Dec. 27, 1932. E. S. BRISTOL 1,892,135

CONTROL SYSTEM

Filed Dec. 12, 1929 2 Sheets-Sheet 1

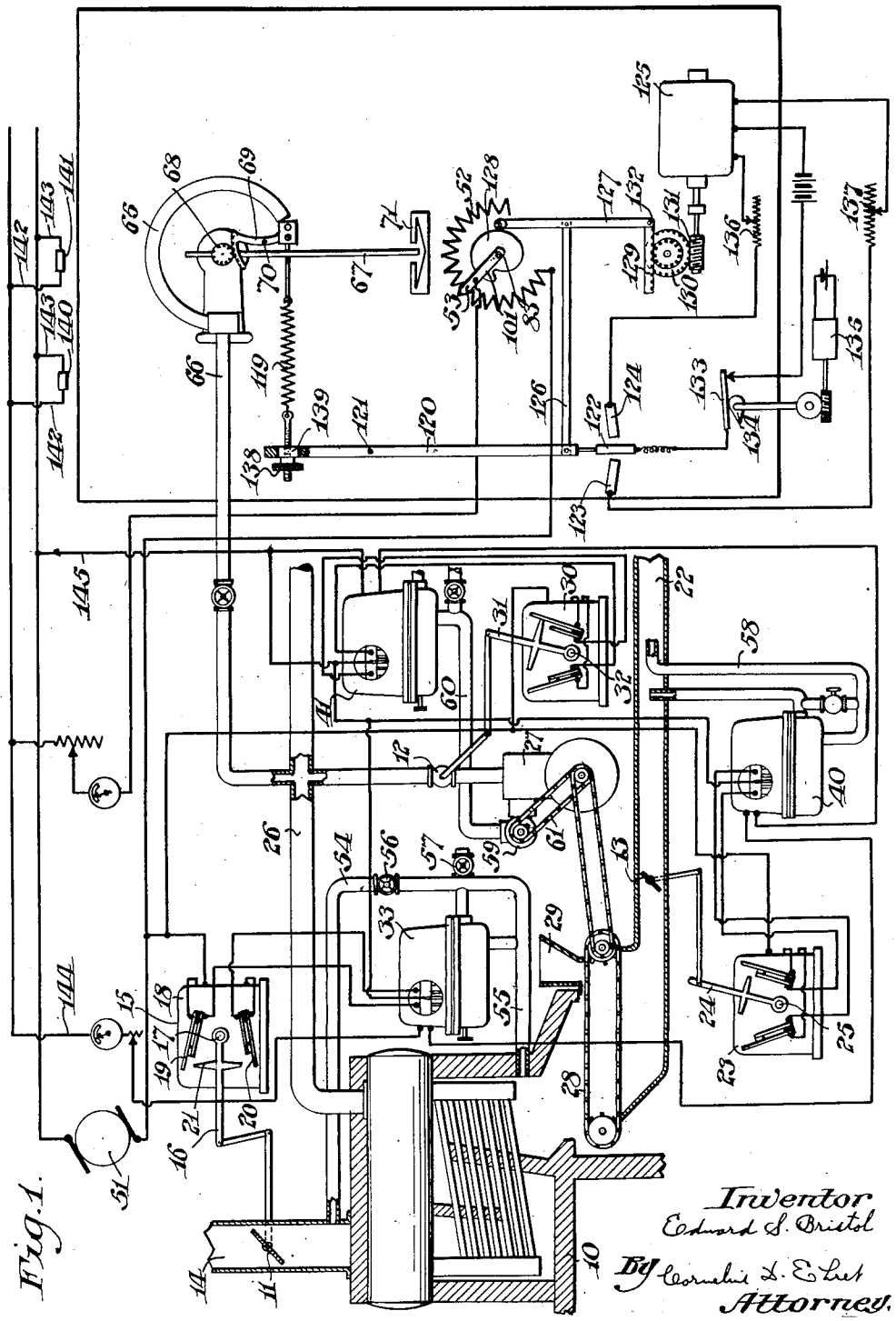


Fig. 1.

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Fig. 2.

