Jan. 18, 1938. L. L. CUNNINGHAM 2,105,686

COMBUSTION CONTROL SYSTEM

Filed July 15, 1935 2 Sheets-Sheet 1

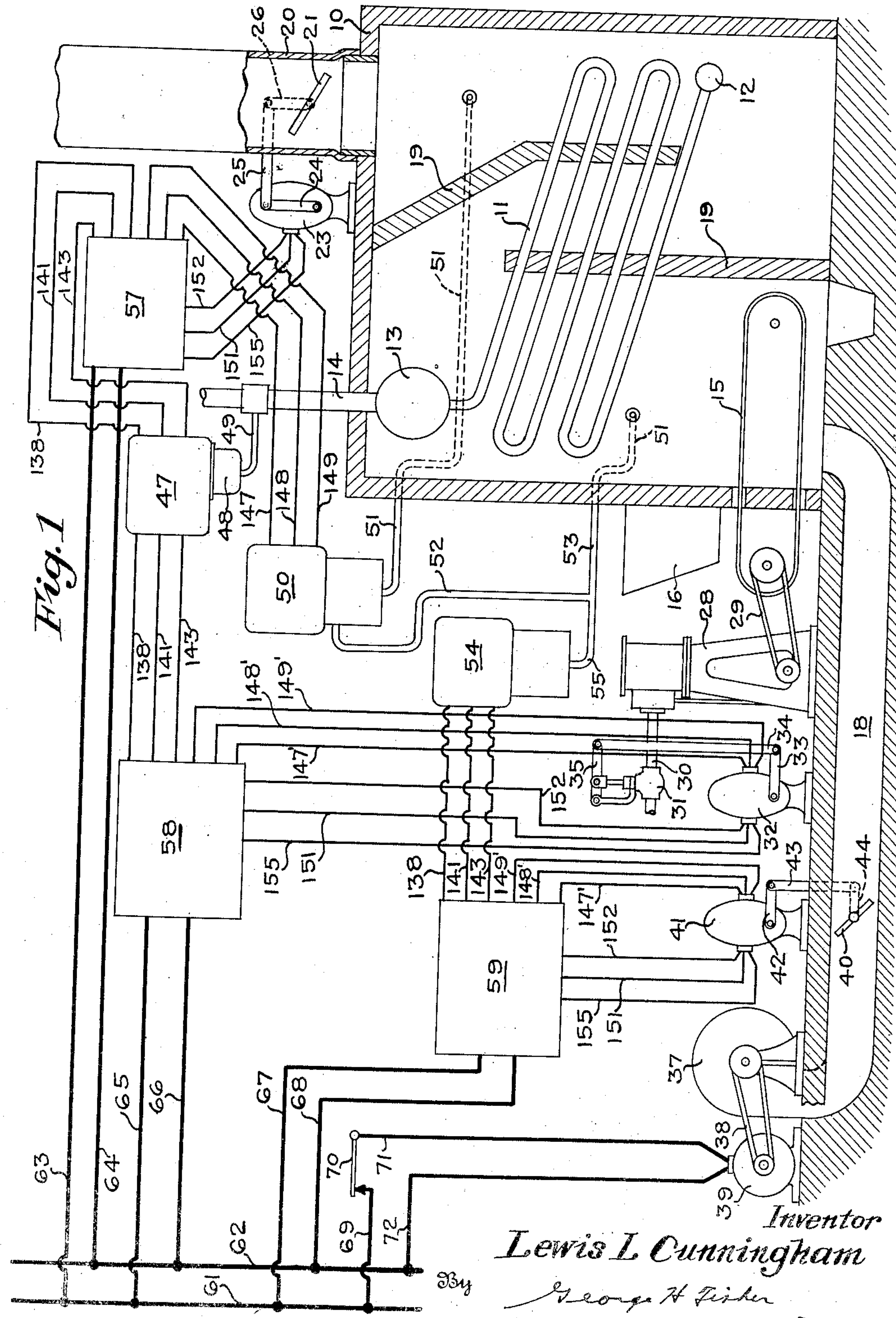

Fig. 1

Inventor

Lewis L Cunningham

By George H Fisher

Attorney

Jan. 18, 1938.

