Sept. 2, 1958 S. R. TONGRET 2,849,990

ELECTRICAL SAFETY DEVICE FOR STEAM BOILERS

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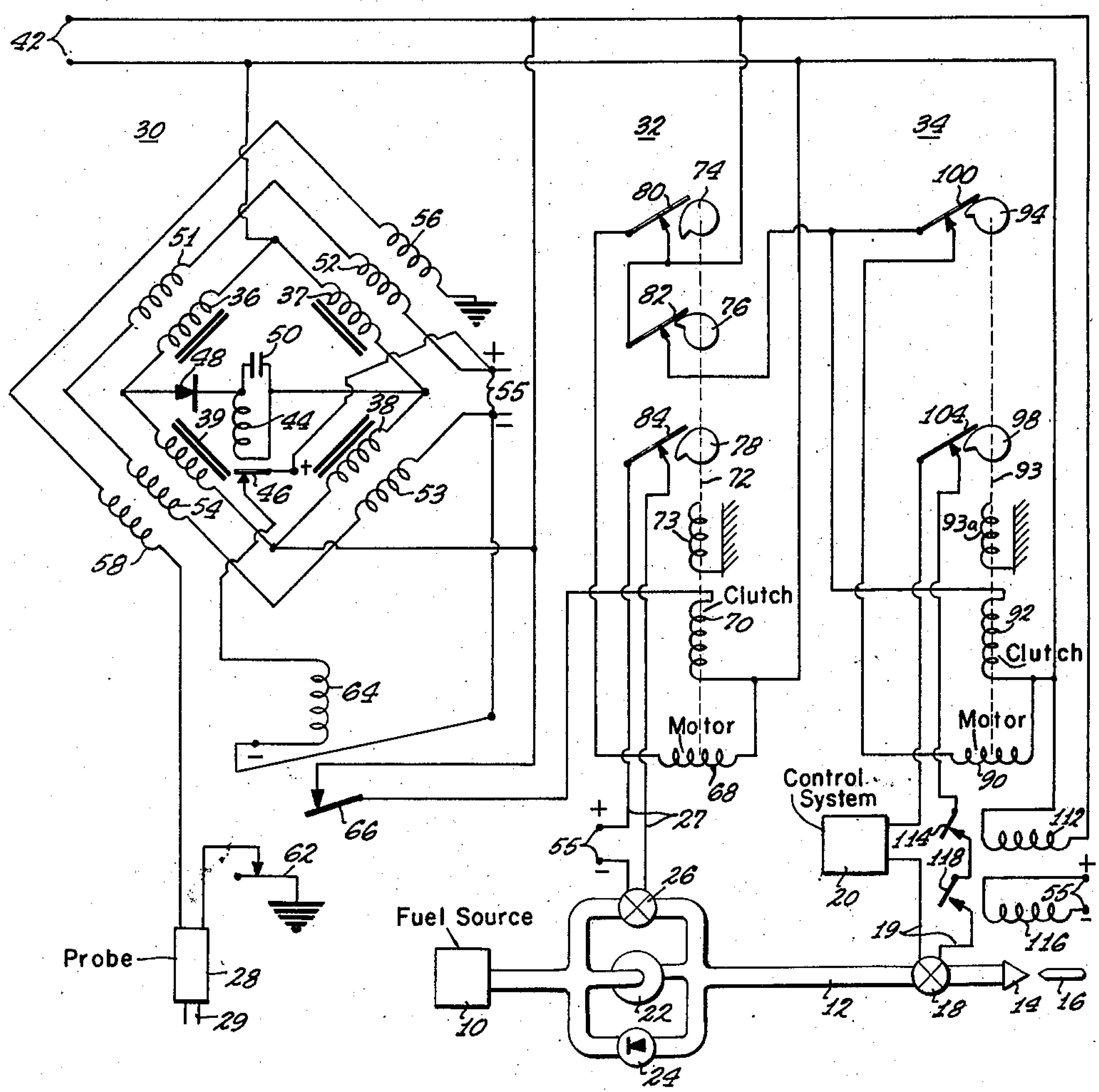
Fig. 1.



