

Oct. 25, 1938.

J. EATON

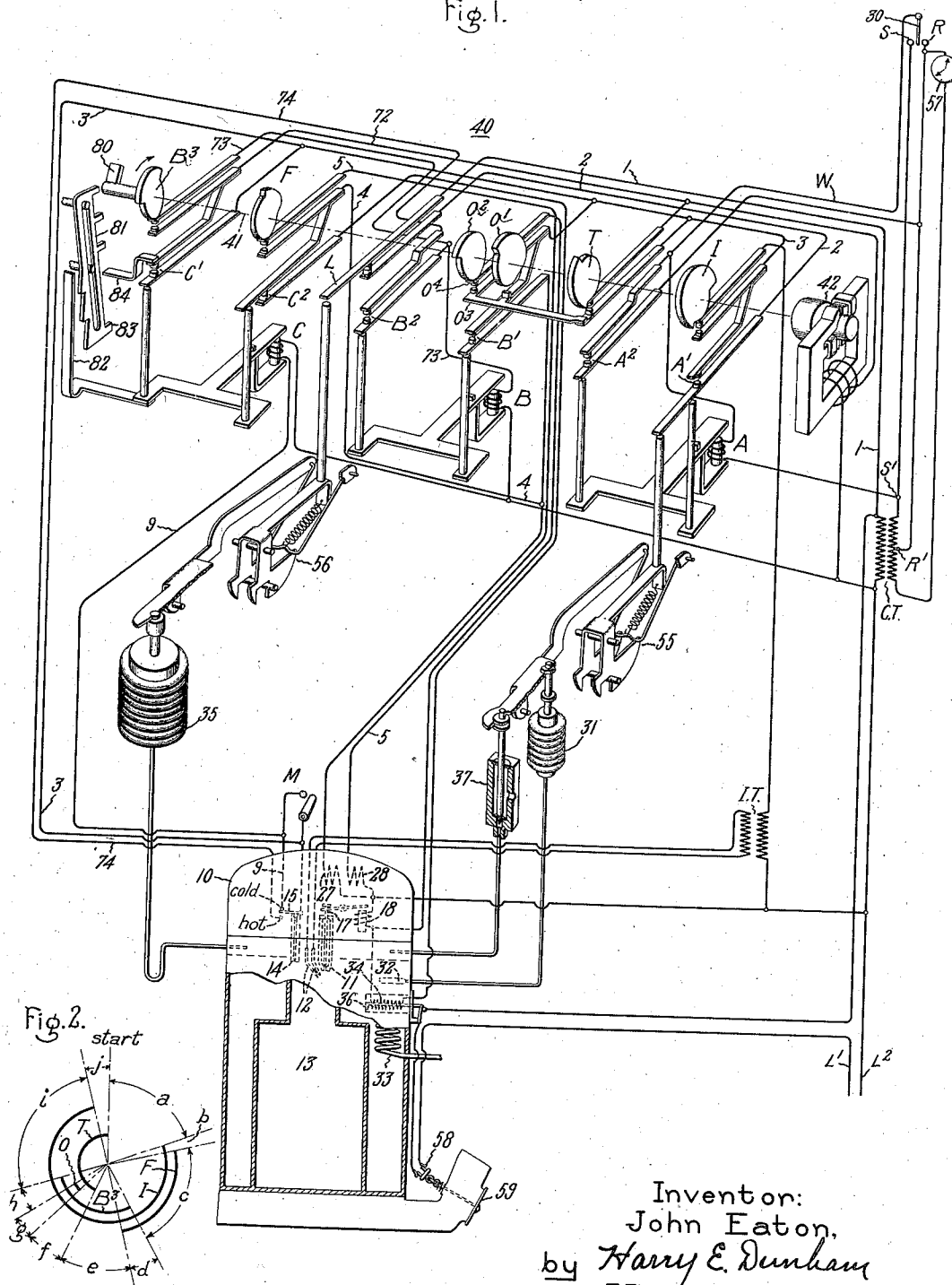
2,134,550

BURNER CONTROL

Filed July 14, 1934

3 Sheets-Sheet 1

Fig. 1.



