May 24, 1949. A. E. BAAK 2,470,969

HYDRAULIC STOKER CONTROL

Filed Aug. 9, 1943

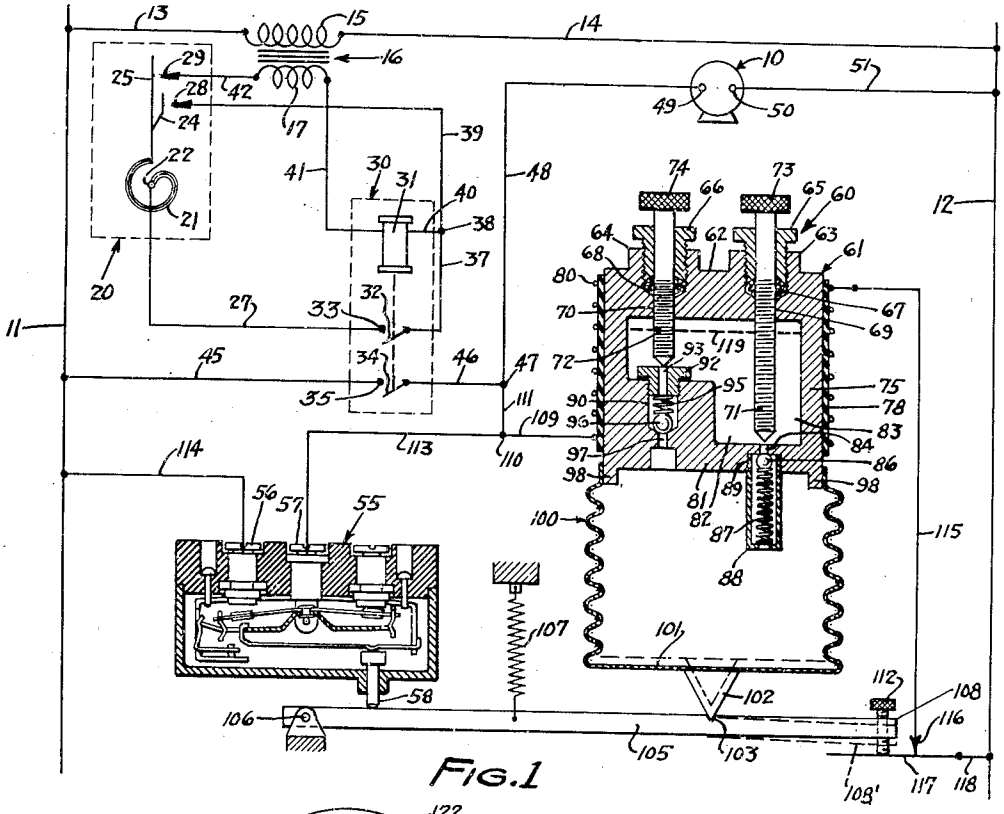


FIG. 1

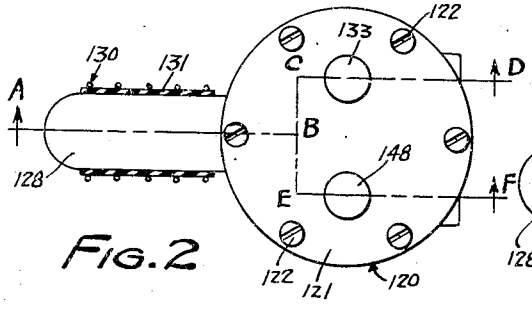


FIG. 2

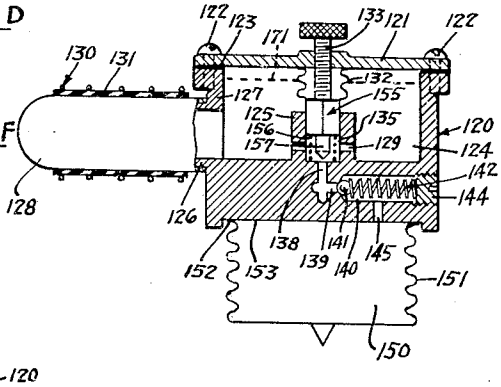


FIG. 3

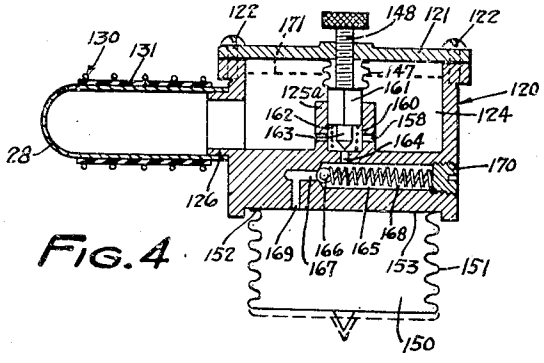


FIG. 4

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Patented May 24, 1949

2,470,969

UNITED STATES PATENT OFFICE

2,470,969

HYDRAULIC STOKER CONTROL

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Application August 9, 1943, Serial No. 497,897

19 Claims. (Cl. 236—46)

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This invention relates to system and apparatus for the control of stokers and similar combustion apparatus in which ignition is maintained by periodic operation of the stoker for short intervals during the periods when the stoker operation in response to heat calls does not occur. The invention has particular usefulness in the control of stokers of the household type wherein it is desired to maintain ignition by periodically operating the stoker during intervals when there is no call for heat indicated in the space to which heat is furnished by the stoker apparatus.

