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**2,849,990**

## ELECTRICAL SAFETY DEVICE FOR STEAM BOILERS

Filed Dec. 20, 1954

3 Sheets-Sheet 1

Fig. 1.

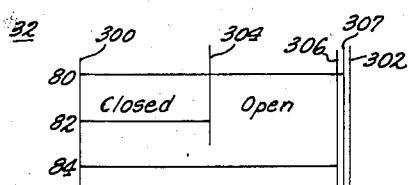
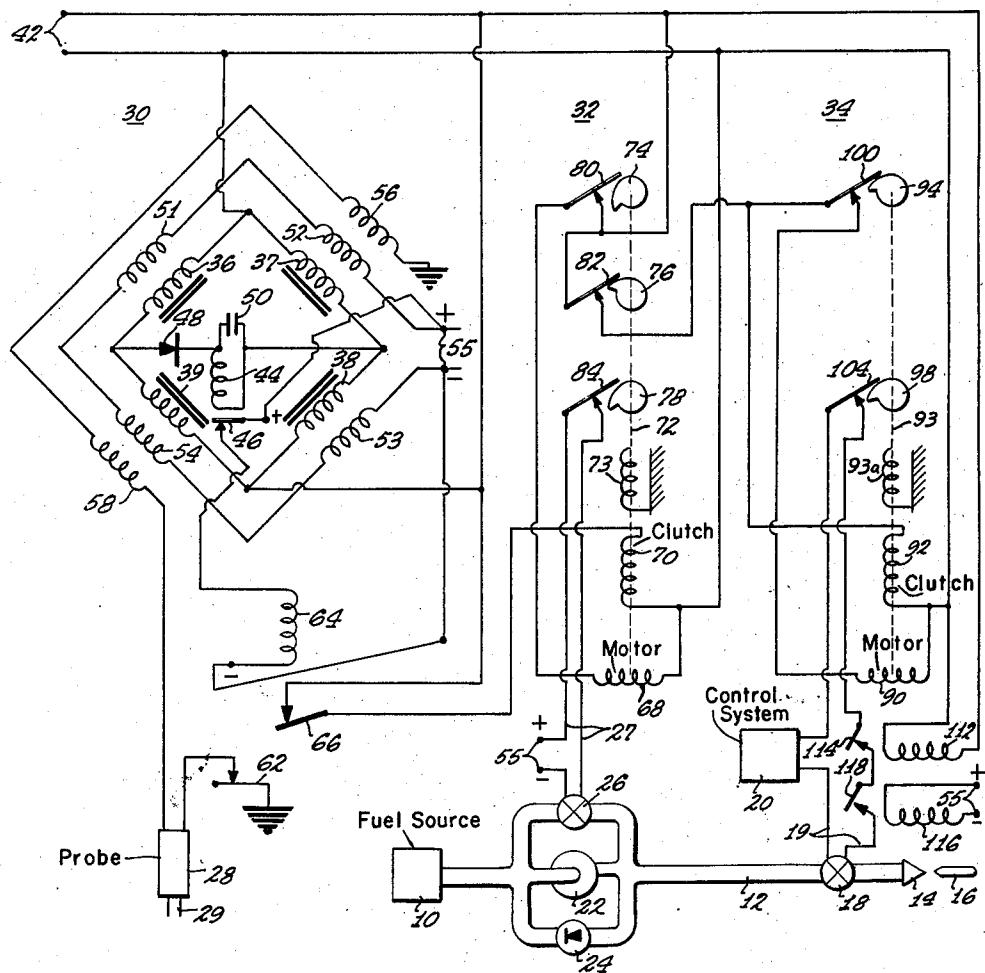


Fig. 2.