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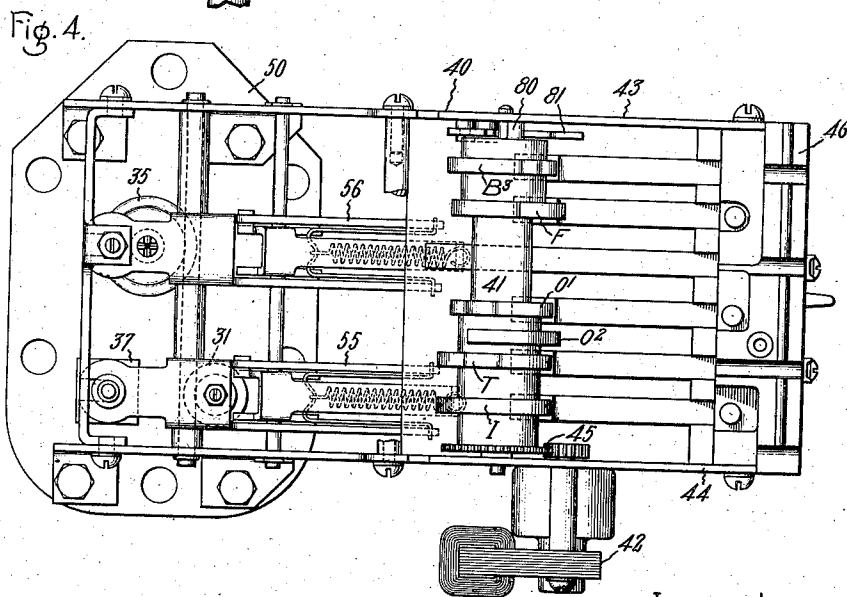
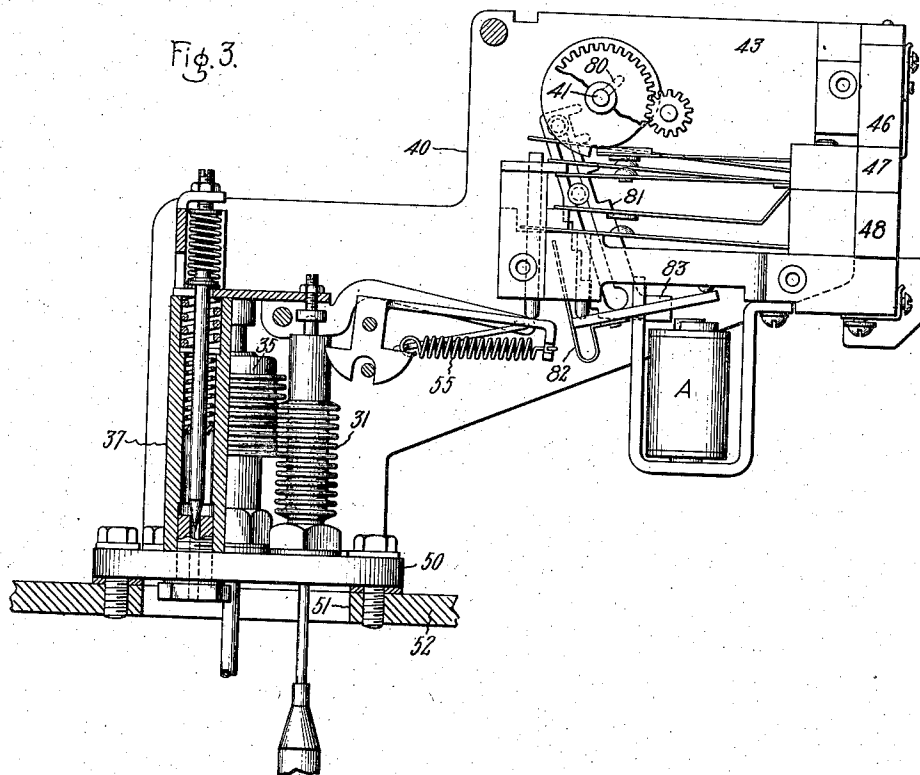
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3 Sheets-Sheet 2



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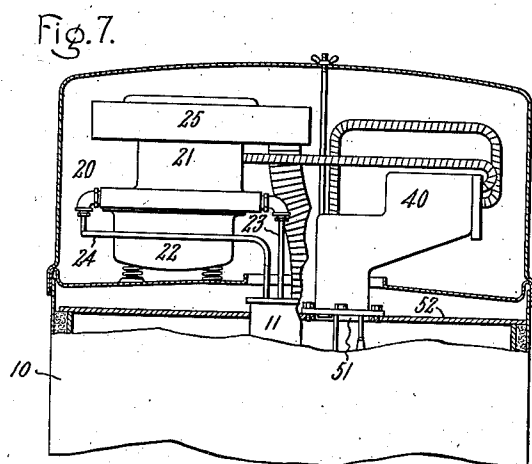
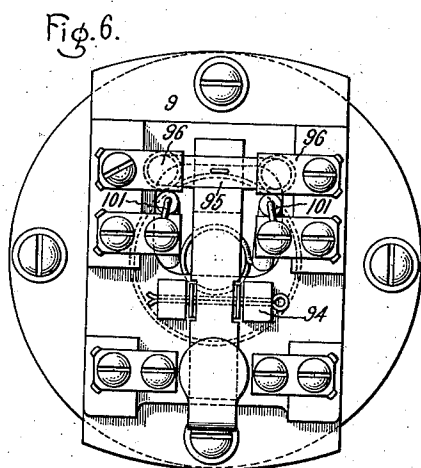
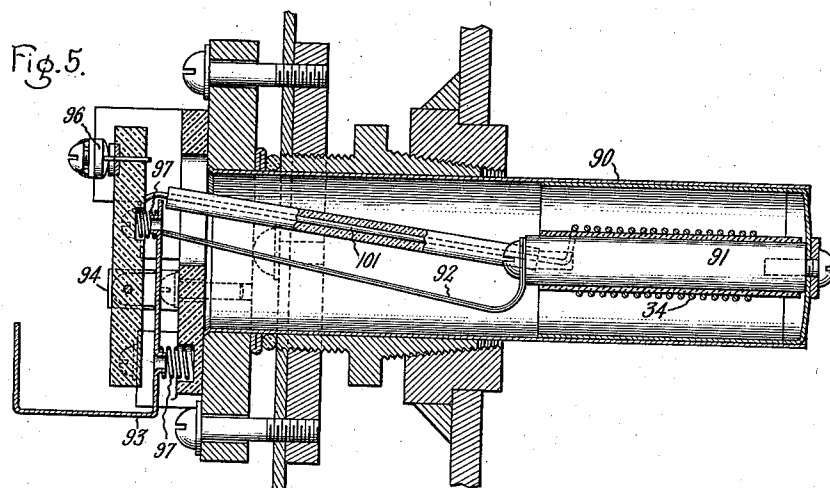
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BURNER CONTROL

