

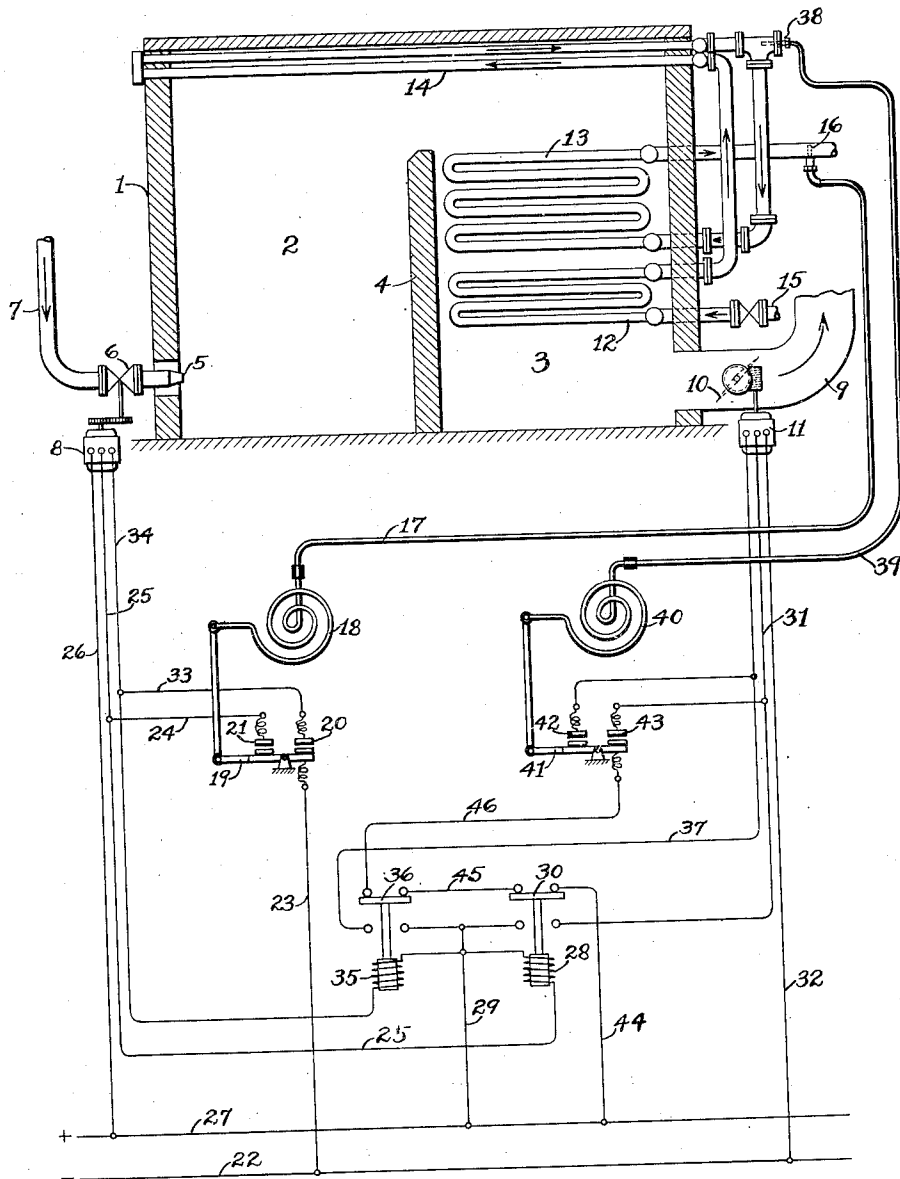
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FURNACE CONTROL

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FURNACE CONTROL

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This invention relates to furnace control, and in particular to provide an improved method of and apparatus for the control of oil heating furnaces, commonly known as pipe or tube stills.