It is an object of the invention to provide such a system and apparatus for the control of stokers and similar mechanism and particularly to provide controls for maintaining combustion in stokers of the household type. It is another object of the invention to provide a stoker control system and apparatus wherein periodic operation of the stoker for maintaining combustion is provided at uniform intervals but such combustion maintaining operations are not initiated until after a time delay period following a normal operation of the stoker apparatus in response to a call for heat.

It is a further object of the invention to provide a system and apparatus for the control of stokers which is capable of being manually adjusted for operation under widely varying cyclic conditions and which is capable of operation over long periods of time without servicing.

It is a further object of the invention to provide a stoker control system and apparatus which is economical to manufacture, rugged in construction and simple to operate.

Other and further objects of the invention are those inherent and implied by the apparatus illustrated, described and claimed.

The invention is illustrated with reference to the drawings in which:

Figure 1 is a wiring diagram in which certain of the control elements are shown in sectional elevation.

Figure 2 is a plan view, partly in section, of a modified form of one of the control elements utilizable in the system illustrated in Figure 1.

Figure 3 is another view of the apparatus of Figure 2 and is a sectional elevational view partly broken away and taken along the lines A, B, C, D of Figure 2.

Figure 4 corresponds to Figure 3 and is an elevational sectional view taken along the lines A, B, E, F of Figure 2.

Referring to Figure 1, there is illustrated a motor, generally designated 10, of the stoker, the

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motor 10 being provided for the feeding of fuel and for the blowing of combustion air in the stoker apparatus. It will be appreciated that in some stokers separate motors are provided for feeding the fuel and blowing the combustion air through the stoker apparatus, and as to such systems, the motor 10 may be regarded as schematically illustrating both motors.

In the system, there are provided alternating current supply feeders 11 and 12, which are connected through lines 13 and 14 to the primary winding 15 of a transformer, generally designated 16. In the space to which heat is provided by the stoker mechanism 10, there is positioned a thermostat, generally designated 20, having a bimetallic element 21, which is anchored at the post 22 and is provided with a pair of contacts 24 and 25 which move to the right as illustrated in Figure 1 as the temperature of the space drops, and to the left as the temperature of the space increases.

Adjacent the stoker apparatus, there is provided a relay mechanism, generally designated 30, having an operating coil 31 and pairs of contacts 32—33 and 34—35 operated by the coil 31. The post 22 of the thermostat 20 is electrically connected by means of line 27 to contact 33 of relay 30, contact 32 being connected through line 37 to junction 38. Line 39 connects junction 38 to the contact 28 of the thermostat 20. The coil 31 of the relay is connected by line 40 to the junction 38 and is connected by line 41 to one terminal of the secondary 17 of the transformer 16, the opposite terminal of the secondary 17 being connected by line 42 to the contact 29 of the thermostat 20. It will thus be observed that as the temperature of the space in which the thermostat 20 is positioned, decreases beyond a predetermined amount, contact 25 will first engage contact 29 and upon further temperature fall, contact 24 will engage contact 28. Thereupon a circuit is established through coil 31; beginning at winding 17 of the transformer the circuit extends through line 42, contacts 29—25, contacts 24—28, line 39, junction 38 and line 40 to coil 31, and through line 41 to the opposite terminal of the secondary 17 of the transformer.

The coil 31 of the relay is accordingly energized and causes contact 32 to engage contact 33, and also causes contact 34 to engage contact 35. The closure of contact 32 upon contact 33 establishes a holding circuit for the coil 31 of the relay as follows: From the left terminal of the secondary 17 of the transformer 16 through line 42 to stationary contact 29, thence through movable con-

tact 26 and the thermostat bimetallic element 21, post 22, line 27, contacts 33 and 32, through line 37, junction 38, line 40, coil 31 and line 41 to the right terminal of the secondary 17. The coil 31 accordingly remains energized until movable contact 25 of the thermostat is separated from the stationary contact 29, upon temperature rise.