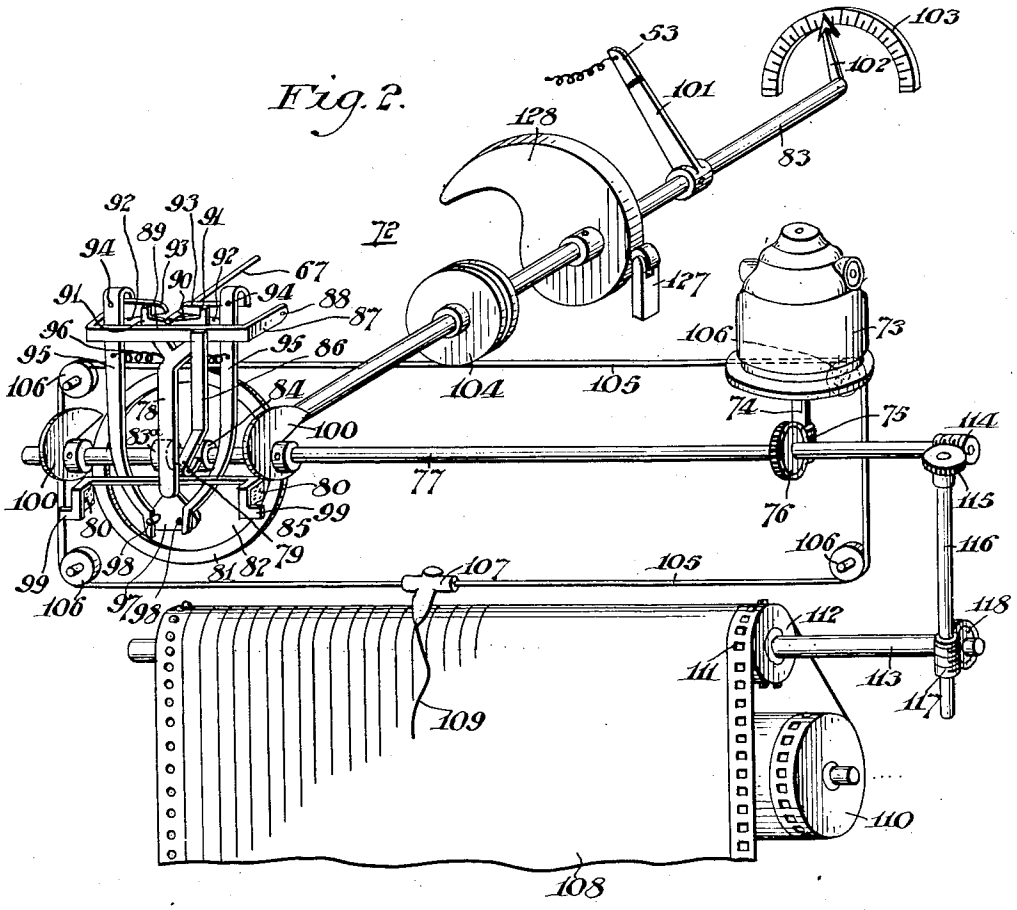


Fig. 3.

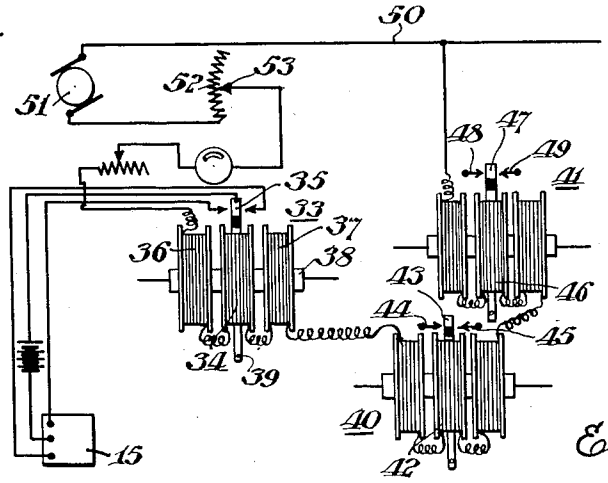
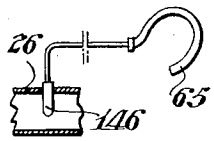


Fig. 4.



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UNITED STATES PATENT OFFICE

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CONTROL SYSTEM

Application filed December 12, 1929. Serial No. 413,482.

My invention relates to improvements in control systems.

In accordance with my invention, the combustion rate of a steam generator is proportioned automatically to correspond to load demand on the generator.

Further in accordance with my invention, the combustion rate of a steam generator is controlled to maintain a standard steam pressure at all loads within the working range.

More particularly in accordance with my invention, a Bourdon tube operates to control the combustion rate of a steam generator in accordance with variations in steam pressure conditions, the Bourdon tube being compensated to provide that standard pressure is restored for the existing load and the corresponding combustion rate.