In the operation of such a furnace it is of primary importance that temperatures at certain points be maintained substantially constant, to prevent spoilage and produce a good and uniform product, as well as to prevent possible damage to the still. At the same time the fuel supplied for heating the furnace should be burned in a manner and amount as efficient as possible.

One object of my invention is to control the combustion in such a furnace to maintain a substantially constant temperature at a desired point in the furnace, for instance that point of heat transfer where the greatest possibility of spoilage to the product would exist if the temperature were allowed to deviate widely from a predetermined value.

Another object is to so control the operation of the furnace that the temperature of the oil leaving the still will be maintained substantially constant.

A further object is to so control the operation of the furnace that combustion of the fuel burned in heating the furnace will occur in as efficient a manner as possible.

Still other objects will become apparent from the description hereinafter.

In the drawing, the one figure is a somewhat diagrammatic representation of a tube still with the control applied.

I have indicated generally, at 1, an oil heating furnace or tube still in connection with which will be described a preferred embodiment of my invention. A combustion chamber 2 communicates with a second chamber 3 over the top of a bridge wall 4 separating the main portions of said chambers. Oil or other fluid fuel for heating the still is supplied to the combustion chamber 2 by a burner or burners 5, at a rate depending upon the adjustment of a valve 6 located in the fuel supply line 7, the valve being adjusted as hereinafter described by reversible means shown as a reversible electric motor 8. Air for combustion is admitted around the burners 5, being drawn in by the draft or suction of a stack (not shown) to which is connected a duct 9; the hot gaseous products of combustion from the combustion chamber 2 passing over the bridge wall 4 and through the chamber 3 to the duct 9 wherein their volume flow is regulated by a damper 10 positioned in

the duct by a reversible means shown as a reversible motor 11.

Positioned within the furnace in heat conducting relation with the hot gases flowing there-through are the banks or groups of tubes 12, 13 and 14 through which flows the oil to be heated. The tube bank 14, commonly known as the roof tubes, is preferably laid across below the roof of the furnace, spanning both chambers 2 and 3, and subjected mainly to radiant heat. The tube banks 12 and 13, preferably are located in the chamber 3, and subjected mainly to convection heating. Oil to be heated enters through the supply pipe 15 and flows in the direction of the arrow through the tube bank 12, then to and through the roof tubes 14 from which it flows to and through the tube bank 13, from which it leaves the still, to other apparatus (not shown) in the general distillation process.

The equipment and arrangement of same which I have so far described is common in this type of tube stills. The various pipes and fittings shown in the drawing as connecting the tube banks 12, 13 and 14 are to be considered as a part of the still, even though they are shown as located external to the general casing or housing of the furnace.

It is known to those familiar with the art that the temperature of the oil in the roof tubes 14 must be held at a reasonably constant value or coking of the oil will result, with possible spoilage of the oil or damage to these tubes. It is also known that a predetermined temperature of the oil leaving the still must desirably be maintained to produce the best product. The maintenance of these two temperatures at substantially predetermined values is of prime importance in the operating of the heating furnace or tube still, and must be accomplished regardless of efficiency of combustion of the fuel entering through the burner 5. In addition, however, it is desirable to burn the fuel in just as efficient a manner as possible, which besides accomplishing a saving in fuel will result in a better control of the temperatures above mentioned through the control of the amount of heated products of combustion passing through the tube groups, by regulation of excess air. The control of temperatures and combustion are, it will be seen, interrelated.

I have found that a very accurate control of the temperature of the oil leaving the still may be had through a control of both the fuel fed to the furnace and the air supplied for com-

bustion, from an indication of the outlet oil temperature.

Responsive to variations in the outlet oil temperature is designated in the drawing a gas filled thermometer system, the bulb 16 being located conveniently in the conduit through which the oil leaves the still and connected by a capillary 17 with a Bourdon tube 18 adapted to move a contactor 19 upon deviation of the exit oil temperature from a predetermined value.