The closure of contact 34 upon contact 35 serves to establish a circuit from feeder 11 through line 45, contacts 35 and 34, which are then closed, line 46 to junction 47, thence through line 48 to terminal 49 of the motor 10, thence from terminal 50 of the motor through line 51 to feeder 12. The motor or motors 10 of the stoker are accordingly energized and operate to supply fuel and combustion air to the stoker mechanism. Accordingly, the stoker operates and furnishes heat to the space in which thermostat 20 is located and after a time movable contact 24 separates from contact 28. This breaks the initial energizing circuit but the holding circuit remains made. On further temperature rise, the movable contact 25 separates from the stationary contact 29 breaking the holding circuit of the relay 30 which accordingly de-energizes and opens the holding circuit at contacts 32—33 and the stoker control circuit. The stoker is therefore under the independent control of the thermostat 20 and operation will ensue at irregular intervals depending upon the needs for heat in the space in which thermostat 20 is positioned.

Since the calls for heat as indicated by the thermostat 20 may occur at widely varying intervals, the degree of combustion in the stoker likewise varies considerably and occasionally the stoker firepot will be cooled to such a degree that combustion is discontinued between calls for heat. Accordingly, upon a subsequent call for heat by thermostat 20, fuel will be fed and air supplied but combustion will not ensue. In order to obviate this difficulty, the stoker is also placed under the independent control of a fire maintaining control apparatus illustrated in the lower part of Figure 1.

The fire maintaining control apparatus comprises a switch mechanism, generally designated 55, and a thermally operated timing apparatus, generally designated 60. The apparatus 60 of Figure 1 may be replaced by that shown in Figures 2, 3 and 4, if desired.

The switch mechanism 55 may be of any desired construction in which the circuit closing elements are capable of being operated by a relatively small movement of an actuating element. For this purpose, I prefer to use a switch such as that illustrated in my Patent No. 2,318,734 issued May 11, 1943. Details of the switch 55 are completely described in said patent and it is sufficient for the purposes of description here to say that the switch 55 is capable of closing a circuit from terminal 56 to terminal 57 upon a very slight movement of the actuating plunger 58 and that the energy required to close and open the switch is of negligible proportion. It is obvious, of course, that any switch mechanism capable of being operated by a relatively slight low energy movement is suitable for use in the present invention and I do not therefore desire to be limited, in the present invention, to the use of the particular switch 55 herein illustrated or referred to.

The thermally operated timing apparatus 60 includes an upper enclosed housing 61 to which there is attached a bellows, generally designated 100. The upper enclosed housing 61 has an upper wall 62 provided with bosses 63 and 64, which are drilled and threaded to receive gland nuts 65 and 66 respectively, the gland nuts being arranged so as to bear upon the compressible packings 67 and 68. The upper housing wall 62 is threaded at 69 and 70 respectively to receive needle valve screws 71 and 72, the latter being provided with knurled or slotted heads 73 and 74 respectively.

The upper enclosed housing 61 is preferably of generally cylindrical shape having a cylindrical sidewall 75 upon which there is wound an insulated layer 78 of mica or other similar material. Around the mica, there is wound a heating coil 80 of any suitable number of turns. The lower wall 81 of the housing 61 is made in two levels so as to provide a depressed part 82 within the interior space 83. The bottom wall 81 is drilled through at 84 to provide a seat for the lower conical end of the needle valve screw 71. The drill hole 84 is shaped at its lower side to receive a ball check valve 86, which is pressed upwardly by means of spring 87 held in the thimble 88, the thimble in turn being threaded into the bottomwall 81 as shown at 89. The thick portion of the bottomwall 81 at the left in Figure 1, is drilled out as illustrated at 90 to receive a threaded valve seat member 92 which has an aperture 93 in line with the lower conical end of the needle valve screw 72. The valve seat member 92 also serves slightly to compress a spring 95 which bears upon the ball check valve member 96, which in turn rests upon the conical seat of aperture 97.

The cylindrical sidewalls 75 of the upper housing 61 extend downwardly as illustrated at 98, and upon the outer surface there is sweated or otherwise secured the upper edge of a bellows 100. The lower closed end 101 of the bellows 100 is provided with a central pivot block 102 which rests in a notch 103 of the operating arm 105. The arm 105 is pivoted upon block 106 and the arm is normally drawn upwardly by means of a tension spring 107. The arm 105 is arranged so as to bear against the operating plunger 58 of the switch mechanism 55 and as the bellows 100 moves from the full line position shown in Figure 1 to the position in which the pivot block 102 and the bottom surface 101 are shown in the dotted line position of Figure 1, the switch mechanism 55 is operated so as to establish a circuit between terminals 56 and 57.