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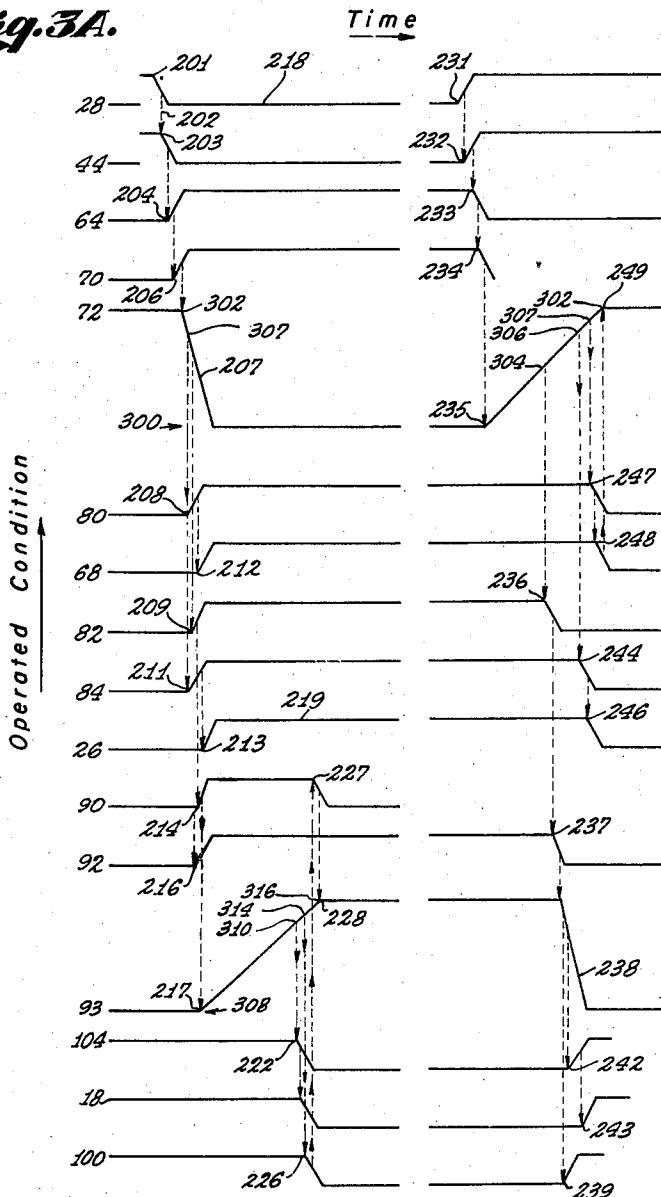
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3 Sheets-Sheet 2

Fig. 3A.



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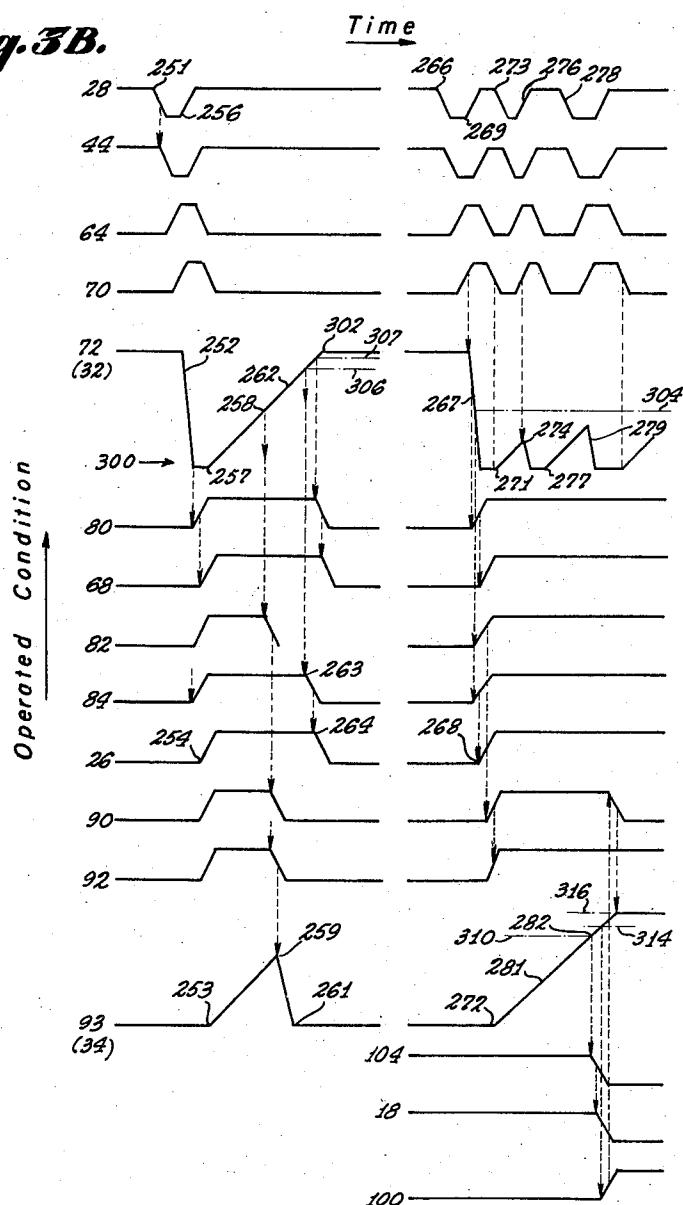
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ELECTRICAL SAFETY DEVICE FOR STEAM BOILERS

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3 Sheets-Sheet 3

Fig. 3B.



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## ELECTRICAL SAFETY DEVICE FOR STEAM BOILERS

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Application December 20, 1954, Serial No. 476,171

2 Claims. (Cl. 122—447)

This invention relates to safety systems, and has particular reference to a system for limiting and ultimately shutting off the flame under a steam boiler if the water level in the boiler should drop below a predetermined point.