My invention resides in a system and apparatus of the character hereinafter described and claimed.

For the purpose of illustrating the present invention, one embodiment thereof is shown in the drawings, wherein

Figure 1 is a diagrammatic view, partly in section, of a system embodying the present improvements, one of the pieces of apparatus included in the system being shown on an enlarged scale;

Fig. 2 is an enlarged, fragmentary, perspective view of apparatus included in the system in Fig. 1;

Fig. 3 is a simplified, diagrammatic view of the control circuit in the system in Fig. 1; and

Fig. 4 is a schematic, fragmentary view, illustrating a modification.

Referring more particularly to Fig. 1, the boiler or steam generator 10 is controlled by adjusting one or more of the valves 11, 12 and 13. Adjustment of any one of these valves operates to change the rate of combustion of the boiler.

The valve or damper 11 disposed in the flue or stack 14 is operated by the motor unit, designated generally by reference numeral 15, and comprising the arm 16 connected as shown to the damper and fixed on the shaft 17 driven by an electric motor disposed in the casing 18 of unit 15. Limit switches 19 and 20 are connected in the motor circuit, as shown, and are engaged by the pin 21 carried by arm 16 when the latter is moved to one or the other of its extreme positions corresponding to the positions of damper 11 whereat the same is completely closed or wide open. The damper 13 operates to control the rate of supply of air to the boiler grate by way of conduit 22, and is adjusted by the motor unit 23 identical in construction and manner of operation to unit 15 and including the damper-actuating arm 24 fixed on the motor-driven shaft 25.

The valve 12 operates to control supply of steam from the steam main 26 to the steam engine 27 driving the traveling grate 28 to which fuel is fed by way of the hopper 29. Regulation of valve 12, therefore, operates to vary the speed of operation of engine 27 and the rate of fuel-feeding to the boiler. Valve 12 is adjusted by the motor unit 30, also identical in construction and manner of operation to unit 15 and including the valve-actuating arm 31 fixed on the motor-driven shaft 32.

The motor unit 15 is controlled by the controller unit designated generally by reference numeral 33 and including the movable coil 34 carrying the contact 35 and disposed between the fixed coils 36 and 37. The core 38 extends through the coils as shown and has a loose fit with respect to coil 34 to permit free pivotal movement of the same about point 39 as a center. The motor units 23 and 30 are controlled, respectively, by the control units 40 and 41 identical in construction and manner of operation to control unit 33. The movable coil 42 of unit 40 carries contact 43 engageable with either of the contacts 44 or 45 to effect forward or reverse operation of the associated motor unit 23. Similarly, control unit 41 includes the movable coil 46 carrying contact 47 engageable with either contact 48 or 49 to effect forward or reverse operation of the associated motor unit 30.

As more clearly shown in Fig. 3, the control units 33, 40 and 41 are connected in series relation in a closed control circuit, designated generally by reference numeral 50, and including a suitable source of current supply 51. Connected in the control circuit is a re-

sistance 52 and associated adjustable contact 53.

The arrangement is such that upon adjustment of contact 53 to provide for a given current in the control circuit, the control units 33, 40 and 41 are balanced, that is, the respective movable coils 34, 42 and 46 are in their central positions shown. The arrangement, further, is such that upon movement of contact 53 to cut out resistance in the control circuit and accordingly increase current conditions therein, control units 33, 40 and 41 are placed out of balance and the respective coils 34, 42 and 46 moved to actuate the associated contacts 35, 43 and 47 and thus excite motor units 15, 23 and 30 whereby valves 11, 12 and 13 are caused to open further to increase the rate of combustion of the boiler.

Upon movement of contact 53 to increase the amount of resistance in the control circuit and decrease current conditions therein correspondingly, the control units are unbalanced in the other direction, that is, contacts 35, 43 and 47 are moved in the opposite direction to cause reverse operation of motor units 15, 23 and 30 whereby closing movement is imparted to valves 11, 12 and 13 to decrease the rate of combustion of the boiler.

From the foregoing it will be seen that contact 53 is a master controlling element or member with respect to valves 11, 12 and 13, the latter being caused to open or close simultaneously upon movement of contact 53 in one direction or the other.

Control unit 33 is also responsive through connections 54 and 55 to differences in pressure conditions over grate 28 and in stack 14. By closing valve 56 and opening valve 57 to atmosphere, the unit may be made responsive to differences between atmospheric pressure and pressure conditions over grate 28. The action is such that upon variation in the differential pressure to which unit 33 is subjected, the same becomes unbalanced to effect operation of motor unit 15 to adjust the valve or damper 11 in the proper direction to restore the original differential pressure and rebalance the control unit.