The heating coil 80 is connected by means of line 109 to junction 110 and thence through line 111 to junction 47 of lines 46 and 48. From junction 110 there also extends a line 113 to terminal 57 of the switch 55, the cooperating terminal 56 of the switch being connected by line 114 to alternating current feeder 11. The opposite terminal of the heating element 80 is connected by means of line 115 to stationary contact 116 of a switch, and through the movable contact 117 of the switch and line 118 to alternating current feeder 12. The movable contact 117 is positioned so as to be in the path of movement of the outer tip 108 of the operating arm 105 so that the movable contact 117 will be moved out of engagement with the stationary contact 116 when the outer tip of the operating arm 105 assumes the dotted line position shown at 108' of Figure 1.

The entire volume of the interior space of the bellows 100 and a considerable portion of the volume of the interior space 83 of the upper housing 61 is filled with a volatile fluid such as an alcohol or ether, the amount of fluid being such that when the entire apparatus 60 is at room temperature and the bellows is pressed upwardly under the influence of spring 107, and the nat-

ural resiliency of the bellows 100, the liquid level will be at line 119.

It will be observed that whenever the switch 55 is operated so as to establish a circuit between terminals 56 and 57, a circuit is established from alternating current feeder 11 through line 114 through the closed contacts 56 and 57 of switch 55, line 113, junction 110, line 109, heater coil 80, line 115 through normally closed contacts 116 and 117 and line 118 to alternating current feeder 12. The heater coil will accordingly be energized and will supply heat to the housing 61. After a predetermined period, the volatile liquid in the housing 61 is heated to the vaporization temperature and sufficient vapor pressure is generated so as to overcome the resistance of ball check valve 86, which is spring pressed upwardly by spring 87 against the seat of drill hole 84. Therefore, the volatile liquid in the upper chamber 83 of the housing 61 will be driven through the drill hole 84 at a rate depending upon the adjustment needle valve screw 71 in respect to the seat 84. By varying the position of the screw 71, the effective size of the orifice 84 may be widely varied and accordingly the time interval required for driving a prescribed quantity of the volatile liquid downwardly into the bellows 100 may be varied throughout a wide range. So long as the switch 55 remains closed, the heat provided by coil 80 causes the liquid in space 83 to be driven downwardly through the orifice 84 and after a time interval, depending upon the adjustment of screw 71, the bellows 100 will be moved from the dotted line position to the full line position of Figure 1 and in so doing, will move the operating arm 105 causing the plunger 58 to move downward with resultant operation of switch 55 to open the circuit between terminals 56 and 57. When this occurs, the circuit to coil 80 is interrupted, and the body 61 of apparatus 60 begins to cool.

So long as the circuit through switch 55 is maintained, and during the time that coil 80 is energized and is supplying heat to the casing 61, a circuit is also established to the stoker motor or motors 10 as follows: From alternating current feeder 11, line 114 through closed contacts 56 and 57 of switch 55, line 113, junction 110, lines 111 and 48 to terminal 49 of the motor 10, thence from terminal 50 of the motor through line 51 to the alternating current feeder 12. Therefore, while the coil 80 is energized and heating body 61 (and hence during the time interval that the bellows is being expanded), the stoker motor or motors likewise operate supplying fuel and combustion air to the stoker so as to maintain combustion in that mechanism.

When switch 55 has been moved to the open circuit condition due to the expansion of bellows 100, the circuits to heating coil 80 and stoker motor or motors 10 are interrupted and since the coil 80 is therefore no longer heated, the resiliency of spring 107 and/or the natural resiliency of the bellows 100 apply pressure to the liquid contained in the bellows and cause the fluid to be driven upwardly through the orifice 97 and past the check valve 96, through the orifice 93, which is controlled by needle valve screw 72 to the space 83 in the upper housing 61. During this interval, it will be noted, check valve 86 prevents the passage of liquid inwardly through the orifice 84, and therefore the time interval for the passage of a given quantity of liquid from the bellows chamber to the upper housing 61 is determined by the adjustment of screw 72.

This time interval is preferably much longer than the time interval required for driving the liquid downwardly into the bellows so as to allow a reasonable waiting period between each fire maintaining operation of the stoker. It will, however, be appreciated that the time intervals of the fire maintaining operation (which is under the control of the adjustment screw 71), and the time interval between fire maintaining operations, (which is under the control of the adjustment screw 72), may be varied at the will of the operator, as desired.