It is an object of this invention to provide means for shutting off flow of fuel to a burner under a boiler in response to a condition requiring limiting or shutting off of the flame, such as the dropping of the water level in the boiler.

It is another object of this invention to provide a system whereby the disappearance of water at a certain point in the boiler system effects an instantaneous limiting but not an instantaneous shutting off of fuel to the burner.

It is a further object of this invention to provide a system wherein disappearance of water from a predetermined point in the boiler system will first limit the flow of fuel to the burner so as to decrease the burner intensity, and then if the water does not reappear within a few seconds, will shut off the flame entirely.

It is another object of this invention to provide a system in which the flame may be automatically shut off if the water should disappear, and in which the flame will come on only partially at first when the water does reappear at the particular point where its presence is being sensed.

It is another object of this invention to provide an improved amplifier having particular adaptability to a control system for a sensing means and shut-off valve actuated thereby.

In accordance with these and other objects which will become apparent hereinafter, a preferred form of the present invention will now be described with reference to the accompanying drawings wherein:

Fig. 1 is a circuit and schematic diagram illustrating the control system of the present invention.

Fig. 2 is a timing diagram illustrating schematically the operation of certain timing means used in the circuit of Fig. 1, and,

Fig. 3 (which is in two parts, 3A and 3B) is a series of timing curves illustrating the sequence of operation of the elements illustrated in Fig. 1.

Referring to Fig. 1, the control system of the present invention is shown applied particularly to a burner system for heating a boiler (not shown). The burner system comprises a source 10 of fuel, as for example, fuel oil, connected by means of a pipe or fuel line 12 to a burner 14, where the fuel is burned to create a flame 16. The flame 16 heats water in a boiler (not shown) into steam and the steam is transmitted by suitable piping to any suitable engine or other utilizing device.

The flow of fuel to the burner 14 through the fuel line 12 is controlled by a shut-off valve means 18, which is electrically operated from a source of control and voltage shown schematically at 20. When voltage is applied to the valve 18 through the control leads 19, the shut-

2

off valve 18 is maintained open to permit flow of fuel. When voltage is removed from the conductors 19, the shut-off valve 18 is automatically biased to closed position.

5 Normally, control of the valve 18 is effected in any desired manner from the control system 20, which serves to supply electric energy for the valve 18 in accordance with any desired programming, which may be manual if desired. As a safety measure, contacts 104, 114, and 10 118 are placed in series in the circuit connection 19 in order to automatically shut off the valve 18 in the case of existence or appearance of certain conditions requiring such stopping of fuel flow. The contacts 104, 114 and 118 are kept closed during normal operation of the system, but are open whenever abnormal conditions appear, as will become apparent hereinafter.

15 Also in the fuel line 12 is a fuel pump 22 situated between the fuel source 10 and the burner 14. The pump 22 is bypassed by a shunt connected check valve 24, which permits fuel to circulate idly back to source 10 in case the pressure in the fuel line 12 should increase beyond a predetermined point, such as would be the case if the shut-off valve 18 were closed.

20 The fuel burner system thus far described is also provided with a limiting valve means having a limiting position and a delimiting position. Such limiting valve means takes the form of an electrically operated valve 26 connected in shunt around the pump 22. When the valve 26 is closed, it is in its delimiting position, because there is no loss of pressure in the fuel line 12, and hence there is a full flow of fuel to the main valve 18. When the valve 26 is open, a portion of the fuel pumped by the pump 22 circulates back through the valve 26, thus lowering the pressure in the fuel line 12, with consequent decrease in fuel flow to the burner 14. Thus the open position of the valve 26 represents the limiting position of the limiting valve means.

25 The valve 26 is biased to closed position, and is opened by the application of voltage thereto through conductors 27 from a source of direct current 55. In series in the conductor circuit 27 is a contact 84 of a timer 32, which will be described hereinafter. When the apparatus is operating normally, the circuit is open at 84, so that the valve 26 is de-energized and closed. The appearance of 30 abnormal conditions causes energization of the valve 26 with the resultant limiting of fuel flow to the burner 14.

35 The particular condition which the circuit illustrated in Fig. 1 is especially adapted to be responsive to is the disappearance of water at a chosen point in the boiler system or in the tubing leading therefrom. At this chosen point, there is inserted into the boiler system, a probe 28 having a pair of spaced terminals 29 constituting a normally open switch. The presence of water between the terminals 29 completes the circuit and causes the switch 28 to be, in effect, closed. The probe 28 constitutes a sensing means responsive to a condition requiring limiting of fuel flow, i. e., disappearance of water, to actuate a pair of timer means 32 and 34 through an amplifier 30.