The wiring from the contactor 19 is so arranged that should the temperature of the exit oil vary in one direction or the other from a predetermined value, the proper circuits will be closed in the contactor 19 to energize for operation the reversible motor 8, and simultaneously the reversible motor 11, in one direction or the other, as will be explained hereinafter.

If, for example, the temperature at the bulb 16 should decrease below the predetermined value, then the gas pressure in the thermometer system being cooled will become lower, causing the Bourdon tube 18 to tend to close, its free end moving in a clockwise direction, moving the contactor 19 in a direction to close circuit with the contact 21. Thus a circuit would be completed from the power main 22 through the conductor 23, the contact 21, the conductor 24 and the conductor 25 to the reversible motor 8, returning through the conductor 26 to the power main 27. Simultaneously a circuit will be completed from the conductor 25 to energize the solenoid 28 of a pair of relays; through the conductor 29 to the power main 27, to the end that the contact bar 30 of the solenoid 28 will move downward and complete circuit between the conductor 29 and a conductor 31 to the reversible motor 11, returning to the power main 22 through the conductor 32.

The completion of the circuits above detailed to the reversible motor 8 for opening the valve 6 and simultaneously to the reversible motor 11 for opening the damper 10 will result in an increase in the rate of feed of fuel and air for combustion to the furnace, whereby the temperature of the oil leaving the still will be returned toward its predetermined value.

It will be apparent that should the temperature of the exit oil at the thermometer 16 increase above the desired predetermined value, the reverse operation will occur, in that the increased temperature, resulting in an increased pressure within the gas filled thermometer system will tend to move the Bourdon tube 18 in a counter-clockwise direction, causing a closure of contactor 19 with the contact 20, which through the conductors 33 and 34 completes circuit to the motor 8 for operation in a throttling direction of the fuel valve 6. Simultaneously an energization of the solenoid 35 causes the contact bar 36 to complete circuit through the conductor 37 to the reversible motor 11 for operation in a throttling direction of the damper 10.

After primarily correcting the rate of supply of fuel and air to the furnace for combustion in accordance with variations in the exit oil temperature, I introduce a secondary control measure responsive to variations in the temperature in the roof tubes of the still, and effective as a readjustment to the rate of supply of air to the furnace, through a further positioning of the damper 10. I have found that by causing my secondary or readjusting control to be responsive to variations in the temperature of the oil flowing through the roof tubes 14, I

have a distinct advantage over a control responsive to variations in temperature in the furnace itself, even though taken near the roof tubes. This due to the fact that were the temperature of the gases or at a point in the furnace itself to be held constant, the rate of feed of oil through the still might be decreased to a value where the oil temperature in the roof tubes would exceed the temperature at which coking is experienced. In other words, if the amount and corresponding velocity of the oil flowing through the roof tubes decreases, the temperature of the tubes and of the oil will tend to rise, for the heat applied to the outside of the tubes will not be carried away as rapidly. It is therefore not safe to depend upon the temperature at a point in the furnace as an indicator of the temperature of the oil within the tubes.

Responsive to variations in the temperature of the oil leaving the roof tubes 14 is shown in the drawing a gas filled thermometer system of which 38 is the bulb, 39 a connecting capillary and 40 a Bourdon tube; the bulb 38 being in heat-conducting relation with the oil. The Bourdon tube 40 through the proper linkage, positions the contactor 41 to close a circuit with the contact 42 or with the contact 43 in case the temperature at the bulb 38 deviates in one direction or the other from a predetermined value, allowing a circuit to be completed from the power main 27 through the conductor 44, contact bar 30, conductor 45, contact bar 36, the conductor 46, to either the conductor 31 or conductor 37, energizing the motor 11 for positioning, in the proper direction, the damper 10. The wiring between the reversible motors, the contactors and the relays being so arranged as to give precedence to the primary control (contactor 19) from variations in temperature of the oil leaving the still. This will be apparent through the fact that when the contactor 19 closes circuit and energizes either solenoid 28 or 35, energization of either of the solenoids breaks the circuit to the contactor 41, making said contactor inoperative electrically.