During the time period that the stoker motor or motors 10 are operated under the influence of the thermostat 20 and relay 30, a circuit is also established to the heating coil 80 as follows: From alternating current feeder through line 45, through closed switch contacts 34—35, line 46, junction 47, line 111, junction 110, line 109, coil 80, line 115, normally closed switch contacts 116—117 and line 118 to alternating current feeder 12. Therefore, as the stoker motor 10 operates under control of thermostat 20 and relay 30, the upper housing 61 of the apparatus 60 is also heated and fluid from the upper enclosure 83 is driven downwardly into the bellows space 100. Inasmuch as the heat providing operations of the stoker under the command of the room thermostat are normally of greater duration than the fire maintaining operations, the heat provided through coil 80 is likewise greater and causes the bellows to expand downwardly beyond the full line position shown in Figure 1 until the operating arm 105 reaches the position such that its outer end 108 is in the dotted line position 108'. When tip 108 is in this dotted line position, the bellows 100 is expanded considerably beyond the position at which opening of switch 55 occurs. Hence, the position of opening of switch 116—117 is not reached during the fire maintaining operations previously described. When bar 105 is so moved, the adjustment screw 112 through the end of bar 105 bears against the movable contact 117 and moves it away from the stationary contact 116, which accordingly breaks the circuit previously described, through the heating coil 80, without however interrupting the circuit to the stoker motor or motors 10. The interruption of circuit to heating coil 80 accordingly permits the upper housing 61 to cool and the bellows is moved upwardly by spring 107 and its natural resiliency until contact 117 is again permitted to engage upon stationary contact 116 whereupon heating of coil 80 is resumed so long as the stoker motor or motors 10 are energized under the control of the thermostat 20.

When the thermostat 20 interrupts the circuit between contacts 25 and 29 and hence interrupts the circuit to the stoker motor or motors 10, this likewise interrupts the circuit to heating coil 80 of the fire maintaining timer apparatus 60, but since the bellows 100 has been expanded to a marked degree to open the circuit between contacts 116 and 117, the time period which elapses before the bellows 100 has contracted sufficiently again to close switch 55 is greater than the time period between normal fire maintaining operations. This time period may be adjusted, as desired by varying the position of the adjusting screw 112 on the outer end 108 of the operating lever 105. Thus by turning the adjusting screw 112 downwardly, the time period for beginning the fire maintaining operation after a call for heat has ended, may be shortened whereas by screwing it upwardly with respect to the outer

end 108 of lever 105, this time period is lengthened. After a normal operation of the stoker 10 in response to a call for heat from thermostat 20, the fire in the stoker will normally be quite hot and will therefore be capable of maintaining combustion for a considerable period. Therefore, by suitably adjusting the screw 112 with respect to the outer end 108 of the operating lever 105, it is possible to provide a desirably long period after a call for heat stoker operation before the first fire maintaining operation of the stoker occurs, under the influence of the mechanism 60. The time interval between the first, second and subsequent fire maintaining operation is, however, under the control of the adjustment screw 72 and therefore may be as long or as short as desired.

Referring to Figures 2, 3 and 4, there is illustrated a modified form of fire maintaining control apparatus in which the upper housing, generally designated 120, is provided with a cap 121, held in place by a plurality of screws 122, a fluid-tight joint between the cap and the housing being maintained by a suitable gasket 123. The housing 120 is provided with an annular chamber 124 into which bosses 125 and 125A extend. From the sidewall 127 of the housing 120, there is a tubular extension 126 upon which is sweated a relatively thin metallic shell 128, the shell being provided with a heater element, generally designated 130, which is insulated from the shell by mica or other suitable insulation 131. The bosses 125 and 125A are respectively provided with drilled holes 135 and 160 shown respectively in Figures 3 and 4.

Referring to Figure 3, the drill hole 135 is provided with a lower central drill passageway 138 which connects with another passageway 139 leading to the check valve chamber 140. The check valve chamber contains a ball check valve 141 which is held in place by spring 142, the latter being in turn held in place by a screw plug 144. The check valve chamber 140 is connected by drilled passage 145 leading to the chamber 150 enclosed by a bellows 151. The bellows is sweated or otherwise attached at 152 to the lower flat surface 153 of the housing 120.

The drill hole 135 in the boss 125 receives a valve member, generally designated 155, of polygonal or circular cylindrical shape sized so as to move without wobbling in the drill passageway 135. The valve member 155 is spring pressed upwardly by a return spring 156 and is provided with a central valve stem 157 having a conical end which seats in the drill hole 138. The cover 121 is provided with a small bellows 132 which is positioned so that its lower flat surface is in line with the valve member 155 when the cover 121 is in place upon the housing 120. The bellows 132 is sweated to the under-surface of the cover 121 so as to provide a fluid-tight joint, and aligned with the small bellows 132, there is a threaded adjustment screw 133 which, through the bellows seal, provides the upper limit to which the spring 156 may retract the valve member 155. Thus, by turning the screw 133, the position of the valve stem 157 in respect to the drill passageway 138 may be varied as desired. When the screw 133 is screwed outwardly, the spring 156 moves the valve member 155 upwardly, collapsing the bellows 132.