40 The general operation of the combination thus far described is such that a disappearance of water at the probe 28 actuates the timer 32 through the amplifier 30. The timer 32 in turn operates the limiting valve 26 to cut the intensity of the flame 16. The timer 32 also sets into timing operation the second timer 34, which, if the water does not return within a predetermined time, opens the circuit 19 to close the valve 18 and shut off the flame 16 completely.

45 Upon return of the water at the probe 28, the amplifier 30 causes the timer 32 to effect operation of the timer 34 after a predetermined time, thereby opening the valve 18.

The valve 26, however, is kept open by the timer 32, for a further time, so that the flame 16 returns initially only at its low value. If the water remains present for a further predetermined time, then the valve 26 is finally closed by the timer 32, and fully normal operation is resumed.

The particular construction of the principal components, namely the amplifier circuit 30, the timer 32, and the timer 34 will now be described.

The amplifier 30 is a magnetic amplifier comprising four windings, 36, 37, 38 and 39, each wound about its own individual core, and connected in bridge fashion, as shown in Fig. 1. Across the vertical diagonal of the bridge comprising the amplifier 30 is applied an alternating voltage 42. The horizontal diagonal of the bridge constitutes the output of the amplifier and comprises a rectifier 48 and a relay 44 connected in series. Shunted across the relay 44 is a capacitor 50 which removes most of the ripple voltage from the relay 44. The rectifier 48 is employed so that a D. C. relay 44 may be used rather than an A. C. relay. The relay 44 has a contact 46 which is normally closed, i. e., the contact 46 is biased to closed position when the relay 44 is de-energized and is open when the relay 44 is energized.

Each winding 36-39 is provided with a respective biasing winding 51-54 by means of which each core may be saturated to the proper direct magnetic bias. The windings 51-54 are energized in a series from a source of direct current 55. As will be readily evident to those skilled in the art, the biasing windings 51-54 are not absolutely requisite, and may be omitted under certain conditions.

Linked magnetically with one of the primary windings, i. e., the winding 37 (and of course with its biasing winding 52) is a first control winding 56. The primary winding 39 which is opposite in the bridge from the winding 37 is also provided with a similar control winding 58. The control windings 56 and 58 are connected in series and one side of the circuit is directly grounded, the other side being connected to the probe 28 and thence to ground through a normally closed test jack 62.

It will be seen that when there is no water at the probe 28, so that the terminals 29 represent an open circuit, no current can flow through the windings 56 and 58, and hence the bridge operates as if these windings were not present. Without the windings 56 and 58, the bridge is a balanced bridge, and hence there is no voltage appearing across the horizontal output terminals across which the relay 44 is connected. Therefore, the contact 46 is in closed position.

In the normal condition of operation of the apparatus, there is water to be found at the probe 28, and therefore, the circuit will be closed through the windings 56 and 58. In this event, the bridge is unbalanced. That is to say, the winding 56 reflects a low impedance into the primary winding 37 and the winding 58 reflects a low impedance into the primary winding 39. Under this circumstance, the bridge is unbalanced, since the windings 37 and 39 represent low impedance, while the windings 36 and 38 represent high impedance. Under this condition, there is an output voltage appearing across the relay 44 which energizes the same to hold the contact 46 open. Thus, with the entire system in its normal operating state, i. e., with water at the probe 28, the contact 46 is open.

It will be readily understood that the bridge could operate also with only one of the windings 56 and 58, inasmuch as it would still create an unbalance in the bridge and cause a voltage to appear across the relay 44. However, the effect is doubled by providing both control windings 56 and 58, which operate together in series or push-pull fashion, insofar as the effect on the bridge is concerned.

The contact 46 of the relay 44 is connected in a circuit leading from the plus terminal of the D. C. source 55 through the contact 46, thence through a relay 64 and

back to the negative terminal of the D. C. source 55. Under steady state normal operating conditions, it will be seen that with the contact 46 open, the relay 64 is de-energized and its contact 66 is open. When the probe 23 detects or senses a lack of water at its terminals 29, the relay 44 is de-energized to close the contact 46, energizing the relay 64 and closing its contact 66. Closing of the contact 66 sets the remainder of the circuit into operation, by cocking the timer 32, as will now be described.

The timer 32 comprises an electric motor, shown schematically at 68, which rotates a shaft 72 through an electrically operated clutch, shown schematically at 70. The clutch 70 is biased to engaged position, i. e., when the clutch 70 is de-energized, the motor 68 is clutched to the shaft 72. When the motor 68 is energized, it causes the shaft 72 to slowly turn in a given direction against the bias of a torsion spring 73 which urges the shaft 72 in a direction contrary to that in which it is

20 driven by the motor 68.