Tube stills or oil heating furnaces of the continuously operating pressure type will normally be operated at a maximum wherein the rate of flow of the oil to be heated will not vary widely, and will be left uncontrolled; that is, the flow of oil to the still being in accordance with the output of other apparatus in the refining process. The rate of heat absorption will vary with the rate of oil flow as well as the condition such as temperature or pressure (either initial or back-pressure) of the oil. The heat generated in the furnace, however, will vary depending upon the rate of fuel feed, the calorific value of the fuel and the amount of air supplied for combustion.

According to my invention, the rate of supply of fuel and air for combustion is controlled to maintain substantially constant temperatures, and as efficient combustion as is possible. The temperature of the final product of the still, namely the oil leaving the still, is dependent upon total heat absorption, that is, the total amount of heat which the oil has absorbed in its passage through the still, and this naturally is based upon the rate of combustion or the supply of fuel and air to the furnace. Should a drop in the outlet oil temperature be experienced, the rate of fuel feed will be increased and the damper opened. Any time lag, before the effect of the increased rate of supply of fuel is re-

flected in change in the outlet oil temperature, will be obviated by temporary increase in the outlet oil temperature due to the increase in excess air immediately upon an increase in the fuel and air supply.

Furnace temperature being a function of excess air and the rate of combustion, will immediately tend to rise, and this increase in temperature, reflected in a rise in temperature of the roof tube oil, will result in a slight readjusting or throttling of the damper.

It is desirable to maintain the furnace temperature under the roof tubes as high as possible without coking the oil on the inside of the tubes. It is usually necessary, however, to operate at a relatively high excess air to keep the roof tube oil temperature down. The limiting factor of roof tube oil temperature being the rate of heat absorption, while the limiting factor for furnace temperature being excess air and rate of combustion. Under normal conditions when operating at full capacity and with the furnace temperature being held constant, a definite excess air will result, which will be an indication of combustion efficiency.

Maintenance of furnace temperature is the limiting factor of combustion efficiency, and through its control the most economical use of the fuel being burned will be accomplished. If the rate of oil flow through the still decreases, the rate of combustion must be decreased, which for the same excess air will result in a lower furnace temperature. However, if furnace temperature is to be held constant, the excess air must be reduced, which would mean that the combustion efficiency would be increased as the rate of combustion is reduced.

Through the control of both fuel and air for combustion in response to variation in the temperature of the oil leaving the still, I have the advantage of tending to maintain the exit temperature substantially constant, which is desirable from the standpoint of obtaining a good and uniform product.

I obtain the further advantage of maintaining the heat absorption in the roof tubes as high as possible without damage to the oil or to the tubes, through a readjustment or secondary control of the supply of air for combustion from variations in the roof tube oil temperature.

In addition to maintaining the temperature of the product leaving the still at a desirable value and the rate of heat absorption in the roof tubes as high as possible, I utilize the fuel supplied for heating the furnace in the most efficient manner.

While I have described and illustrated a preferred embodiment of my invention wherein an oil heating furnace is of a certain design both as to general arrangement and location of tubes, and is heated by the combustion of liquid fuel, it is apparent that variations may be had without departing from the spirit of the invention. For instance, the general shape of the furnace and the number and relative locations of tube banks may vary. Likewise gaseous or solid fuels might equally as well be used to heat the furnace, and the air supply might be from a fan rather than depending upon the suction of a stack.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. In the control of furnaces for fluid heating, the method which consists in simultaneously varying the rate of supply of combustible fuel and the rate of supply of air to the furnace in

response to temperature changes in the fluid leaving the heater, and readjusting only the rate of supply of air in response to variations in temperature of the fluid at a second predetermined point in the fluid flow.