The control unit 40 is made responsive to conditions of air flow in conduit 22 through connections 58. The action is such that upon variation in the rate of air flow in conduit 22, unit 40 becomes unbalanced to effect operation of motor unit 23 to adjust damper 13 in the proper direction to restore conditions of air flow in conduit 22 whereat unit 40 is rebalanced.

Control unit 41 is made responsive to the rate of fuel supply through an air blower 59 connected to the unit by connection 60 and driven from engine 27 through chain 61. Upon variation in current conditions in control circuit 50 to unbalance control unit 41 and increase the rate of fuel supply by regulating valve 12, the pressure in connection 60 varies at the same time and correspondingly to rebalance unit 41 at the new existing load on the system.

That part of the system thus far described is explained more in detail and forms the subject matter of my copending application Serial No. 234,410, filed November 19, 1927, in view of which the foregoing disclosure has been made only to such extent as will enable those skilled in the art to readily understand the utility and cooperating action in the system of the control apparatus now about to be described.

Referring to Fig. 1, the Bourdon tube 65 is connected to steam main 26 by connection 66 and operates upon variation in steam pressure conditions in the main to deflect the pointer or element 67 in one direction or the other from the central or neutral position shown, the tube being connected to element 67 through any suitable means, such as the pinion 68 and segment 69 mounted for pivotal movement about point 70 and connected to the free end of the tube.

The element 67 has a neutral position with respect to clamping mechanism, designated generally by reference numeral 71, and forming part of automatic control apparatus shown in Fig. 2 and designated generally by reference numeral 72.

Referring to Fig. 2, 73 is an electric motor or any other suitable source of power, which rotates the shaft 74 preferably at substantially constant speed to drive the worm 75 and the associated worm gear 76 fixed on shaft 77. Pivoted near its upper end is a lever 78, back of which and pivoted on the lever on a horizontal axis is the arm 79, on each end of which is a shoe 80 of cork or other suitable material frictionally engaging the rim 81 of the clutch disc or wheel 82 fixed on the shaft 83. Fixed on the shaft 77 is a cam 83*a* which periodically engages the lever or member 78 and moves the same outwardly away from disc 82 in opposition to a spring, not shown, thereby lifting shoes 80 free from rim 81, the aforesaid spring returning the shoes into engagement with rim 81 after predetermined rotation of cam 83*a*. Upon shaft 77 is secured a second cam 84 which, after cam 83*a* has lifted shoes 80 from rim 81, actuates the end of the finger 85 on the lower end of the arm 86 secured at its upper end to the member 87 pivoted at 88 for oscillatory movement about a horizontal axis. Upon the frame or member 87 is secured the member 89 whose upper edge 90 is inclined and increases in height from the center toward each side. Disposed immediately above the edge 90 is the element or pointer 67 actuated by the Bourdon tube 65 in accordance with variations in steam pressure conditions of boiler 10. At opposite ends of member 89 are the abutments 91 for limiting the deflection or swing of pointer 67. Above the pointer and beneath which it

normally freely swings or moves, are the edges 92, preferably straight and horizontal, upon members 93, pivoted at 94, 94 and extending toward each other, leaving a gap of sufficient width between their inner ends to allow the free entry of pointer 67 when the same is in the neutral or mid position shown in Fig. 1, the pointer normally moving between the edges 90 of member 89 and the lower edges 92 of the members 93 which have the downwardly extending arms 95, 95 drawn toward each other by the spring 96. Attached to the lower end of the lever 78 is the triangular plate 97 carrying the pins 98, 98 cooperating with the lower ends of members 95, 95. At opposite ends of the arm 79 are the ears or lugs 99, 99 adapted to be engaged by the cams 100, 100 similar in shape and similarly positioned and fixed on shaft 77.

Fixed on shaft 83 is the arm 101 carrying at its outer end adjustable contact 53 disposed for movement over the relatively fixed resistance element 52.

Also fixed on shaft 83 is the pointer or dial 102 disposed for movement over a suitable calibrated scale 103.

Fixed on shaft 83 is a grooved pulley or wheel 104 around which passes the cord 105 which passes over suitable pulleys 106 and is secured to the marker or recorder pen 107 movable transversely on suitable guides, not shown, with respect to the recorder paper 108, on which it draws a record mark or curve 109. The paper 108 is stored on a roller or spool 110 and has marginal perforations 111 engaging teeth or pins on the periphery of the roller 112 fixed on the shaft 113 driven by motor 73 through the worm 114, worm gear 115, shaft 116, worm 117 and worm gear 118 fixed on shaft 113.