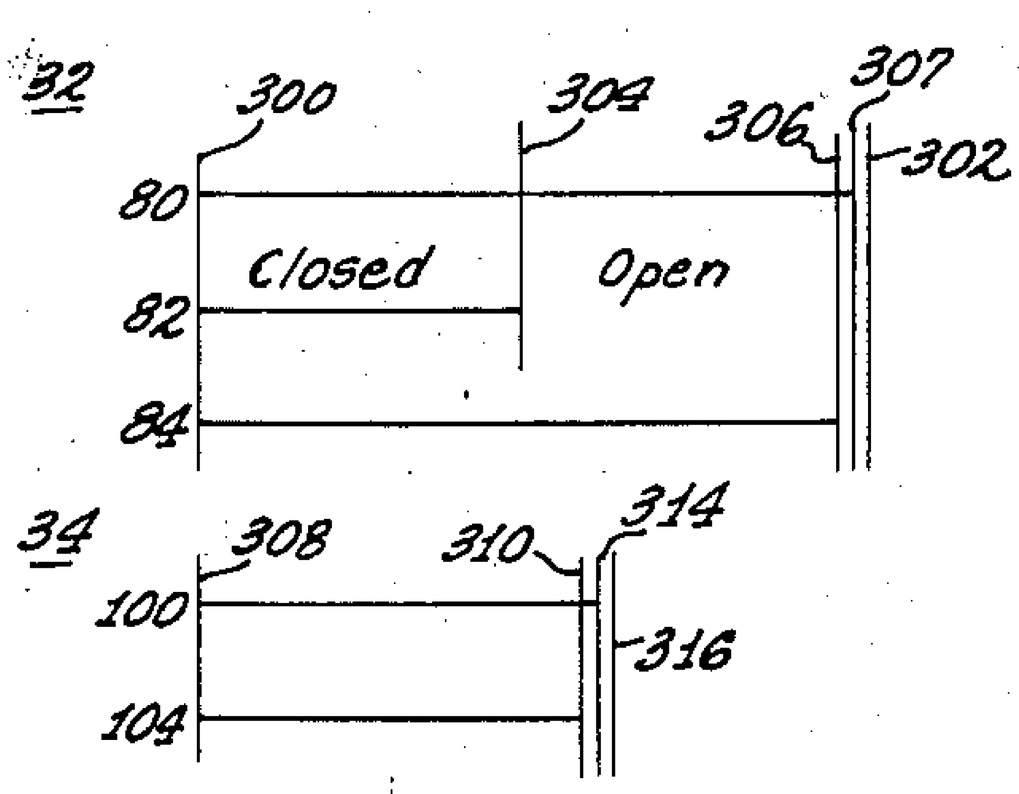


Fig. 2.

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Fig. 3A.