L. L. CUNNINGHAM

2,105,686

COMBUSTION CONTROL SYSTEM

Filed July 15, 1935

2 Sheets-Sheet 2

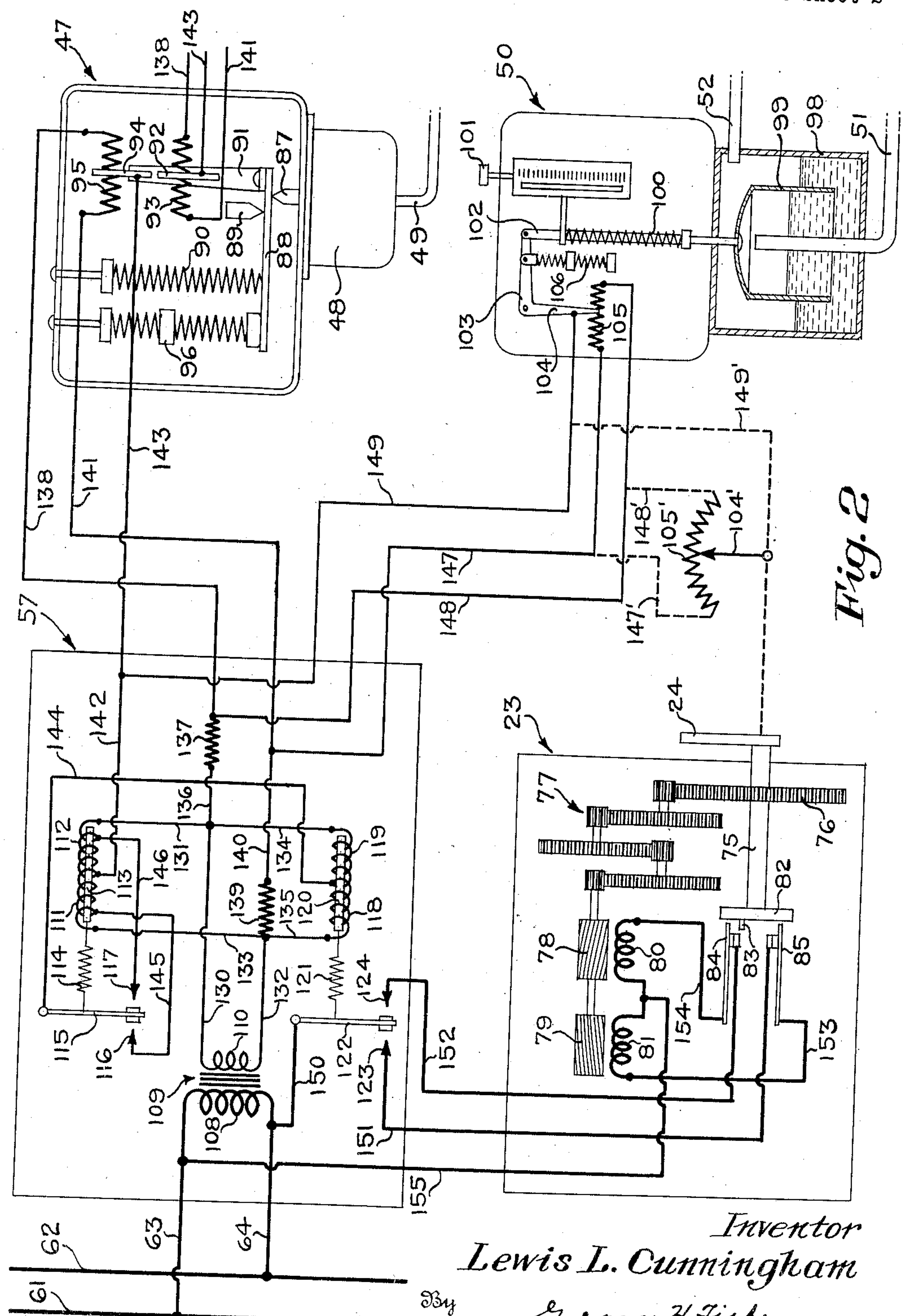

Fig. 2

Inventor

Lewis L. Cunningham

By George H. Fisher

Attorney

Patented Jan. 18, 1938

2,105,686

UNITED STATES PATENT OFFICE

2,105,686

COMBUSTION CONTROL SYSTEM

Lewis L. Cunningham, Minneapolis, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Application July 15, 1935, Serial No. 31,462

1 Claim. (Cl. 236—15)

This invention relates to combustion control system.

The prime object of this invention is to provide a combustion control system which will maintain desired combustion conditions in a boiler or furnace regardless of the effects of outdoor atmospheric conditions on the draft.

An object of this invention is to provide a combustion control system wherein the fuel feeding means is controlled in response to the demand on the boiler and the rate of flow of combustion gases through the boiler is controlled in response to the demand on the boiler and the rate of flow of combustion gases through the boiler.

Another object of this invention is to provide a combustion control system wherein the fuel feeding means is controlled in response to the demand on the boiler wherein the air supply means is controlled in response to the over-fire pressure and wherein the draft through the boiler is controlled in response to the demand on the boiler and in response to the rate of flow of combustion gases through the boiler.

Another object of this invention is to provide a combustion control system for a boiler having a draft regulating damper, a variable speed fuel feeding mechanism, and an air supplying mechanism with a floating motor for controlling the damper, a proportioning motor for controlling the speed of the fuel feeding means, a proportioning motor for controlling the supply of air to the boiler.