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,134,550

BURNER CONTROL

John Eaton, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application July 14, 1934, Serial No. 735,103

2 Claims. (Cl. 122-504)

The invention relates to automatic fuel burner control systems and apparatus such as used with oil fired boiler furnaces for heating homes or in other similar service.

The principal object is to provide improvements which insure the maximum safety in the automatic control and operation of the fuel burner as well as safe operation of the boiler furnace.

A further object is to provide an improved form of boiler low water cutoff for preventing operation of the fuel burner in case the boiler water level falls below a predetermined safe value in a steam or vacuum vapor heating system.

A still further object is to provide an improved form of combined room thermostat and limit control for effecting operation of the fuel burner in accordance with both room temperature and certain other conditions such as boiler temperature, domestic hot water temperature, steam pressure or the like.

Another important object is to provide a fully automatic fuel burner control system and apparatus which fails safe by insuring against continued operation of the burner in case of accidental failure or faulty operation of the important safety control elements, such as the flame detector, the low water cutoff, the fuel supply control and the like.

It is also a special object to provide an improved unitary structural arrangement for the automatic fuel burner and boiler control mechanism whereby reliability, ease of installation, inspection and adjustment of the various automatic operating elements are obtained.

A preferred form of automatic oil burner control system and apparatus embodying the improvements of the present invention is illustrated in the accompanying drawings. Fig. 1 is a schematic diagram showing the improved form of oil burner safety control system and apparatus applied to an electric motor driven oil burner mechanism adapted for use in combination with a vacuum vapor house heating boiler; Fig. 2 is a sequence diagram indicating the predetermined timed relations in which the various operations involved in starting the oil burner and establishing combustion are accomplished under the control of a room thermostat, a boiler thermostat or similar master control element, by the improved safety control system and apparatus shown in Fig. 1; Fig. 3 shows more fully the cooperating arrangement and detailed structure of the various elements of the oil burner timing control mechanism and certain of the safety control elements shown diagrammatically in Fig.

1; Fig. 4 is a top view of the timing and safety control mechanism shown in Fig. 3; Fig. 5 is a sectional view of the improved low water safety control element embodied in the oil burner control system of Fig. 1; Fig. 6 is a front view showing the safety switch mechanism of the low water safety control element, and Fig. 7 is a view of the top part of the oil burner boiler showing more clearly the manner in which the oil burner mechanism and timing and safety control mechanism therefor is mounted on the boiler. To comply with the requirement of the Patent Office, a divisional application, Serial No. 11,100, was filed March 14, 1935, with claims directed to the improved oil burner control system illustrated in Fig. 1, which divisional application was issued as Patent No. 2,085,577 on June 29, 1937.

As diagrammatically shown in Fig. 1 the boiler furnace 10 is of the improved type described and claimed in the copending application of Henry S. Woodruff, Serial No. 676,651, filed June 20, 1933, and assigned to the assignee of my present invention. It will be understood, however, that the improvements of my present invention are applicable to control any ordinary type of automatically fired boiler or furnace.

The oil burner nozzle 11 supplies atomized oil which is ignited during the starting operation of the oil burner mechanism by an electric spark between electrodes 12 to establish combustion in the boiler combustion chamber 13, in the manner described in detail hereinafter. A quick acting flame detector 14 having a control switch 15 movable between the "cold" and "hot" positions is provided for detecting the presence or absence of combustion. As indicated the flame detector 14 is of the expansible heat responsive type although any quick acting type of flame detector may be employed.

An oil control valve 17 is shown incorporated in the oil burner nozzle 11 for starting and stopping the supply of oil into the combustion chamber 13. Oil valve 17 is normally closed and is opened only when the oil valve operating electromagnet 18 is energized. As pointed out hereafter electromagnet 18 is provided with a holding circuit for maintaining valve 17 open after it is once opened independently of the initial energizing circuit. As shown in Fig. 7 oil and air are supplied under pressure to the burner nozzle 11 from the electric motor operated oil burner blower compressor mechanism 20.

The oil atomizing nozzle 11 and oil valve 17 preferably are of the type described and claimed in my copending joint application, Serial No. 55

691,320, filed September 28, 1933, although the present invention is not limited thereto.