Mounted on the shaft 72 are three cams, 74, 76, and 78. The cam 74 serves to actuate a contact 80; the cam 76 actuates a contact 82; and the cam 78 actuates a contact 84.

25 The cycle of operation of the timer 32 is shown schematically in Fig. 2. When the clutch 70 is energized, the biasing spring quickly snaps the shaft 72 to the cocked position of the timer 32, which is the position illustrated in Fig. 1. In Fig. 2, this is represented by the position

30 numeral 300. At this position of the shaft 72, as shown schematically in Fig. 2, the contact 80 is closed, the contact 82 is closed, and the contact 84 is closed. When the clutch 70 is de-energized, so as to engage the shaft 72 and the motor 68, and with the motor 68 energized, the shaft 72 starts to turn slowly, and the cycle moves to the right in Fig. 2. At the time represented by the numeral 304, the cam 76 actuates the contact 82 from closed to open position. In a typical operation of the present invention, this would be about five seconds, although it

40 could be set for any desired time.

As the motor 68 continues to turn the shaft 72, the time 306 is reached, at which point the cam 78 moves the switch 84 to open position. A fraction of a second hereafter, i. e., at the time 307, the cam 74 opens the contact 80 and a still further fraction of a second later, i. e., at the time 302, the shaft 72 comes to a halt by virtue of the de-energization of the motor 68, as will be described hereinafter in connection with operation of the device. In the present operation, the operation noted by

50 numeral 306 might occur at approximately 10 seconds after time 300 and the operations at 307 and 302 would be brief fractions of a second thereafter.

The general construction of the timer 34 is similar to that described hereinbefore in connection with the timer 32, the principal difference being that the motor 90 is normally disengaged from the shaft 93, that is to say the motor 90 is disengaged from the shaft 93 when the clutch 92 is de-energized, and is engaged with the shaft 93 when the clutch 92 is energized. The timer 34 is provided on

60 its shaft 93 with two cams 94 and 98, which operate contacts 100 and 104, respectively.

The cycle of operation of the timer 34 is also shown in Fig. 2. When the clutch 92 is de-energized so as to disengage the shaft 93, a spring 93a biases the shaft 93 to the left in Fig. 2, that is, to the position 308. At this position of the shaft 93, the contact 100 is closed and the contact 104 is closed. When the motor 90 and the clutch 92 are both energized, the motor 90 slowly turns the shaft 93, represented by a rightward movement in Fig. 2. At the time 310 in Fig. 2, the cam 98 causes the contact 104 to open. A fraction of a second later, as shown at 314, the cam 94 causes the contact 100 to open. Finally, a still further fraction of a second later, at 316, the motor 90 comes to rest by virtue of

75 its de-energization, as will be explained hereinafter.

The events represented by the time lines 310, 314, and 316 occur very close together and may, in the present invention, occur, for example, at about 6 seconds following initiation of the timing run at 308.

In accordance with the present invention, the timers 32 and 34 are electrically connected as follows:

The clutch 70 of the timer 32 is connected to the A. C. source 42 through the contact 66 of the relay 64. Thus under normal steady state operation of the system, with the contact 66 open, the clutch 70 is de-energized, so that the shaft 72 is coupled or clutched to the motor 68. The motor 68 is connected across the A. C. source 42 through the timer contact 80. Thus, as seen in Fig. 2, the motor 68 is deenergized whenever the shaft 72 is in the position 302 and is energized at all other times.

The limiting valve 26 is operated in accordance with the contact 84 of the timer 32, through the conductor 27 and from the D. C. source 55, as explained hereinbefore.

The contact 82 of the timer 32 serves to actuate the timer 34 as will now be described.

The timer 34 is connected into the system as follows: the clutch 92 is energized from the A. C. source 42 through the contact 82 of the timer 32. The motor 90 is also energized through the contact 82, and in addition, has in series therewith the contact 100 of the timer 34.

The contact 104 of the time 34 controls the shut-off or main valve 18, through the circuit 19, as described hereinbefore. Thus, the main valve 18 is open during the interval 308-310 of the time shaft 93 and is closed by being de-energized at the other positions of 314, 316 of the shaft 93.

As a safety precaution to create a fail-safe system, a relay 112 having a contact 114 in series with the circuit 19 is connected across the A. C. source 42; and a relay 116 having a contact 118 in series with the circuit 19 is connected across the D. C. source 55. Thus if either source of voltage 42 or 55 should fail, the valve 18 would close and shut off the flame 16.

The operation of the system illustrated in Figs. 1 and 2 will now be described with reference to the timing diagram illustrated in Fig. 3, composed of Figs. 3A and 3B.