The operation of mechanism 72 and associated parts is as follows:

Upon decrease in steam pressure conditions of the boiler, the Bourdon tube 65 will contract correspondingly to effect, through segment 69 and pinion 68, movement of the element or pointer 67 to the right. Due to the periodic vertical movement of member 87 by cam 84 driven by shaft 77, the pointer will be clamped between the inclined edge 90 and the lower edge 92 of the right hand member 93, causing the right hand arm 95 to be tilted on its pivot 94 in a clock-wise direction, thereby pushing on the right hand pin 98 on plate 97 to tilt the movable or driving clutch member in a clockwise direction while cam 83*a* is holding shoes 80, 80 from the rim 81 of disc 82, the extent of angular movement of member 79 being dependent upon the degree of deflection of pointer 67 and therefore upon the amount of variation of the steam pressure.

The cam 83*a* soon allows, because of further rotation of shaft 77, the shoes 80, 80 again to grip rim 81 of disc 82, and soon thereafter the left hand cam 100 engages the left lug 99 which has been elevated, pushing it downwardly and restoring member 79 to the horizontal position indicated. In so moving back to normal position, member 79 rotates clutch disc 82 in a counter-clockwise direction, rotating shaft 83 and arm 101 and pointer 102 in like direction. By this action the arm or control member 101 moves to position contact 53 whereat the amount of resistance 52 in control circuit 50 is decreased to increase current conditions in the circuit correspondingly and unbalance the control units 33, 40 and 41, whereby the combustion rate of boiler 10 is increased. This action is accompanied by movement of marker 107 transversely of paper 108 to produce thereon the mark or curve 109 representative of variations in position of contact 53. The record is, therefore, also representative of variations in current conditions in control circuit 50 and variations in the rate of combustion of boiler 10.

Upon increase in steam pressure conditions of the boiler, the Bourdon tube 65 will expand correspondingly to impart left hand movement to pointer 67, so that the same will be clamped between the inclined edge 90 and the lower edge 92 of the left hand member 93, causing the left hand arm 95 to be tilted in a counter-clockwise direction to push the left hand pin 98 and tilt the driving clutch member 79 in a counter-clockwise direction while cam 83*a* is holding shoes 80, 80 from rim 81, the extent of angular movement of member 79 being dependent upon the degree of deflection of member 67 and therefore upon the amount of increase in steam pressure. After cam 83*a* allows shoes 80, 80 to again grip rim 81, the right hand cam 100 engages the right hand lug 99, which has been elevated, pushing it downwardly and restoring member 79 back to normal position causing corresponding clockwise movement of clutch disc 82 and contact 53 to increase the amount of resistance 52 in control circuit 50 whereby the rate of combustion of boiler 10 is decreased.

For a more detailed showing and explanation of the construction and manner of operation of the apparatus just described, reference may be made to Patent No. 1,125,699 of January 19, 1915 to Leeds.

Referring again to Fig. 1, a tension spring 119 is connected, as shown, to the free end of the Bourdon tube and the upper end of the lever 120 supported for pivotal movement at the point 121 and carrying at its lower end contact 122 engageable with contacts 123 and 124 to effect operation of the electric motor 125 in one direction or the other. Lever 120 is connected by the link 126 to the follower lever 127 engaging at its upper end with the cam 128 fixed on shaft 83, and pivoted at its lower end to rack 129 meshing with the pinion 130 driven by motor 125 through worm gearing 131. The tension of