The oil burner motor compressor mechanism 20 preferably is of the type described and claimed in the copending application of Walter O. Lum, Serial No. 737,063, filed July 26, 1934, and assigned to the assignee of my present invention. The oil burner mechanism 20 has an electric driving motor 21 which drives a suitable oil and air pumping means located inside of the tank 22 for pumping oil and air under pressure into the tank. The air under pressure is supplied from tank 22 directly to the burner nozzle through the pipe 23 and the oil under pressure is supplied to the nozzle upon opening of oil control valve 17 through the pipe 24. Low pressure combustion air is supplied from the blower 25. As indicated diagrammatically in Fig. 1 the oil burner motor 21 is provided with a running winding 27 and a starting winding 28.

The oil burner mechanism is operated under the control of the room thermostat 30 to heat the water in the boiler 10 to supply steam or vapor to a room heating radiator system (not shown). In addition the oil burner mechanism is also operated under the control of the water thermostat 31. As shown the water thermostat 31 is of the expansible bellows type having the bulb 32 responsive to the temperature of the water in the boiler 10. The thermostat 31 serves to operate the oil burner mechanism to maintain the boiler water temperature above a predetermined value sufficient to heat an adequate supply of domestic hot water by means of the water heating coil 33 which is shown immersed in the boiler water.

A bellows 35 is responsive to the pressure in boiler 10 and serves to shut down the oil burner mechanism whenever an excessive pressure occurs. An improved form of electrically heated low water cutoff switch mechanism 36 having a heater 34 is provided for preventing operation of the oil burner mechanism whenever the boiler water level falls to an unsafe value. The detailed construction of the low water cutoff mechanism 36 is more clearly illustrated in Figs. 5 and 6, and will be described in detail hereinafter.

A vacuum relief valve 37 is provided for venting the boiler in accordance with the invention described and claimed in the copending application of Walter O. Lum, Serial No. 735,128, filed July 13, 1934, and assigned to the assignee of my present invention. The improved arrangement whereby the vacuum relief valve 37 is operated directly by the domestic water temperature control thermostat 31 is an improvement of my present invention.

In order to obtain a predetermined timed sequence of operation of the various elements comprising the oil burner mechanism, a timing control device indicated generally by the reference numeral 40 is provided. In the preferred form indicated diagrammatically in Fig. 1 and shown more in structural detail in Figs. 3 and 4, a cam shaft 41 is driven by the electric timing motor 42 which preferably is of the alternating current constant speed type such as commonly used in electric clocks. The cam shaft 41 carries a series of timing cams indicated respectively as B³, F, O¹, O², T, and I, all of which are rotated in unison in a clockwise direction as indicated by the arrow in Fig. 1 upon operation of the timing motor 42. Each of these cams has a corresponding cam operated switch contact mechanism arranged so that a definite series of switching operation is performed in timed sequence in the manner de-

scribed more fully hereinafter in connection with the operation.

Cooperating with the timing cam operated switch mechanism are a series of electromagnetically operated switches indicated as A, B and C, each having a pair of circuit controlling switch contacts indicated respectively as A¹, A², B¹, B² and C¹, C² in Fig. 1.

As shown more in detail in Figs. 3 and 4, the cam shaft 41 is rotatably supported between the side plates 43 and 44 with the motor 42 driving the cam shaft through the speed reducing gearing 45. The series of spring contacts operated by the cams B³, F, O¹, O², T and I are mounted between suitable blocks of insulating material 46 and 47. Likewise the spring switch contact mechanism of the electromagnetic switches A, B and C are mounted between blocks 47 and blocks 48, the operating electromagnets therefor being mounted below the contact mechanism as indicated in Fig. 3. The side plates 43 and 44 are secured to a cover plate 50. As indicated in Fig. 3 plate 50 is arranged to cover an opening 51 provided in the top wall 52 of boiler 10, being removably bolted in place with suitable gasket to seal the boiler wall.

The cover plate 50 carries the boiler water thermostat 31, the boiler pressure responsive bellows 35 and the vacuum relief valve 37, all as a unitary structure with the oil burner timing control mechanism 40. With this improved unitary arrangement, the expansible bellows thermostat 31 is connected through the overcenter snap action spring operating mechanism 55 to mechanically operate the contact switch mechanism A¹ of the electromagnetic switch A. At the same time the thermostat 31 operates the vacuum relief valve 37. Similarly the expansible bellows of the boiler pressure responsive device 35 operates the spring contact switch L through the agency of the overcenter spring snap action mechanism 56.

The operation of the improved burner control system and apparatus illustrated is as follows: When the room thermostatic switch 30 calls for heat, the running contact R is closed. When the room thermostat exceeds the temperature which it is adjusted to maintain the contact S is closed to stop the oil burner. While not shown in detail it will be understood that the electrically driven clock 57 serves to vary the setting of the room thermostat 30 to provide different day and night temperature in home heating service in the customary manner. When the room thermostat 30 closes the running contact R, the A electromagnetic switch or relay is energized. As shown in Fig. 1 the A relay is energized from the low voltage secondary winding of the control transformer CT having the primary winding thereof energized from a suitable alternating current power source L¹, L² with the contacts of the low water cutoff switch 36 and also the safety plug switch 58 connected in the primary circuit. The safety switch 58 is arranged to be opened by the pressure relief door 59 in case an excessive pressure should develop within the combustion chamber 13 of the oil burner 10. Likewise the low water cutoff switch 36 opens in case the water in boiler 10 reaches a dangerously low level, the precise manner in which the switch 36 is opened being described more fully hereinafter. However, upon the occurrence of either of these abnormal and unsafe conditions, the primary of the control transformer CT is deenergized thus effectively preventing further operation of the oil burner.

