

2. Apparatus according to claim 1 wherein said passage for said heat-transfer fluid encloses at least in part the heater throughout at least a substantial portion of its heating surface.

3. Apparatus according to claim 2 in which said heater comprises a plurality of electrically resistive elements and said means for effecting operation of said heater includes means for connecting all of said resistive elements to a source of electrical current when said heat-transfer fluid is flowing, and for disconnecting at least one but less than all of said resistive elements from said source of electrical current when said heat-transfer fluid is not flowing.

4. Apparatus according to claim 2 in which said heater comprises a plurality of electrically resistive elements and said means for effecting operation of said heater includes switching means for connecting said resistive elements to a source of current in a configuration presenting a high resistance to said source when said heat-transfer fluid is not flowing and in a configuration presenting a lower resistance to said source when said fluid is flowing.

5. Apparatus according to claim 2 in which said heater comprises three electrically resistive elements and said means for effecting operation of said heater includes switching means for connecting said resistive elements to a three-wire source of current in a Y-configuration when said heat-transfer fluid is not flowing and in a "Delta" configuration when said heat-transfer fluid is flowing.

6. Apparatus according to claim 2 in which said heater comprises means for burning a fluid fuel, and in which said means for effecting operation of said heater includes means for delivering fuel to said burner at a high rate when said heat-transfer fluid is flowing and for delivering fuel to said burner at a lower rate when said heat-transfer fluid is not flowing.

7. Apparatus according to claim 2 in which said heater comprises means for burning a fluid fuel, and in which said means for effecting operation of said heater includes means providing a first path for the flow of fuel from a supply to said burning means, means providing an additional path for the flow of fuel from a supply to said burning means, a valve in said additional path, and means for opening said valve when said heat transfer fluid is flowing.

8. Apparatus according to claim 2 including a pump for the heat-transfer fluid and in which said means responsive to the flowing or non-flowing condition of the heat-transfer fluid comprises means for simultaneously controlling the operation of said pump for pumping said heat-transfer fluid and controlling operation of said heater, the last-mentioned means being arranged to effect operation of said heater at a low heating level when said pump is not operating and to effect operation of said heater at a higher level when said pump is operating.

9. Apparatus according to claim 2 in which said means responsive to the flowing or non-flowing condition of the heat-transfer fluid includes a flow sensing means arranged to respond to the pressure of the heat-transfer fluid and connected to effect operation of said heater at a low heating level when the pressure of said fluid is low and to effect operation of said heater at a higher heating level when the pressure of said fluid is high.

10. Apparatus according to claim 9 wherein said flow sensing means comprises a pressure-operated switch.

11. Apparatus according to claim 2 including thermostatic means for regulating the temperature of the

11

fluid in the storage tank by overriding said means responsive to the flow condition of the heat-transfer fluid to effect operation of said heater at a reduced heating level when the temperature of the fluid in the tank reaches a predetermined level.

12. Apparatus according to claim 2 including thermostatic means for regulating the temperature of the fluid in the storage tank by overriding said means responsive to the flow condition of the heat-transfer fluid to effect operation of said heater at a reduced heating level when the temperature of the fluid in the tank reaches a predetermined level.

13. Apparatus according to claim 2 including thermostatic means for regulating the temperature of the fluid in the storage tank by overriding said means responsive to the flow condition of the heat-transfer fluid to effect operation of said heater at a reduced heating level when the temperature of the fluid in the tank reaches a predetermined level, and manually operable means for rendering the last-mentioned thermostatic means inoperative to reduce the heating level of said heater.

14. Apparatus according to claim 2 including thermostatic means responsive to the temperature of said

12

heat-transfer fluid for shutting off the heater when the temperature of said fluid reaches a predetermined maximum limit.

15. Apparatus according to claim 2 in which said heater comprises at least one electrically resistive element adapted to be connected to a source of current, and including an interlock relay adapted to be operated when another electrical component supplied by said source of current is in operation, and connected to cut off the current in said resistive element when so operated.

16. Apparatus according to claim 1 wherein said passage for said heat-transfer fluid surrounds the heater throughout at least a substantial portion of its heating surface.

17. Apparatus according to claim 1 wherein said heater has an elongated portion extending into said storage tank, said portion is enclosed in an elongated casing extending into said storage tank, and said passage for said heat-transfer fluid encloses said casing to provide a passage chamber for said circulating heat-transfer fluid located between said heater casing and the fluid in said storage tank.

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