spring 119 is adjusted so that pointer 67 assumes the neutral position when the steam pressure is at the desired standard value and lever 120 is in the vertical position shown. Upon an increase in steam pressure, the Bourdon tube will expand and impart left hand movement to pointer 67 in amount corresponding to such increase whereby contact 53 will be moved in a clock-wise direction to provide for decrease in the rate of combustion. At the same time, cam 128 will be rotated in a clockwise direction to effect through follower lever 127 and link 126 counter-clockwise movement of lever 120 about point 121 to effect engagement of contact 122 with contact 124 and to increase the tension in spring 119 by such amount as to pull the Bourdon tube back into its original position or shape whereat the pointer 67 will be in neutral position again with respect to the clamping mechanism 71 of apparatus 72. Contact 53 will then remain in its new position of adjustment to provide for combustion in the boiler at the lower rate. At the completion of this initial response to increased steam pressure, the combustion rate will have been reduced so as to prevent further pressure rise, but the pressure will have a value above standard. During the period of such high pressure, motor 125 will be operating intermittently, due to engagement of contact 122 with contact 124, and the occurring intermittent operation of interrupter contact 133 by cam 134. Motor 125, through worm gearing 131 and the associated rack 129, imparts slow movement to fulcrum point 132 of lever 127 to the left. Lever 120, by reason of its connection with lever 127 through 126, will then be rotated in a clockwise direction about point 121 to reduce the tension of spring 119 and permit the Bourdon tube 65 to expand as though a further slight increase in steam pressure had occurred. Pointer 67 will, accordingly, move to the left and effect a further slight clockwise adjustment of contact 53 to still further decrease the combustion rate and thus reduce the steam pressure. This supplementary response to pressure change or, in other words, the compensating action provided by motor 125 and associated parts, will continue until a return to standard pressure is effected, at which time the mechanism will operate to return lever 120 to the vertical position shown whereat contact 122 is intermediate and out of engaging relation with contacts 123 and 124. Motor 125 will then stop, and no further compensating action will take place. It will therefore be seen that cam 128, levers 126 and 127, motor 125 and associated parts provide a compensating action with respect to the Bourdon tube 65 to provide variation in the relation between steam pressure and the position of contact 53. For the standard pressure, therefore, contact 53 may assume the position required to proportion combustion rate to load demand. Without such compensating action, every position of contact 53 would correspond to a different steam pressure within the working range, so that for each combustion rate there would be a different steam pressure. With the compensating action, however, the working pressure range of the Bourdon tube apparatus is shifted until standard pressure is restored for the existing load.

Upon decrease in steam pressure conditions consequent to increase in load demand, the Bourdon tube contracts to effect right hand movement of pointer 67 and counter-clockwise movement of contact 53 an amount corresponding to the deflection of member 67. The rate of combustion of boiler 10 will then increase correspondingly. Such movement of contact 53 is accompanied by similar movement of cam 128 to bring the lower portion of the same in engagement with the upper end of lever 127, whereby lever 120 is permitted to move in a clockwise direction under the action of spring 119. Contact 122 is thereby engaged with contact 123 and tension in spring 119 relieved and the Bourdon tube permitted to expand to its original position with respect to the clamping mechanism of apparatus 72. Contact 53 will then remain in its new position of adjustment corresponding to the drop in steam pressure which occurred, and the rate of combustion of the boiler increased to a point corresponding to the new position of the contact, the steam pressure being at a value below standard. During the period of subnormal pressure, motor 125 will operate, due to engagement of contact 122 with contact 123, in such direction as to shift fulcrum point 132 to the right, whereby lever 120 will be rotated in a counter-clockwise direction about point 121 to increase the tension of spring 119 and cause the Bourdon tube 65 to contract as though a further slight decrease in steam pressure had occurred. The combustion rate will, accordingly, be increased until the resulting rise in steam pressure causes pointer 67 and the associated apparatus 72, controlled thereby, to effect counter-clockwise rotation of cam 128 through an angle sufficient to permit lever 120 to return to its normal vertical position whereat contact 122 is in the neutral position out of engaging relation with contact 123. When lever 120 assumes its normal vertical position, the steam pressure will have been returned to normal, and pointer 67 will again be in its neutral position with respect to clamping mechanism 71.

From the foregoing it will be seen that the Bourdon tube controller is responsive to variations of line drop caused by changes in total steam flow, thereby securing an immediate response to load changes. The rheostat 52—53 adjusts the control current in circuit

50 to act as a loading force upon the individual fuel feed and air flow control units 33, 40, and 41. A given change of header steam pressure produces a definite change of control current. For an increase of load, the primary action above referred to comes to balance at a pressure lower than the original value, while for a decrease of load, balance is reached at a higher pressure. This type of initial pressure response gives a metered response to load change free from a overshooting that would result from attempting to produce an instantaneous return to standard pressure. The compensating action supplements the primary action, and functions to shift the working pressure range of the Bourdon tube controller so as to effect a return to standard pressure at any load. In this way, the initial pressure change accompanying the load change is corrected at a slow rate, such that a minimum disturbance in combustion rate results.