Under normal conditions the secondary winding of the control transformer CT is continuously energized and the relay A is energized therefrom through a circuit which may be traced from the intermediate point R¹ through contact R of thermostat 30 and thence through conductor W and the energizing winding of the electromagnetic relay A to the terminal S¹ of the transformer secondary winding. This results in operation of relay A to close both contacts A¹ and contacts A². Contacts A² shunt the room thermostat contact R and connect the energizing winding of relay A directly to the terminals R¹ and S¹ of the transformer, thus maintaining relay A continuously energized independently of the room thermostat 30.

Upon closure of contacts A¹ an energizing circuit for the operating winding of relay C is closed provided the movable contact 15 of the flame detector 14 is in the cold position as indicated in Fig. 1.

Normally the flame detector 14 operates its movable control contact 15 to the cold position quickly in response to the absence of combustion in the combustion chamber 13 of the boiler 10. Relay C is energized from the supply line L¹, through conductor 1, the normally closed contacts of the pressure limit switch L, conductor 2, contacts A¹, conductor 3, the cold contacts of the flame detector 14, conductor 9, the winding of relay C and thence to the supply line L².

Upon the resulting operation of relay C, contacts C¹ and C² are closed. Contact C¹ establishes an energizing circuit for the timing motor 42. This circuit is traced from conductor 3 which remains energized from the supply line L¹ as long as the contacts A¹ and the limit contacts L remain closed, through contacts C¹ and conductor 72, the energizing winding of timing motor 42 to the supply line L². Thereupon the timing motor 42 begins to rotate the series of timing cams carried by the shaft 41.

At the same time the opening of the normally closed contact C² opens the holding circuit of the oil valve operating electromagnet 18, this circuit being traced from the supply line L¹ through the safety door switch contact 58, the low water cutoff switch 36, the conductor 1, the limit switch L, the conductor 2, the contact A¹, conductor 3, the contact B¹, conductor 4, the normally closed contact C², the electric heater 34 of the low water cutoff switch and thence through the energizing winding of the valve operating electromagnet 18 to the supply line L². As will be pointed out hereinafter, this opening of the oil valve holding circuit is an important factor in insuring safe operation of the oil burner control.

As indicated in the sequence chart of Fig. 2, there is a considerable interval *a* of time after the starting of the timing motor 42 before the sequential operation of the timing cam switches begins. At the end of interval *a* the cam I closes its contacts to energize the primary winding of the ignition transformer IT, the circuit extending from the conductor 3 which remains energized as previously pointed out through the contacts of the cam switch I, the primary of the ignition transformer to the supply line L². The cam contact I remains closed to maintain the spark ignition electrode 12 energized from the high voltage secondary winding of the ignition transformer during almost the entire starting cycle of the oil burner. This insures that any oil supplied from the nozzle 11 at any time during this cycle is ignited. This insures that ignition is al-

ways present to ignite any oil delivered from the oil burner nozzle 11 at any time during the starting cycle.

After a relatively short time interval *b*, the cam F operates to close its contact and establish a circuit for energizing the start winding of the oil burner motor. After a longer time interval *c*, cam B³ operates to close its contact. Thereupon an energizing circuit for the relay B is established. This circuit is traced from conductor 3 which remains energized from the supply line L¹, as previously pointed out, through contact C¹, conductor 72, cam contact B³ and thence through conductor 73 and the energizing winding of the operating electromagnet of relay B. Relay B responds to close both of its contacts B¹, B². Upon closure of contact B¹ both the start and the run windings of the oil burner motor are energized. The circuit for the running winding is traced from the conductor 3 which remains energized from supply line L¹ under normal conditions through the cam contact B³, conductor 4 and thence through the run winding to supply line L². The energizing circuit of the start winding extends from conductor 4 through the previously closed cam contact F, conductor 5, and thence through the start winding to supply line L². The oil burner driving motor immediately starts operation of the oil and air pumping means to pump oil and air under pressure into the tank 22 and to supply air from the blower 25 to the combustion chamber 13 of the boiler. However, under normal conditions there is no oil supplied into the combustion chamber due to the fact that the oil supply control valve 17 remains closed.

During the interval *d* the oil burner motor comes up to speed and operates with both the running and the starting winding energized. At the end of interval *c* cam F opens its contact to deenergize the starting winding and the oil burner motor continues at full speed operation with the run winding energized alone.

During the intervals *d* and *e*, the operation of the oil burner motor serves to build up full pressure of the oil and air in the tank 22, at the same time the ignition electrodes are in operation to provide a spark for igniting the oil. At the end of interval *e*, the cam T closes its contact to maintain the timing motor 42 energized through a circuit which is independent of the initial energizing circuit established by closure of contact C¹ as previously described. Upon closure of the cam contact T, the conductor 3 is connected directly through the T contact to conductor 72, thus maintaining the energizing winding of the timing motor 42 energized. The closure of cam contact T also maintains the operating winding of B relay energized independently of contact C¹ as long as the cam contact B³ remains closed since the conductor 72 is connected to conductor 3 through the cam contact T.