Still another object of this invention is to provide a damper for controlling the rate of flow of gases of combustion through the passes of a boiler which damper is operated by a motor under the control of a pressure controller, responsive to boiler steam pressure and a pressure regulator responsive to the pressures existing in the various passes of the boiler.

Other objects and advantages will become apparent to those skilled in the art upon reference to the accompanying specification, claim and drawings, in which drawings:

Fig. 1 is a diagrammatic illustration of my combustion control system as applied to a boiler, and

Fig. 2 is a wiring diagram of a portion of the control system disclosed in Fig. 1.

Although a furnace could be equally well used, for purposes of illustration I have shown my invention as applied to a boiler designated at **10**. Contained within the boiler **10** are water tubes **11** which are connected between a supply header **12** and a steam header **13**. Steam generated in the boiler **10** and collected in the header **13** is taken therefrom through a pipe **14** which may lead to some point of use for any desired purpose. Fuel is shown as supplied to the boiler **10** by means of a chain-grate stoker **15**, the fuel being fed on the chain-grate from a hopper **16**. Located beneath the stoker is an air duct for supplying air to the fuel for combustion purposes. Located in the boiler are a plurality of baffles **19**, forming passes in the boiler through which the gases of combustion pass over the tubes **11** and into a stack **20**. Located in the stack **20** is a draft damper **21** for regulating the rate of flow of the combustion gases through the boiler **10**.

The draft damper **21** is controlled by a floating motor **23** through a crank arm **24** operated by the motor **23**, a link **25** and a lever **26** connected to the draft damper **21**.

The chain-grate stoker is operated by a steam engine **28** through any suitable driving mechanism such as a chain **29**. Steam is supplied to the steam engine **28** through a pipe **30** leading from some source, not shown, and the flow of steam to the steam engine **28** is regulated by a throttle valve **31**. The throttle valve **31** is shown to be operated by a proportioning motor **32** through a crank arm **33** operated by the proportioning motor **32**, a link **34** and a lever **35** secured to the valve.

Air is supplied through the duct **18** for combustion purposes by means of a fan **37** which is driven by an electric motor **39** through any type of driving means such as a belt **38**. The flow of air through the duct **18** is controlled by a damper **40**. The damper **40** is positioned by means of a proportioning motor **41** through a crank arm **42** operated by the proportioning motor **41**, a link **43** and a lever **44** connected to the damper **40**.

A pressure controller **47**, having a bellows chamber **48**, is connected to the steam supply pipe **14** by a pipe **49** so that the pressure controller **47** responds to variations in boiler steam pressure or the demand on the boiler. The details of this pressure controller **47** are shown and described in my copending application S. N. 752,481, filed November 10, 1934.

The low pressure side of a pressure regulator **50** is connected by a pipe **51** to one of the passes in the boiler **10** such as the pass next preceding the stack **20**. The high pressure side of the pressure regulator **50** is connected by pipes **52** and **53** to another pass in the boiler **10** which may be the portion of the boiler immediately above the fuel bed. Therefore, the pressure regulator **50** responds to furnace pressures existing in different passes within the boiler and since these pressures vary in accordance with the rate of flow of combustion gases through the boiler, the pressure regulator 50, in effect, is responsive to the rate of flow of combustion gases through the boiler.

A static pressure regulator 54, identical with the pressure regulator 50, is connected by pipes 55 and 53 to one of the passes of the boiler which may be the portion of the boiler immediately above the fire bed. Therefore, the pressure regulator 54 responds to a pressure existing within one of the passes of the boiler and, more specifically to the over-fire pressure. The details of construction of the pressure regulators 50 and 54 are shown and described in my copending application S. N. 31,463 filed July 15, 1935. The pressure regulator 47 responding to boiler steam pressure or the demand on the boiler and the pressure regulator 50 respond to the rate of flow of combustion gases through the boiler operate through a relay 57 in control of the floating motor 23 to accurately position the draft damper 21. The pressure controller 47 responding to boiler steam pressure or the demand on the boiler also operates through a relay 58 to control the proportioning motor 32 to regulate the speed of the power driven fuel feeding mechanism 15. The pressure regulator 54 responding to over-fire pressure conditions operates through a relay 59 for controlling the proportioning motor 41 for regulating the supply of air for combustion purposes.

Line wires leading from some source of power, not shown, are designated at 61 and 62. The relay 57 receives its power from the line wires 61 and 62 by being connected thereacross by wires 63 and 64. The relay 58 receives its power from the line wires 61 and 62 and is connected across these line wires by wires 65 and 66. In a like manner, the relay 59 receives its power from line wires 61 and 62 and is connected across the line wires 61 and 62 by wires 67 and 68. A wire 69 extending from the line wire 61 is connected to a manually operated switch 70 which in turn is connected by a wire 71 to the electric motor 39. Electric motor 39 is also connected to the line wire 62 by a wire 72 so that when the switch 70 is closed, the electric motor 39 is placed in operation to drive fan 37.