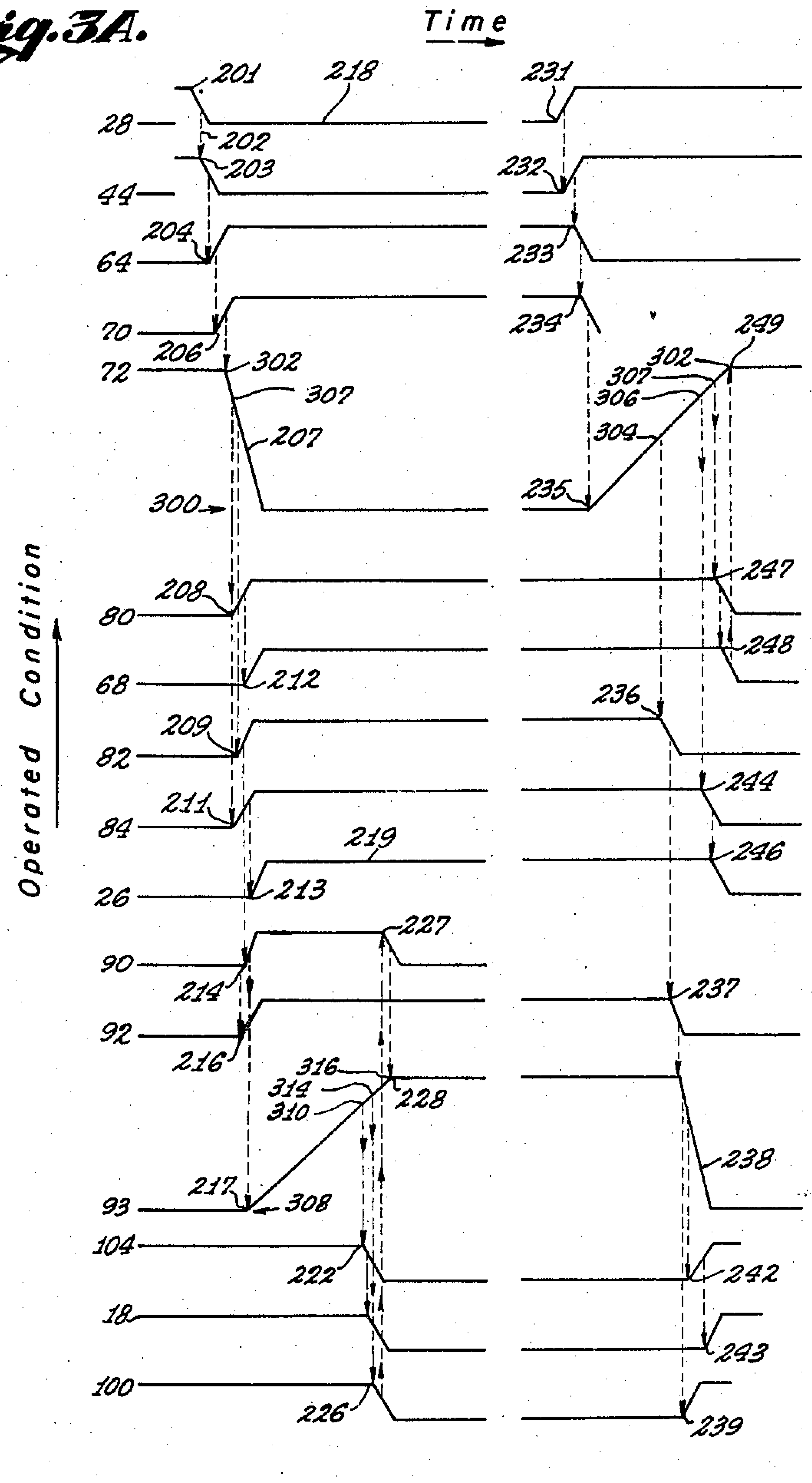

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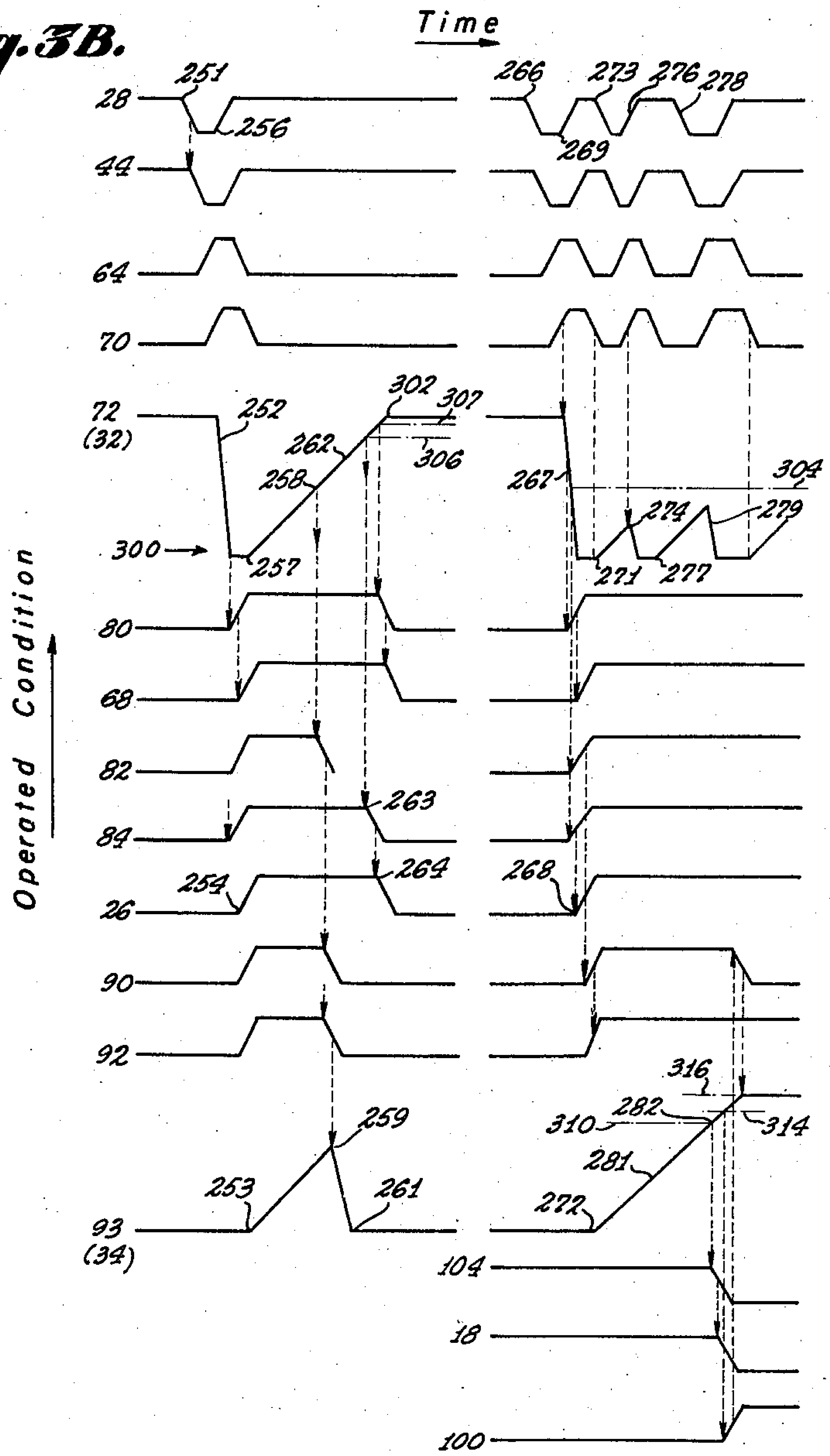
Fig. 3B.



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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 obect 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-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.

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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 **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.

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.

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.

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 abnormal conditions causes energization of the valve **26** with the resultant limiting of fuel flow to the burner **14**.

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**.

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.

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 **28** 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 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**.

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 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 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 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 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 **93*a*** 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 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 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 **80,** 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 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 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 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 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 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 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 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.

References Cited in the file of this patent

UNITED STATES PATENTS

2,016,805	Kinnan	Oct. 8, 1935
2,048,162	Kriechbaum	July 21, 1936
2,174,275	Raney	Sept. 26, 1939
2,286,296	McGrath	June 16, 1942
2,446,778	Mesh	Aug. 10, 1948
2,449,538	Ackerman	Sept. 21, 1948
2,617,090	Ogle	Nov. 4, 1952
2,677,099	Rau	Apr. 27, 1954