All that remains to be done to establish combustion conditions is to open the oil valve 17 for a predetermined limited interval such that only a safe amount of unburned oil is projected into the combustion chamber 13 of the boiler 10 in case for some unknown reason there is failure to establish combustion. The opening of the oil valve for this predetermined limited interval *g* is accomplished by the joint action of the two timing cams O¹, O². Cam O¹ serves to close the energizing circuit for the operating electromagnet 18 of the oil valve at the end of interval *f* and cam O² operates to open this circuit at the end of the short limited interval *g*.

This is accomplished in the following manner: During the rotation of the cam shaft 41, the cam O¹ is moved into engagement with the spring contact O³ and the cam O² is moved into engagement with the spring contact O⁴. Upon continued rotation of cam shaft 41 during the time preceding the end of interval *f*, cams O¹ and O² serve to move the spring contacts O³ and O⁴ downwardly without, however, bringing these contacts into engagement. At the end of interval *f*, the cam O¹ disengages the contact O³ and the latter springs with a snap action into engagement with the contact O⁴. At the end of interval *g*, cam O² disengages the contact O⁴ and the latter springs out of engagement with contact O³. Thus contacts O³ and O⁴ remain in engagement only for the predetermined limited interval *g*.

The oil valve energizing circuit is traced from conductor 3, which remains energized as before from supply line L¹ through the bottom spring contact O³, the snap contacts O⁴ and thence directly through the energizing winding of the valve operating electromagnet 18 to the supply line L². The electromagnet 18 immediately operates the oil valve 17 to admit oil under pressure through the atomizing nozzle 11 into the combustion chamber 13. Under normal conditions the atomized oil is immediately ignited by the spark between the ignition electrodes 12 thus establishing combustion in the boiler.

The flame detector 14 at once responds to the presence of combustion and starts to operate its control contact from the cold side to the hot side. Upon the initial movement of the flame detector contact from the cold side, the energizing circuit of relay C is interrupted. Thereupon, contact C¹ opens and contact C² is re-closed.

Upon reclosure of contact C², the holding circuit for the oil valve operating electromagnet 18 is reestablished through the circuits previously traced. The reestablishment of the holding circuit for the oil valve operating electromagnet 18 provides an additional period for maintaining the oil valve open simultaneously with operation of the other elements of the oil burner mechanism after the limited combustion establishing period provided by the closure of cam contacts O³, O⁴ and the reopening thereof. These contacts are opened by operation of the cam O² to move the lower contacts O³ away from the upper contacts O⁴ at the end of the predetermined limited combustion establishing period *g*. In this way the oil valve is maintained open while the contactor of the flame detector 14 is moving from the cold side to the hot side as the flame detector continues to progressively respond to the presence of combustion in the combustion chamber 13. However, the movable contacts of the flame detector must reach the hot side before the expiration of the additional interval *h* during which the B³ cam contact is maintained closed. Since the flame detector 14 is of the quick acting type, it is able under normal operating conditions to move from the cold side during the interval *g* and reach the hot side before the end of the additional interval *h*.

As soon as the movable contact of the flame detector 14 reaches the hot side, an entirely new and independent energizing circuit for relay B is established. This circuit is traced from conductor 3 which remains energized as before through the movable contacts of the flame detector in the hot position, conductor 74, the

contacts B² which are closed upon initial closure of the relay B and the operating winding of relay B to the supply line L². The independent energizing circuit for the relay B just traced serves to insure continued operation of the oil burner motor and the oil valve opening independently.

This establishment of the independent energizing circuit for the relay B through the hot side of the flame detector contacts as just traced serve to continue operation of the oil burner motor with the oil valve opened independently of further operation of the timing control mechanism as long as combustion is maintained in the combustion chamber 13 and contact A¹ remains closed. However, the timing control motor 42 continues to operate during the interval *i* at the end of which the ignition cam contact is open to deenergize the ignition transformer and at the end of the final interval *j* the cam contacts T open to deenergize the operating winding of the timing motor 42 with the timing shaft 41 and all of the timing cams thereon returned to the initial "start" position.

Upon operation of the oil burner long enough to cause the boiler 10 to supply sufficient heat to the room heating radiator system to satisfy the room thermostat 30, the room thermostat operates to close on contact S and stop further operation of the oil burner. Upon closure on contact S the operating winding of relay A is short circuited and thereby deenergized. Thereupon the contacts A¹, A² are open. Upon opening of contact A¹ conductor 3 is disconnected from the supply line L¹ and all elements of the oil burner mechanism and control are deenergized. At the same time, the opening of contact A² disconnects the relay winding A from the mid terminal R¹ of the control transformer CT. The flame detector 14 quickly returns its movable contact 15 to the cold position in response to the absence of combustion in the combustion chamber 13. Thus the oil burner and control mechanism is in its initial condition ready for a new start whenever the room thermostat 30 again closes on contact R to run the oil burner.