2. In the control of furnaces for fluid heating, the method which consists in simultaneously varying the rates of supply of the elements of combustion to the furnace in response to variations in temperature of the fluid leaving the heater, and readjusting only the rate of supply of but one element of combustion to the furnace in response to variations in temperature at a second location in the fluid flow through the heater.

3. In continuously heating oil in a tube heater, the method which consists in simultaneously varying the rate of supply of combustible fuel and the rate of supply of air to said heater in response to temperature changes in the oil leaving the heater, and further varying only the rate of supply of air in response to variations in temperature of the oil at a predetermined point in the heater.

4. In combination, a tube heater for continuously heating oil flowing therethrough, combustible fuel supplying means to the heater, means for supplying air to said heater, control means for the fuel supplying means, regulating means for the air supplying means, means sensitive to variations in temperature of the oil leaving said heater for positioning said control means and said regulating means, and means sensitive to variations in temperature of the oil at a second predetermined point in the heater for also positioning only said regulating means.

5. In combination, a heat exchanger for continuously heating fluid flowing therethrough, comprising a furnace, a group of tubes located near the roof of said furnace, a plurality of groups of tubes located in the gas passages of said heat exchanger, said groups of tubes connected together for fluid flow therethrough and in heat-conducting relation with said furnace; combustible fuel supplying means for said furnace, means for supplying air for combustion to said furnace, an electric motor for controlling the fuel supplying means, a second electric motor for controlling the air supplying means, a thermostat sensitive to variations in temperature of the fluid leaving the heat exchanger, an electric contactor positioned by said thermostat, said contactor effective to energize said electric motors, a second thermostat sensitive to variations in temperature of the group of tubes located near the roof of said furnace, an electric contactor positioned by the last-named thermostat, said last-named contactor effective to energize said second-named electric motor, and means giving precedence of the first-named contactor over the second-named contactor.

6. In a control of a furnace for fluid heating, the method which consists in simultaneously varying the rates of supply of the elements of combustion to said furnace in response to variations in temperature at a predetermined point in the fluid flow, and further varying only the rate of supply of but one element of combustion to said furnace in response to variations in temperature at another predetermined point in the fluid flow.

7. In combination, a heat exchanger for continuously heating fluids flowing therethrough, comprising a furnace, a group of tubes located near the roof of said furnace, a plurality of groups of tubes located in the gas passages of