The interrupter switch 133 causes the compensating action to proceed step-by-step at a retarded rate. The pressure-restoring action is thus applied at a rate with which the resulting boiler pressure change can keep pace, and overshooting is avoided. As shown, the switch 133 is disposed in the circuit of motor 125 and is opened at regular intervals by the cam 134 operated by motor 135. The apparatus may be properly timed or adjusted by regulating the speed of operation of motor 125, for which purpose adjustable resistances 136 and 137 are disposed in the motor circuit, as shown. The cam 134 may be driven from one of the shafts of apparatus 72, such as shaft 77 or shaft 116, in which case the driving motor 135 would be omitted.

The spring 119 is shown as being connected to the upper end of lever 120 by the thumb screw 138. The standard steam pressure maintained by the Bourdon tube controller can be varied by turning screw 138 to change the initial tension of spring 119. The working pressure range of the primary action referred to may be varied by changing the effective lever arm of screw 138, for which purpose the upper end of lever 120 is provided with the slot 139 to permit of vertical adjustment at the point of connection of spring 119 with lever 120.

Assuming that the load is increased resulting in a drop in pressure, the rheostat contact 53 is adjusted by the control mechanism previously described to establish a higher combustion rate and simultaneously the tension of spring 119 is decreased to restore the needle 67 to its neutral position. The tension on spring 119 is increased intermittently by the intermittent operation of motor 125 which shifts fulcrum 132. The tendency of the change in tension is to unbalance the forces acting on needle 67. If the rate of the increase of tension is equal to the rate of return of steam pressure to normal, needle 67 does not deflect as the opposing forces of the spring and the steam pressure remain in equilibrium. If, however, the steam pressure is returning faster or slower than the desired rate, (the rate of increase of tension of spring 119) the needle deflects in the proper sense to effect decrease or further increase in the combustion rate to restore equilibrium. When the pressure is returned to normal, the member 120 is in its vertical position shown and the motor remains deenergized.

Similarly if the pressure increases due to decrease of load, for example, the combustion rate is immediately changed to check further change of pressure, and the pressure is returned to the desired or standard magnitude at the desired rate by supplemental control of the rate of combustion if the actual rate of change of pressure departs from the desired rate of return.

Since the position of contact 53 is changed in accordance with required variations in the rate of combustion, the dial 103, which has the same movement as contact 53, provides an indication as to the rate of combustion, for which purpose scale 103 may be calibrated so that direct readings may be taken.

It will be appreciated that other boiler or steam generator units, indicated generally by reference numerals 140 and 141, may be controlled simultaneously with the unit shown in the left half of Fig. 1, in which case the additional units, such as 140 and 141 would be connected in the control system through connections 142 and 143, corresponding respectively to connections 144 and 145.

As shown in Fig. 4, the Bourdon tube 65 may be made responsive to temperature conditions in steam main 26 through a pressure bulb device 146 of any suitable construction, such, for example, as one of the so-called gas-expansion thermometers.

The invention claimed is:

1. A combustion control system comprising a deflecting element, actuating means therefor responsive to departure of vapor pressure from a predetermined value, means for varying the rate of combustion controlled by said deflecting element when displaced from neutral position, means controlled by said deflecting element causing it to assume said neutral position for any pressure to which said actuating means is subjected, and means preventing said deflecting element from remaining in neutral position until said pressure attains said predetermined value.

2. A combustion control system comprising a movable element responsive to vapor pressure, means controlled thereby for effecting initial variation in the rate of combustion by an amount determined by the extent of departure of vapor pressure from a predetermined value, and means effecting

further and intermittent movement of said element in accordance with the difference between the rate of change of the vapor pressure and a predetermined rate of return toward said predetermined value.

3. A combustion control system comprising a deflecting element, actuating means therefor responsive to departure of vapor pressure from a predetermined value, means for varying the rate of combustion controlled by said deflecting element when displaced from a neutral position, means for applying a biasing force controlled by said deflecting member and causing said member to assume a neutral position for any pressure to which said actuating means is subjected, and means controlling said biasing means to prevent said deflecting element from remaining in normal position until said pressure attains said predetermined value.

4. A combustion control system comprising a deflecting element, actuating means therefor responsive to departure of vapor pressure from a predetermined value, a control circuit, an impedance for varying the current in said circuit to change the rate of combustion adjusted by said deflecting element when displaced from a neutral position, means controlled by said deflecting element causing it to assume said neutral position for any pressure to which said actuating means is subjected, and means preventing said deflecting element from remaining in neutral position until said pressure attains said predetermined value.