The boiler water temperature thermostat 31 functions to mechanically close the contact A¹ whenever the boiler water temperature falls below a predetermined value. At the same time the vacuum relief valve 37 is opened by thermostat 31. Exactly the same sequence of the starting control operations are accomplished upon mechanical closure of the contact A¹ as previously described when A¹ was closed by energizing the operating winding of the relay A under the control of the room thermostat 30. In this case the boiler water thermostat 31 mechanically opens the contacts A¹ when the operation of the oil burner has been continued long enough to raise the boiler water temperature to the value at which the thermostat 31 is set to operate. As previously pointed out, water thermostat 31 permits the oil burner boiler to be operated in the summer time to supply all domestic hot water heating requirements under the control of the boiler water temperature thermostat 31. However, at any time, winter or summer, that the room temperature falls below the value at which the room thermostat is set to close the contacts R, the oil burner will automatically operate to supply heat to the house heating radiator system. The operation of the vacuum relief valve 37 by the boiler water temperature thermostat 31 effectively prevents a supply of heat in a vapor

system to the house heating radiators when the oil burner is operated under the control of the domestic hot water control thermostat. It will be understood that the thermostat 31 may, if desired, be arranged to respond directly to the temperature of the water in the domestic hot water storage tank instead of the temperature of the water in the boiler.

When it is desired to shut down operation of the oil burner for any considerable length of time, the main supply lines L¹, L² are disconnected from the source of power by means of a suitable disconnecting switch (not shown). This deenergizes all of the oil burner operating and control apparatus. During such a shutdown interval, ambient temperature changes may occur in combustion chamber 13 such that the contact 15 of the flame detector 14 may be moved from the cold position. Consequently, upon reenergizing lines L¹, L², relay C will remain deenergized and hence prevent starting the cycle of operation of the burner to establish combustion. In order to permit energization of relay C independently of the position of the flame detector contact 15, an auxiliary switch M is provided for shunting the cold contact of the flame detector 14. Thus upon closure of switch M relay C is energized and the normal cycle of operation previously described up to the end of interval g is accomplished. However, in case the switch M is maintained closed after the end of interval g, it will be impossible for the flame detector 14 to effect deenergization of the relay C so as to return the contact C² to the closed position and establish a holding circuit for the oil valve in the manner previously pointed out in case flame is established. Hence the oil valve holding circuit will remain open and the oil valve will close at the end of interval g. This cuts off the supply of oil and stops combustion in the furnace. However, upon release of the switch M after the interval g, the oil burner control mechanism will start a new cycle under normal conditions so that the next time combustion is established during the interval g, the flame detector 14 is capable of operating to deenergize the relay C and thus maintains combustion established thereafter. The switch M preferably is biased to the open position by means of a spring or other suitable means so that it cannot be left permanently in the closed position.

The improved control system and apparatus of the present invention automatically protects against the following changes or abnormal conditions.

If the oil fails to ignite during the limited period g during which the oil valve is opened by operation of the cams O¹, O², the flame detector contact will not leave the cold position and the oil valve will reclose at the end of period g. The oil burner motor 21 will continue to run until disconnected by opening of cam contact B³ at the end of interval h which in turn opens the contact B¹. The operation of the timing motor 42 continues to complete its cycle. In so doing the arm 30 which is carried by the cam shaft 41 engages with the upper tooth of the lockout ratchet member 31 to lift this member one notch. As long as the B relay remains energized due to the flame detector remaining in the cold position, the spring latch 32 serves to engage the first notch on the ratchet member 31 and maintain it in the advance position. As long as the contact A¹ is maintained closed by either the room thermostat or by the water thermostat 31, the

cam motor 42 continues to operate and start a new cycle. If flame again fails to be established during the limited interval g, the arm 30 engages the next tooth on the lockout ratchet 31 and advances this member another notch. Upon completion of the third cycle, the lockout ratchet 31 is advanced to bring the finger 33 into engagement with the arm 34 extending from the contact C¹ so as to open this contact. Thereupon the energizing circuit for the timing motor 42 as previously traced is interrupted and the oil burner mechanism is rendered inoperative until the difficulty causing the failure of establishment of combustion is corrected.

In case combustion is established during either the second or the third attempt, the flame detector 14 moves from the cold position and thereby deenergizes the relay C. This disengages the locking pawl 32 from the ratchet member 31 and permits the latter to return to its initial position. It is evident that the lockout ratchet mechanism may be reset at any time by interrupting the main power circuit L¹, L².

Whenever the boiler pressure exceeds the value at which the pressure responsive device 35 is set to open the limit contact L, the conductor 3 is disconnected from supply line L¹, thus deenergizing all parts of the oil burner mechanism and control. When normal boiler pressure conditions are restored, a new starting cycle will begin whenever the room thermostat 30 or water thermostat 31 calls for heat.

Should the boiler water level fall below a predetermined value, the contacts of the low water cutoff device 36 will be operated to disconnect the conductor 1 from the supply line L¹ and thereby deenergize all of the equipment. As more clearly shown in Fig. 5, the low water cutoff mechanism consists of a tube 90 which is mounted in a suitable opening provided in the side of the boiler 10 at the minimum safe low water level line. The tube 90 has a post of heat conducting material 91 mounted in the end thereof immersed in the boiler. A bimetallic thermostatic element 92 is mounted at the free end of the post and extends into latching relation with the cutout switch 93. As shown in Fig. 6, the switch 93 is pivotally mounted on the post 94 and carries the movable bridging contact 95 which is normally maintained in engagement with the cooperating stationary contacts 96. The switch 93 is normally biased to the open position by the springs 97.