- said heat exchanger, said groups of tubes connected together for fluid flow therethrough and in heat conducting relation with said furnace; combustible fuel supplying means for said furnace, means for supplying air to said furnace, electrically actuated control means for the fuel supplying means, electrically actuated regulating means for the air supplying means, means responsive to variations in the temperature of the fluid leaving the heater for positioning said control means and said regulating means, and means responsive to variations in temperature of the fluid in one of the groups of tubes for also positioning said regulating means only.
8. Apparatus for controlling combustion in a furnace for fluid heating, comprising in combination, means for supplying the elements of combustion to said furnace, a first thermostat responsive to temperature of the fluid leaving the heater for controlling said means, a second thermostat responsive to temperature of the fluid at a predetermined point in the fluid conducting pipe for modifying the control of said means as to one of the elements of combustion, and means giving precedence of the first-named thermostat over the second-named thermostat.
9. Apparatus for controlling combustion in a furnace for fluid heating, comprising in combination, means for supplying fuel for combustion to said furnace, means for supplying air to support combustion to said furnace, a first thermostat responsive to temperature of the fluid leaving the heater for controlling both of said means, a second thermostat responsive to temperature of the fluid at a predetermined point in the fluid conducting pipe for controlling said second-named means, and means giving precedence of the first-named thermostat over the second-named thermostat.
10. In the control of furnaces for fluid heating, the method which includes subjecting the supply of combustible fuel and the supply of air simultaneously to control responsive to temperature of the fluid leaving the heater, subjecting the supply of air to control responsive to temperature of the fluid at another predetermined point in the heater, and allowing the former control to take precedence over the latter.
11. In the control of furnaces for fluid heating, the method which includes subjecting the supply of elements of combustion to the heater simultaneously to control responsive to temperature of the fluid leaving the heater, subjecting the supply of one of the elements of combustion to control responsive to temperature of the fluid at another predetermined point in the heater, and allowing the former control to take precedence over the latter.
12. The method of controlling a closed fluid heater having surfaces heated primarily by radiation and other surfaces heated primarily by convection and supplied with the elements of combustion, which includes simultaneously varying the rates of supply of the elements of combustion to the furnace in response to variations in temperature of the convection heated surfaces, and further varying the rate of supply of one of the elements of combustion in response to variations in temperature at the radiant heated portion.
13. A tube heater for continuously heating fluid flowing therethrough, comprising in combination, a group of tubes located in said heater to receive radiant heat, a group of tubes located in the heater to receive heat by convection, fuel supplying means for the heater, means for supplying air to the heater, control means for the fuel supplying means, regulating means for the air supplying means, means sensitive to variations in temperature of the fluid at a predetermined point in the group of tubes heated by convection for positioning said control means and said regulating means, and means sensitive to variations in temperature of the fluid at a predetermined point in the group of tubes radiantly heated for positioning said regulating means only.
14. A tube heater for continuously heating fluid flowing therethrough, comprising in combination, a group of tubes located in said heater to receive radiant heat, a group of tubes located in said heater to receive heat by convection, means for supplying the elements of combustion to said heater, means responsive to the temperature of the fluid leaving the heater for controlling said means, and means sensitive to variations in temperature of the fluid at a predetermined point in the group of tubes radiantly heated for modifying the control of the first-named means as to one of the elements of combustion only.
15. In combination, a tube heater for continuously heating fluid flowing therethrough, a group of tubes located in said heater to receive radiant heat, a group of tubes located in the heater to receive heat by convection, means for supplying the elements of combustion to the heater, means sensitive to variations in temperature of the fluid at a predetermined point in the group of tubes heated by convection for controlling said means, means sensitive to the temperature of fluid at a predetermined point in the group of tubes radiantly heated for modifying the control of said first-named means as to one of the elements of combustion, and means giving precedence of the second named means over the last-named means.
16. The method of controlling combustion in a furnace for heating surfaces primarily by radiation and other surfaces primarily by convection, and supplied with the elements of combustion, which includes proportioning the elements of combustion for most efficient combustion, readjusting said proportions for a desirable relation between radiant and convection heating, and allowing the former proportioning to take precedence over the latter.
17. The method of controlling the furnace of a fluid heater having a section primarily adapted to be heated by radiation and another section primarily adapted to be heated by convection which includes, simultaneously subjecting the supply of fuel and air to the furnace to control responsive to the temperature of the fluid at a predetermined point in the section primarily heated by convection, and subjecting the supply of air only to control responsive to the temperature at a predetermined point in the radiantly heated section.
18. The method of controlling the furnace of a fluid heater having a section primarily adapted to be heated by radiation and another section primarily adapted to be heated by convection which includes, simultaneously subjecting the supply of fuel and air to the furnace to control responsive to the temperature of the fluid at a predetermined point in the section primarily heated by convection, subjecting the supply of

air only to control responsive to the temperature at a predetermined point in the radiantly heated section, and allowing the former control to take precedence over the latter.

supply of fuel and air to the furnace to control responsive to the temperature of the fluid at a predetermined point in the section primarily heated by convection, subjecting the supply of air to control responsive to the temperature at a predetermined point in the radiantly heated section, and allowing the former control to take precedence over the latter.

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5	19. The method of controlling the furnace of a fluid heater having a section primarily adapted to be heated by radiation and another section primarily adapted to be heated by convection which includes, simultaneously subjecting the	80
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