Let it be assumed that the apparatus is to be put into operation. The boiler is cold, but adequately filled with water. Under these circumstances the circuit is completed at the contacts or terminals 29, so that the control circuit through the windings 56 and 58 is closed. Power is applied at the D. C. terminals 55 and the A. C. terminals 42 respectively. Application of A. C. power to the bridge 30, which is now unbalanced by virtue of the closing of the probe 28, produces an output voltage which energizes the relay 44 and opens its contact 46.

If it is assumed that the timer 32 has been left in the position indicated by the numeral 300 in Fig. 2, then contact 80 will be closed and the motor 68 is energized to rotate the shaft 72 to the position 302 in Fig. 2, at which time the contact 80 is opened and the timer 32 comes to rest at position 302. Thus the timer 32 is left with the motor 68 engaged with the shaft 72, and with the shaft at its position 302, wherein the return spring is stressed the maximum.

The timer 34 will be in its position 308, since the clutch 92 is de-energized by virtue of the open contact 82 on the timer 32. Hence, the spring of the timer 34 will have moved the timer shaft 93 to the position 308. Energization of the two voltage sources closes the contacts 114 and 118; the contact 104 is closed by the timer 34. Thus the safety contacts in the circuit 19 have all been closed, readying the system for normal control through the control apparatus, designated schematically at 20. The main valve 18 has been kept closed by a suitable manual or automatic operation

in the control circuit 20, which is not ready for operation until the safety system described herein has been energized in the manner described above. Thus, at this point, the main valve 18 is deenergized and hence, closed; and the limiting valve 26 is also closed.

The fuel pump 22 is started by any suitable and well known means, and the control circuit 20 is then suitably operated to supply voltage to the main valve 18. Fuel flows to the burner 14. At the burner 14, any well known pilot device, automatical or constantly burning, serves to ignite the flame 16. Since there is a full water supply, the full flame comes on to heat the water in the boiler. Thus, steady state operating conditions are established.

Let it now be assumed that water disappears at the probe 28. This is illustrated by the time numeral 201 in Fig. 3, wherein the timing diagram representing the probe 28 drops to its lower position, indicating that the probe now is open circuited. Opening of the circuit 20 at the probe 28, as illustrated by the stimulus line 202, de-energizes the relay 44 at the time 203. De-energizing or dropping out of the relay 44 closes its contact 46 with consequent energization of the relay 64, as shown at 204. Energization of the relay 64 with consequent closing of its contact 66 energizes the clutch 70 of the timer 32, as shown at 206.

Up until this point, the shaft 72 of the timer 32 has been held at its position 302 as shown in Figs. 2 and 3. Energization of the clutch 70 de-clutches the shaft 72 from the motor 68, allowing the biasing spring on shaft 72 to take over. The spring rapidly rotates the shaft 72 to its position 300, as illustrated by the line 207. This traverse of the shaft 72 causes closing of the contact 89, as shown at 208; causes closing of the contact 82 as shown at 209; and causes closing of the contact 84, as shown at 211, and starts motor 68 turning. However, since the clutch 70 is still energized, the shaft 72 is de-clutched from the motor 68, and the motor 68 simply turns idly without moving the shaft 72.

Closing of the contact 84 closes the circuit 27 to the limiting valve 26, and this valve is energized to open position, as shown at 213. Thus at the time 213 the valve 26 is open, bypassing an appreciable portion of the fuel from the pump 22 and effecting lowering of the flame 16 because of the resulting lower pressure of fuel at the burner 14. Hence it will be seen that the disappearance of water at the probe 28 immediately effects a lowering of the flame 16 from full flame to partial flame position.

Closing of the switch 82, as shown at 209, closes the circuit to the motor 90 of the timer 34 and also to the clutch 92 of the timer 34, inasmuch as the contact 100 is closed. These operations are shown at 214 and 216 respectively. Thus at time 217, the motor 90 has been energized and is turning and the clutch 92 has been energized to clutch the shaft 93 to the turning motor 90. This starts the shaft 93 turning with the motor, against the bias of its return spring. The shaft 93 thus starts to turn away from the position 308 (Fig. 2) and toward the positions 310-316.

In the interim 308-310 it will be assumed that absence of water continues at the probe 28, as indicated by the line 218, and the limiting valve 26 is in the open or limiting position, as indicated by the line 219, to cause the flame 16 to burn at partial value. When the position 310 is attained by shaft 93, which may be for example after approximately 6 seconds, the water not having returned to the probe 28, the cam 98 causes the contact 104 to open, as indicated at 221. Opening of the contact 104 de-energizes the shut-off valve 18, as indicated at 222, to close the valve and shut off fuel completely from the burner 14, and causing the flame 16 to go out completely.