Referring to Figure 4, it will be observed that the cover 121 is provided with a second bellows 147 which is sweated to the inner surface of the cover 121, and is provided with another adjustment screw 148. The boss 125A is likewise drilled at a second place at 160 to receive another valve member 161 which is spring pressed upwardly by means of the interior spring 162. The valve member 160 is provided with a stem 163, the lower conical end of which is aligned with drilled passageway 164 communicating with the ball check valve chamber 165 containing the ball check valve 166, the latter being spring pressed against the passageway 167 by means of the spring 168. The passageway 167 is connected by means of the drill hole 169 to the chamber 150 of the bellows 151. The ball check valve chamber 165 is sealed by means of a suitable screw plug 170. The boss 125 is preferably side drilled, as shown at 129, so as to allow passage of fluid from the annular chamber 124 to the space below the valve member 155 and the boss 125A is similarly drilled at 158 to allow the flow of fluid from beneath the valve member 160 into the annular chamber 124.

The operation of the apparatus illustrated in Figures 2, 3 and 4 is similar to that shown at 60 in Figure 1. When the mechanism is cooled, the fluid stands at the lever illustrated by the dotted line 171. When heat is supplied by heater element 130, the volatile liquid which entirely fills the bellows chamber 150 and fills the upper chamber 124 to the level 171, causes the volatile liquid to be vaporized and the liquid is driven downwardly from the upper chamber 124 through holes 129, through the orifice determined by the position of valve stem 157 in respect to the drill passageway 138, thence past the ball check valve 141 and through chamber 140 and passage 145 to the bellows 150. The flow continues until the circuit to heater 130 is broken, as previously described, and thereupon the resiliency of the bellows 151 and any force applied to it causes the liquid in the bellows chamber 150 to be returned through passages 169 and 167, past the ball check valve 166 through the orifice, the position of which is determined by the valve stem 163 in respect to the passage 164, and thence through hole 158 to the upper housing chamber 124. The timing of the flow downwardly may be adjusted at will by means of screw 133 and the return flow may likewise be adjusted at will by means of the screw 148.

Many obvious variations will be apparent to those skilled in the art and such are intended to be within purview of the invention illustrated, described and claimed.

I claim as my invention:

1. A stoker control system comprising a stoker motor, a first switch connected in circuit with the stoker motor for controlling the operation of said motor in response to calls for heat, a second switch connected in circuit with said motor for operating it to maintain combustion in the stoker, thermal means for operating said second switch including an expansible bulb, a reservoir chamber above said bulb, a fluid in said bulb and reservoir, fluid connection means between said reservoir and bulb, flow regulating means in said fluid connection means for restricting the flow to a predetermined rate in each direction between said bulb and reservoir, an electrical heater element for said reservoir connected to said first switch, said second switch means also in circuit with said heater element, said switch means being closed so as to energize the heater and motor when the expansible bulb is in a contracted condition and open when said bulb is expanded to a predetermined amount, and means for controlling

said first and said second named circuits to cause a selectively greater expansion of said bulb by said first circuit than by said second circuit.

2. A thermally operated time switch comprising a reservoir, a fluid tight enclosure, the volume of which is capable of being changed under the influence of fluid pressure therein, a fluid capable of expansion upon heating in said reservoir and enclosure, fluid connection means between said reservoir and enclosure, independent flow regulating means in said fluid connection for selectively controlling the flow of said fluid in each direction, a heater element for the fluid in said reservoir, circuit means for energizing said heater, switch means in said circuit means, said switch means comprising a first switch operable under certain conditions to cause deenergization of said heater when said enclosure is expanded to a predetermined condition and a second switch operable under other conditions to cause energization and deenergization of said heater when said enclosure is expanded beyond said predetermined condition.

3. A thermally operated time switch comprising a reservoir, a fluid tight enclosure, the volume of which is capable of being changed under the influence of fluid pressure therein, a fluid capable of expansion upon heating in said reservoir and enclosure, fluid connection means between said reservoir and enclosure, flow regulating means in said fluid connection for independently controlling the flow of said fluid in each direction, and hence the rate of contraction and expansion of said enclosure, a heater element for the fluid in said reservoir, first switch means in the circuit of said heater operable by said enclosure for intermittently energizing said heater, said first switch being movable to energize said heater when the enclosure is contracted to a predetermined condition and movable to deenergize said heater when expanded to a predetermined amount, and second normally closed switch means in circuit with said heater and operable by said enclosure, said second switch means being normally closed and movable to deenergize said heater when the enclosure has expanded beyond said first switch opening condition.

4. A thermally operated time switch comprising a reservoir having one side enclosed by a cap, a bellows attached in fluid tight relationship to the reservoir wall opposite the cap, communicating passageways through the reservoir wall opposite the cap, spring retracted needle valves providing independent flow regulating means positioned in operative relation in respect to each of said passageways, bellows means on the cap, screw means threaded through the cap to expand said bellows means to form a stop for said spring retracted needle valves, each of said stops providing independent means for adjustably limiting the extent of movement of said needle valves, check valves in each passageway said valves being oriented so one checks flow from the reservoir to the bellows and the other checks flow from the bellows to the reservoir, a heat expansible fluid in the bellows and reservoir, electrical heater means for the fluid of the reservoir and a circuit closer in circuit with said heater, said circuit closer being movable to closed condition when the bellows is contracted and to open condition when the bellows is expanded to a predetermined degree, and a second circuit closer in circuit with said heater and movable to open and closed condition when said bellows is expanded to a predetermined degree beyond said first circuit closer operating position, said first and said second circuit closers being operable to cause intermittent energization of said heater when said bellows is below and above said predetermined degree.