5. A combustion control system comprising an element responsive to vapor pressure, means for varying the rate of combustion including a movable control member, a source of power, a disengageable connection between said source of power and said control member controlled by said element, and means including said element and said movable control member for effecting immediate variation in the rate of combustion which is a function of the extent of change of vapor pressure and for effecting a further and gradual change in the rate of combustion which is a function of the difference between the rate of change of pressure and a predetermined rate of change toward said predetermined magnitude.

6. A combustion control system comprising means responsive to vapor pressure, means controlled thereby for effecting an immediate change in the rate of combustion which is in accordance with change of said vapor pressure, and means including an intermittent contact mechanism for further and more slowly varying the combustion rate in accordance with the difference between the rate of change of vapor pressure and a predetermined rate of return of pressure toward said predetermined magnitude.

7. A control system comprising an element movable in response to changes of a condition, as pressure or temperature, a movable member, a spring connecting said element to said member, control structure, means for adjusting said structure upon departure of said element from neutral position and substantially simultaneously moving said member to change the tension of said spring to restore said element to neutral position, and means for thereafter moving said member at a predetermined rate toward its neutral position.

8. In a combustion control system, an element movable in response to changes of vapor pressure, a movable structure, a source of power, a disengageable mechanical connection between said movable structure and said source of power controlled by said deflecting element, electrical control mechanism controlled by said movable structure, means for determining the rate of combustion actuable by said electrical control mechanism, means actuated by said movable structure to return said element to neutral position substantially immediately after departure therefrom, and means for intermittently moving said element from neutral position so long as the pressure is different from a predetermined value to effect further change in the combustion rate.

9. In a combustion control system, a movable element responsive to changes of vapor pressure, movable control structure controlled by said movable element, a compensating control member in neutral position when said vapor pressure is of predetermined value, a spring connecting said control member to said movable element, and means for controlling the position of said control member comprising said control structure and means actuated upon departure of said control member from neutral position.

10. A control system comprising a movable element responsive to changes of vapor pressure, a movable member, a spring connecting said movable member to said movable element, movable control structure controlled by said movable element, a pivoted lever connected to said movable member for determining its position, means movable with said control structure for determining the position of one end of said lever, and means for determining the position of the other end of said lever comprising an electric motor and control means therefor actuated upon displacement of said movable member from a neutral position.

11. A control system comprising a movable element responsive to changes of vapor pressure, a movable member, a spring connecting said movable member to said movable element, movable control structure controlled by said movable element, a pivoted lever connected to said movable member for determining its position, means movable

with said control structure for determining the position of one end of said lever, and means for determining the position of the other end of said lever comprising an electric motor, control means therefor actuated upon displacement of said movable member from a neutral position, and means for adjusting the speed of said motor.

12. A control system comprising a movable element responsive to changes of vapor pressure, a movable member, a spring connecting said movable member to said movable element, movable control structure controlled by said movable element, a pivoted lever connected to said movable member for determining its position, means movable with said control structure for determining the position of one end of said lever, and means for determining the position of the other end of said lever comprising an electric motor, control means therefor actuated upon displacement of said movable member from a neutral position, and mean intermittently to de-energize said motor.

13. A combustion control system comprising a movable element responsive to changes of vapor pressure, means controlled by movement of said member in response to change in pressure from normal immediately to change the rate of combustion and to restore said element to neutral position irrespective of the changed pressure, including means whose tension is changed by restoration of said element to neutral position, and means responsive to actuation of said controlled means for gradually returning the tension of said means towards its original magnitude to effect further movements of said element for further action of said control means.

14. In a combination control system, a movable element responsive to changes of vapor pressure, means producing a force for balancing the force exerted by the pressure of said element to maintain it in a neutral position, combustion control means, mechanism responsive to movement of said element for adjusting said combustion control means and readjusting said balancing means substantially immediately to return said element to neutral position irrespective of the existing value of vapor pressure, and means responsive to the changed magnitude of said balancing force for gradually returning it to its normal magnitude thereby effecting further movements of said element from its neutral position for changing the rate of combustion until the opposing forces tending to produce movement of said element are balanced at their original magnitudes.

15. In a combustion control system, a movable element, means responsive to vapor pressure connected thereto, movable structure for controlling the rate of combustion, a source of power, a disengageable mechanical connection between said source and said movable structure controlled by said movable element, means responsive to actuation of said movable structure to restore said element to neutral position substantially immediately after movement thereof, and independently of the existing vapor pressure, and means controlled by said restoring means for intermittently moving said element from neutral position thereby to effect further and gradual change in the rate of combustion until the vapor pressure is returned to normal.

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