The shaft 93 continues to turn, and a fraction of a second later at time 314, the cam 94 opens the contact

100, as shown at 226 in Fig. 3. Opening of the contact 100 de-energizes the motor 90, as shown at 227. The clutch 92, however, is still energized through the closed contact 82; therefore the shaft 93 comes to rest at position 316, and is held in this position against the bias of the spring by virtue of the fact that it is still clutched to the now de-energized motor 90.

Thus conditions remain until water returns to the probe 28. The flame 16 is completely cut off and no heat is being applied to the boiler.

As is often the case in the operation of equipment of this type, the disappearance of water at the position of the probe 28 is often momentary and it is sometimes due only to a transient overheating of the boiler. Under this circumstance, the water may reappear at probe 28 after a brief period of time. Reappearance of water causes re-actuation of the valves 18 and 26 in the following manner:

At the time 231, shown in Fig. 3, let it be assumed that water has re-appeared at the probe 28. Reappearance of water at the probe 28 closes the circuit through the windings 56 and 58 and re-establishes the unbalance in the bridge 30. This unbalance causes energization of the relay 44, as shown at 232 with resultant de-energization of the relay 64, as shown at 223. De-energization of the relay 64 and opening of its contact 66 de-energizes the clutch 70, as shown at 234, and causes engagement or clutching of the shaft 72 to the motor 68. Thus, as shown at 235, the shaft 72 now starts to turn through its timing cycle, since it is clutched to the motor 68 which has been turning all along. The shaft 72 now starts to move from its position 300 toward the position 304 (Fig. 2).

After a predetermined period of time, which may be for example 5 seconds, the position 304 of the shaft 72 is attained, at which point the contact 82 is opened, as shown at 236 in Fig. 3. Opening of contact 82 de-energizes clutch 92 of the timer 34, as shown at 237, and the consequent release of the shaft 93 from the motor 90 permits the biasing spring on the shaft 93 to rapidly turn the shaft from its position 316 back to its position 308, as shown by the line 238.

In this rapid traverse of the shaft 93, contacts 100 and 104 are re-closed, as shown at 239; closing of contact 104 effects re-energization, with consequent opening of the main valve 18, as shown at 243. In this manner, flow of fuel to the burner 14 is resumed and the flame 16 is re-established by means of the conventional pilot flame mentioned hereinbefore. The flame is only at partial value, however, since valve 26 is still open.

The timer 32 continues its timing run, moving from its position 304 to its position 306. During this time, the main valve 18 is open permitting flame at the nozzle 14 but the bypass valve 26 is also open by virtue of the fact that contact 84 is still closed. Therefore the flame 16 is only at its partial value rather than at full flame. When the shaft 72 of timer 32 reaches position 306, which may occur for example approximately 5 seconds after the main valve 18 has been opened, the cam 78 causes the contact 84 to open, as shown at 244, and the valve 26 is thus de-energized and closed, as shown at 246. This applies full pressure of fuel to the line 12 and full flame occurs at 16.

The shaft 72 continues to turn and a fraction of a second later the position 307 is attained at which the contact 80 is opened by the cam 74, as shown at 247. This de-energizes the motor 68, as shown at 248, and causes the shaft 72 to come to rest at its position 302, as shown by reference line 249.

The system has thus returned fully to normal, with full flame at the nozzle 14. It will be noted that this return to normal operation following return of water at 231 has been effected in two steps. First, there was a period when no flame appeared, from the position 300 to the position 304 of the timer 32. Thus, the water is

required to stay on a given period, for example 5 seconds, before any flame at all appears at the burner 14. When the flame does appear, it is only at a partial value and the water must continue to endure steadily for an additional five seconds, while the timer 32 moves from its position 304 to its final position 302 in order to return full flame to the burner 14.

The operation of the system will now be considered under a condition where the water flashes off only momentarily.

Let it be assumed that the system is operating normally. Water disappears, as shown at 251 (Fig. 3B). Disappearance of the water energizes the clutch 70, as explained hereinbefore, and causes the timer shaft 72 to move rapidly to its position 300, as shown by the traverse line 252. Movement of the shaft 72 to its position 300 sets into operation a sequence described hereinbefore which energizes the clutch and the motor of the timer 34 and starts a timing run of this timer, as shown at 253. In this sequence, the partial flame valve 26 is opened, as shown at 254, to reduce the flame 16 to partial value, in the manner described hereinbefore.

Now let it be supposed that the water, instead of remaining off, quickly returns, as shown at 256. This return of the water institutes a timing run of the timer 32, as shown in 257, in the manner described hereinbefore in connection with the reference numeral 235. After a predetermined time, for example 5 seconds, the timer 32 reaches its position 204, as shown at 258, and sets into operation a sequence of events described hereinbefore, which results in release of the timer shaft 34, as shown at 259. Since the timer 34 is set for a longer span of operation, as, for example 6 seconds, it has not yet attained its position 310 and therefore the main valve 18 has not been closed. Therefore, the timer 34 snaps to its rest position, at 261, never having closed the main valve 18.