5. A thermally operated time switch comprising a reservoir having one side enclosed by a cap, a bellows attached in fluid tight relationship to the reservoir wall opposite the cap, communicating passageways through the reservoir wall opposite the cap, spring retracted needle valves positioned in operative relation in respect to each of said passageways, bellows means on the cap, screw means threaded through the cap to expand said bellows means to form a stop for said spring retracted needle valves, check valves in each passageway said valves being oriented so one checks flow from the reservoir to the bellows and the other checks flow from the bellows to the reservoir, a heat expansible fluid in the bellows and reservoir, electrical heater means for the fluid of the reservoir and a circuit closer in circuit with said electrical heater means, said circuit closer being movable to closed condition when the bellows is contracted and to open condition when the bellows is expanded to a predetermined degree, and second normally closed switch means operable by said bellows and in circuit with said electrical heater means and positioned to be opened when the bellows is expanded beyond said predetermined degree, said circuit closer and said second switch means being operable to intermittently deenergize said heater when said bellows is at said predetermined and said further expanded positions.

6. In a thermal timing mechanism, an electrically heated expansible and contractible thermal means, a normally closed switch moved to open position by said thermal means when heated and returned to closed position when cooled, a circuit for said thermal means controlled by said switch, and means for independently adjusting the length of time required for said thermal means to move from its switch closing position to its switch opening position and from its switch opening to its switch closing position, a second circuit for energizing said thermal means, and a second switch in said circuit opened by said thermal means after the same has moved a lesser extent than required for opening the first mentioned switch, said first and said second switches being operable to cause intermittent movement of said thermal means toward said first named switch closing position.

7. In a stoker control system, a stoker, an electrically heated expansible and contractible thermal means, a normally closed switching means in control of said stoker which is moved to open position by said thermal means when heated and returned to closed position when cooled, a circuit for said thermal means controlled by said switching means, means for independently adjusting the length of time required for said thermal means to move from its switching means closing position to its switching means opening position and from its switching means opening position to its switching means closing position, a second circuit for causing energization of said stoker and said thermal means, and a second switch in said second circuit for the thermal means opened by said thermal means after the same has moved to a greater extent than required for opening the first mentioned switching means.

8. In a hydraulic timing mechanism, in com-

bination, a fluid operated member biased to a predetermined position, a fluid reservoir, electrical means energizable to force fluid from said reservoir into said member, a circuit for said means, a pair of switches in control of said circuit for intermittently energizing said electrical means, connections between said member and switches for opening one of said switches when the member has received a predetermined amount of fluid and for closing said switch upon reduction of the amount of fluid in said member and for opening the other of said pair of switches when said member has received a predetermined amount of fluid in excess of said first mentioned amount and for closing said other switch upon reduction of said excess amount of fluid in said member, means controlling the rate of fluid delivery from said reservoir to said member, separate means controlling the rate of return of fluid from said member to said reservoir, and means for independently adjusting each of said rate controlling means.

9. In a hydraulic timing mechanism, in combination, a fluid operated expansible member biased to a predetermined position, a fluid reservoir, electrical means energizable to force fluid from said reservoir into said expansible member, a circuit for said means, a switch in said circuit, connections between said expansible member and switch for opening said switch when the expansible member is expanded and for closing said switch upon contraction of said expansible member, means controlling the rate of fluid delivery from said reservoir to said expansible member, means controlling the rate of return of fluid from said expansible member to said reservoir, means for selectively adjusting either of said rate controlling means, and a second switch in said circuit, said connections being disposed to operate said second switch to alternately energize and deenergize said electrical means when said expansible member is remote from its predetermined biased position and to operate said first switch to alternately energize and deenergize said electrical means when said expansible member is adjacent said predetermined biased position.

10. In a hydraulic timing mechanism, in combination, a fluid operated member biased to a predetermined position, a fluid reservoir, electrical means energizable to force fluid from said reservoir into said member, a circuit for said means, a switch in control of said circuit, connections between said member and switch for opening said switch when the member has received a predetermined amount of fluid and for closing said switch upon reduction of the amount of fluid in said member, means operable in conjunction with movement of said fluid operated member beyond said switch opening position for energizing and deenergizing said electrical means, a first adjustable orifice regulating the flow of fluid from the reservoir to said member, a check valve preventing flow of fluid from said member to said reservoir through said first orifice, a second adjustable orifice regulating the flow of fluid from the member to the reservoir, and a second check valve preventing flow of fluid from said reservoir through said second orifice and to said member, said adjustable orifices providing means for selectively and independently controlling the rate of movement of said fluid operated member in either direction.