Surrounding the post 91 is the electrical heater winding 34 which is provided with the two terminal connections 101 so that it may be connected in the holding circuit of the oil valve operating electromagnet 13 as indicated in Fig. 1. This connection of the low water cutout heater in the holding circuit of the oil valve operating electromagnet not only reduces the current therein but effectively insures that in case the heater should accidentally happen to burn out or fail, it will prevent maintaining the oil valve open to supply fuel into the furnace combustion chamber. Thus upon any failure of the low water cutout heater energizing circuit, continued heating of the boiler is rendered impossible due to the fact that the oil valve cannot be maintained open under this condition.

In operation, as long as the boiler water surrounds the tube 90, the heat generated by the heater 11 is conducted through the post 91 to the tube 90 and thence into the boiler water at a rate which maintains the temperature of the

thermostatic element 92 below the value at which the switch contact 93 is released. However, as soon as the boiler water level falls below that of the tube 90, the heat accumulates in the post 91 and is transmitted to the thermal element 92 to raise the temperature of the latter. At a predetermined temperature the free end of the thermal element 92 is moved to disengage the switch member 93 and permits the spring 97 to operate the bridging contact 95 to the open position. This disconnects all of the oil burner mechanism and control apparatus from the supply line L¹ as indicated in Fig. 1.

In a normal starting cycle, if combustion should be established at any time before the interval *g*, as might occur due to a leaky oil valve, protection against continued operation of the oil burner mechanism is obtained as follows:

As soon as flame appears in the combustion chamber 13, the flame detector moves its contact from the cold side, thus deenergizing relay C. Thereupon contact C¹ is opened which in turn causes the timing motor 42 to be deenergized. The opening of contact C¹ also deenergizes relay B, thus allowing contact B¹ to open and stop operation of the oil burner motor 21. As a result combustion is extinguished and the flame detector 14 again moves its contact to the cold side. Thereupon relays C and B are again energized and the starting cycle is resumed at the point of interruption. If this occurs before cam contact S has opened, the process of momentarily establishing flame and operation of the flame detector to stop the oil burner mechanism in the manner just described will be repeated and the cycle will again be interrupted. However, as soon as the cam contact S has opened, as will eventually happen if it is not open at the first occurrence of premature combustion, the oil burner motor 21 will not start since the starting winding is disconnected. This permits the timing motor 42 to continue the timing cycle without the oil burner motor operating. Continuation of the cycle will advance the lockout ratchet mechanism one notch. During the second cycle flame detection due to a leaky oil valve will again cause an interruption of the cycle but will not reset the lockout mechanism because the second tooth of the lockout ratchet member 81 is in engagement with the actuating arm 80. The second cycle is completed in the same way as in the first. In case the oil valve has cleared itself of the dirt or other obstruction causing leaking during the second or third cycle, premature combustion prior to the interval *g* will not be obtained and the normal starting sequence will result. However, in case the oil valve continues to leak the control will automatically lock out after three unsuccessful cycles. In the normal starting cycle, the lockout ratchet member 81 is reset by deener-

gization of relay C only during the oil valve opening period *g* when the flame detector leaves the cold contact.

Beginning a starting cycle before the flame detector contact has reset to the cold side is prevented since the cam motor cannot start until contact C¹ closes and contact C¹ cannot close unless the flame detector is in the cold position.

If the starting cycle is interrupted by either voltage failure or by a change in setting of the water thermostat or room thermostat, the starting cycle will be successfully resumed at the point of interruption unless the interruption occurs after the cam contact F has opened. In this latter case a complete new starting cycle will follow the completion of the interrupted cycle.

While I have illustrated and described the improvements of the present invention embodied in a control adapted for steam or vapor oil fired boiler, it will be evident that substantially the same control may be applied to a hot water boiler. The only variations are that the low water cutoff is omitted and the pressure limit control 35 is replaced by a boiler water temperature limit control which functions to open the limit switch L in case the boiler water temperature reaches a dangerous value. In hot water systems, the heater of the low water cutoff device is replaced by a similar resistor which prevents reopening of the oil valve with the holding circuit energized upon a momentary voltage failure.

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

1. In combination, a boiler having an electric motor operated oil burner for heating the water therein, control means for the burner motor including an electro-responsive switch connected to open and close an energizing circuit for the burner motor and having a separate energizing circuit, a thermostatic switch for controlling the separate energizing circuit of said switch to start and stop operation of the burner motor in accordance with predetermined temperature conditions, and means responsive to boiler conditions connected for mechanically operating said switch to start and stop operation of the burner motor only when the separate energizing circuit of said switch is opened under the control of said thermostatic switch.

2. In combination, a boiler having an electric motor operated oil burner for heating the water therein, a temperature responsive device mounted on the boiler to be responsive to the temperature of the water therein, and control means for the burner motor including an electromagnetically operated switch mounted to be operated mechanically by said temperature responsive device, and separate thermostatic means for controlling the energizing circuit of said switch to operate the switch independently of said device.

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