The timer 32 continues to turn through the transverse period indicated at 262 with the flame 16 at partial value by virtue of the continued energization of the valve 26. When the position 306 is attained, the contact 84 is opened, as shown at 263, de-energizing the by-pass valve 26, as shown at 264 and permitting full flame to reappear at 16. The shaft 72 of the timer 32 continues to turn and comes to rest at its position 302 in the manner described hereinbefore.

Thus if the water should disappear only momentarily, as shown at 251 and 256, it is seen that the circuit 50 operates to cause partial flame for approximately 10 seconds, and then returns the circuit to the full flame position.

An illustration will now be given of a situation where the water disappears momentarily and then returns in 55 spurts. Such a situation is illustrated by the trace beginning at 266 in Fig. 3. As described before, disappearance of the water causes the timer 32 to snap back from its position 302 to its position 300, as shown at 256. This immediately results in energization of the valve 26, as shown at 268 and the flame is cut down to part flame. When the water returns, as shown at 269, the timing run of the timer 32 is instituted as shown at 271.

With the snapping back of the timer 32, as shown at 65 267, a timing run of the timer 34 was also instituted, as shown at 272 and as described hereinbefore.

Let it now be supposed that the water, having returned at 269, instead of remaining on, again flashes off, as shown in 273. Let it be supposed that this disappearance of the water occurs after less than 5 seconds, so that the timer 32 has not had time to attain its position 304. This causes the timer 32 (more particularly its shaft 72) to again snap back to its position 300 as shown at 274. Appearance of the water at 276 70 again institutes a run of the timer 32 as shown at 277.

Disappearance of the water at 278 causes the timer to again snap back to its position 300, as shown at 279, again before attaining the 5 second position 304. Thus, the timer 32 oscillates back and forth, with each flashing disappearance of water at the probe 28.

In the meantime, however, since the timer 32 at no time has attained its position 304, the timer 34 has continued its timing run, as shown at 281; and when the position 310 is attained, as shown at 282, the main valve 18 is closed in the manner described hereinbefore. Thus the flame disappears entirely and will not reappear until water has returned to endure uninterruptedly for at least five seconds, at which time the flame will return at partial value, and then return to full flame after an additional 5 seconds, provided the water should continue to be present at the probe 28, continuously for 10 seconds, as described hereinbefore.

Thus it is seen that once water has disappeared at the probe 28 it must reappear uninterruptedly for at least 5 seconds or else the flame, initially cut to partial flame, will be cut off completely and will not re-appear until water has appeared uninterruptedly for 5 seconds, at which time the flame will again return at partial value.

From the above described operation, it will be seen that the boiler is protected not only against complete disappearance of water at the probe 28, but is also protected against flashing disappearances which generally presages a more serious trouble.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention which is therefore not limited to the details disclosed herein, but is to be accorded the full scope of the claims.

What is claimed is:

1. In a boiler having a burner and means to feed fuel under a determined pressure to said burner; a fuel control system comprising: a source of fuel, a pump to feed fuel at a determined pressure from the fuel source to said burner, a cut-off valve between the pump and burner, a limiting valve between the pump and cut-off valve, said limiting valve in closed position directing all fuel from the pump to said cut-off valve and in open position directing only a portion of said fuel from the pump to the said cut-off valve, a boiler and a water level detecting means

disposed at a predetermined level in said boiler, means actuated by said detecting means when water is absent at said predetermined level to actuate means actuating said limiting valve means from closed to open position and at 5 a predetermined time interval thereafter to actuate means actuating the said cut-off valve from open to closed position, and at a determined time interval thereafter to actuate means operative to maintain the two said valves in said open and closed positions indefinitely, and means actuated by said detecting means when the water level returns to said predetermined level in the boiler to deactivate both of said valve actuating means to return the valves to closed and open positions, respectively.

2. The invention of claim 1, wherein said detecting means comprises an electrical circuit including a relay switch energized when the water level in said boiler is at said predetermined level and de-energized when the water level in said boiler is below said predetermined level, and wherein a second electrical circuit is provided 15 which is energized by said relay switch in de-energized position, said second electrical circuit including means energized position, said second electrical circuit including means energized thereby to successively actuate three switches connected electrically in three valve actuating electrical circuits, the first said valve actuating circuit including means operating to actuate the limiting valve from closed to open position, the second said valve actuating circuit including means operative to actuate the cut-off valve from open to closed position and the third said 20 valve actuating circuit actuating means operative to hold the two said valve actuating circuits in valve open and valve closed position indefinitely and until the said second electrical circuit is de-energized by a return of the water level to said predetermined level with resultant re-energization of the first said electrical circuit.

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