11. In a hydraulic timing mechanism, in combination, a fluid operated member biased to a predetermined position, a fluid reservoir, electrical means energizable to force fluid from said reservoir into said member, a circuit for said means, a switch in control of said circuit, connections between said member and switch for deenergizing said circuit when a predetermined amount of fluid is in said member, and for energizing said circuit upon removal of fluid from said member, means to return the fluid from said member to said reservoir, means to independently adjust the time required to force said predetermined amount of fluid into said member and to remove the fluid therefrom and hence control the rate of movement of said fluid operated member in each direction, and means operable to force fluid in addition to said predetermined amount into said member.

12. In a thermal timing mechanism, a heated thermal actuated means, a heater therefor, an operating member driven by said means, a first means operable by said member for controlling the energization of said heater to actuate said thermal means to drive said operating member in cyclic operations of greater and lesser extents, second means operable by said member for controlling the energization of said heater which causes one of said cycles of operation to be confined to the operations of lesser extent.

13. In a control apparatus, a pressure actuated member, an electric heater therefor, first circuit means for energizing and deenergizing said heater for increasing and decreasing the pressure within said member to cause intermittent operation of said control apparatus, second circuit means operable to energize and deenergize said heater to increase and decrease the pressure within said pressure actuated member, and said second circuit means being operable to maintain a greater pressure within said member when the apparatus is under the control of said second circuit means than when the apparatus is under the control of said first circuit means.

14. In a control apparatus, a pressure actuated member, electric means for heating said pressure actuated member, a first circuit for said electric heater means, timing means for controlling said first circuit to intermittently raise the temperature and pressure within said pressure actuated member to a predetermined degree, a second circuit for controlling said electric means to raise the temperature and pressure within said pressure actuated member to a predetermined degree above said first mentioned degree, and means operable in conjunction with said second circuit for maintaining said temperature and pressure within a predetermined range above said first mentioned degree.

15. A stoker control system comprising a stoker motor, a first switch for controlling the operation of said stoker motor, a second switch for controlling the operation of said motor, means for moving said second switch to closed and to open conditions including an expansible fluid motor, independent means for regulating the rate of expansion and contraction of said expansible fluid motor, a heater for said expansible fluid motor, and a third switch in series with said heater and adapted to be actuated by said motor, said heater being connected to the second switch so as to be energized when the second switch is closed and also to be intermittently energized by action of said third switch when the first switch is closed, said expansible fluid motor operating over a different range when the first switch is closed than when it is open.

16. A stoker control system comprising a stoker motor, a first switch for controlling the operation of said stoker motor, a second switch for controlling the operation of said motor, means for moving said second switch to closed position and for moving said second switch to open position including an expansible chamber, an auxiliary chamber, an expansible fluid in said chambers, an electric heater for said expansible fluid connected so as to be constantly energized when the second switch is closed, and automatically operated switch means actuated by said expansible chamber for energizing and deenergizing said heater during the period said first switch is closed.

17. A stoker control system comprising a stoker motor, a first switch for controlling the operation of said stoker motor, a second switch for controlling the operation of said motor, means for moving said second switch to closed position and for moving said second switch to open position including an expansible chamber, an auxiliary chamber, an expansible fluid in said chambers, an electric heater for said expansible fluid connected so as to be constantly energized when the second switch is closed, and means responsive to the movement of said expansible chamber for intermittently energizing said heater while the first switch is closed.

18. In a stoker control system, a first switch and a second switch connected in parallel, a stoker motor and an electrically operated heat motor in parallel relationship with each other and in series with said switches, said heat motor being positioned to intermittently open and close the second switch when the first switch is open, and a third switch in series with said two switches and said heat motor and positioned to be actuated by said heat motor intermittently to open and closed positions at a heat motor temperature different from that necessary to open said second switch and when said first switch is closed.

19. In a stoker control system, a first switch and a second switch connected in parallel, a stoker motor and an electrically operated heat motor in parallel relationship with each other and in series with said switches, said heat motor being positioned to intermittently open and close the second switch when the first switch is open, means to vary the rates of the opening and closing movements of said heat motor, and a third switch in series with said two switches and said heat motor and positioned to be actuated by said heat motor intermittently to open and closed positions at a heat motor temperature different from that necessary to open said second switch and when said first switch is closed.

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Certificate of Correction

Patent No. 2,470,969 May 24, 1949

ALBERT E. BAAK

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 12, line 18, strike out the word "heated";

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of February, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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