Referring now to Fig. 2, I have shown the manner in which the various pressure controllers and regulators operate through their associated relays to control the operation of the above referred to floating and proportioning motors. The particular portion of the control system illustrated in detail in Fig. 2 is that portion shown in the upper right hand part of Fig. 1. The floating motor 23 comprises a shaft 75 to which is secured the crank arm 24 for operating the damper 21. Rigidly secured to the shaft 75 is a gear 76 which is driven through a reduction gear train 77 by either of the rotors 78 or 79 upon energization of their respective field windings 80 and 81. Also rigidly secured to the shaft 75 is a disc 82 carrying a pin 83. The pin 83 is adapted at extreme positions of the shaft 75 to open limit switches 84 or 85. Upon energization of field winding 80, the shaft 75 is rotated to move the damper 21 towards an open position and upon energization of field winding 81, the shaft 75 is rotated to move the damper 21 towards a closed position.

Although I have described in detail the structure of my pressure controller 47 in application S. N. 752,481, filed November 10, 1934, for purposes of illustration in this application I have shown it to comprise a plunger 87 operated by the bellows contained within the bellows casing 48. The plunger 87 is adapted to rotate a lever 88 above its knife-edge pivot 89 in a counter-clockwise direction. The lever 88 is urged in a clockwise direction by an adjustable tension spring 90. The lever 88 carries an arm 91 to which is secured in an insulating manner a slider 92 adapted to slide across a resistance coil 93. The arm 91 also has secured thereto in an insulating manner a slider 94 adapted to slide across a resistance coil 95. Upon an increase in pressure within the steam line 14, the bellows contained with the bellows casing 48 is expanded to rotate the lever 88 in a counter-clockwise direction to move the sliders 92 and 94 to the left with respect to their associated resistance coils 93 and 95. Upon a decrease in pressure within the steam line 14, the lever 88 is moved in a clockwise direction by the action of tension spring 90 to move the slider 92 and 94 to the right with respect to their respective resistance coils 93 and 95. The range of pressure required to move the sliders 92 and 94 across their coils is controlled by a range adjusting spring assembly 96 which is clearly shown and described in my above referred to copending application.

Although I have disclosed in detail the construction of my pressure regulator 50 in my copending application S. N. 31,463 filed July 15, 1935 I have shown it to comprise a casing 98 containing a liquid therein. Located in the casing 98 and sealed by the liquid is an inverted bell 99 which is urged in an upward direction by the adjustable tension spring 100. The tension spring 100 may be adjusted by the handle 101 in the manner pointed out in my above referred to copending application. The space above the inverted bell 99 is in communication with the over-fire pressure by means of pipe 52 and the space within the inverted bell 99 is in communication with the pressure of the last pass of the boiler by means of the pipe 51. Therefore, the bell 99 is operated by the differential in pressure existing between these two passes within the boiler 10. Since the pressure acting through the pipe 52 is greater than the pressure acting through the pipe 51, the bell 99 is urged downwardly against the action of the adjustable spring 100 and the bell 99 assumes a position corresponding to the differential of these two pressures. Therefore, the bell 99 is positioned according to the rate of flow of combustion gases through the boiler 10. One arm of a bell crank lever 103 is connected by a link 102 to the bell 99 and the other end of the bell crank lever 103 carries a slider 104 adapted to slide across a resistance coil 105. Therefore, it follows that upon an increase in the rate of flow of combustion gases through the boiler 10, the slider 104 is moved to the left with respect to its resistance coil 105 and upon a decrease in the rate of flow of combustion gases through the boiler, the slider 104 is moved to the right with respect to its resistance coil 105. The range of changes in the rate of flow of combustion gases through the boiler 10 required to move the slider 104 across the resistance coil 105 may be varied by means of a range adjusting spring assembly 106 in the manner pointed out in my copending application.

The wires 63 and 64 connect a primary 108 of a step-down transformer 109, having a secondary 110 across the line wires 61 and 62, respectively, the transformer 109 being located in the relay 57. Also located in the relay 57 are oppositely acting coils 111 and 112. These oppositely acting coils 111 and 112 operate a core or armature 113 which is connected by a spring 114 to a pivoted switch arm 115. Cooperating with the pivoted switch arm 115 are spaced contacts 116 and 117 so that when the oppositely acting coils 111 and 112 are equally energized, the switch arm 115 is maintained midway between the contacts 116 and 117. When the coil 111 is energized more than the coil 112, the switch arm 115 is moved into engagement with the contact 116 and likewise, when the coil 112 is energized more than the coil 111, the switch arm 115 is moved into engagement with the contact 117. Also located within the relay 57 are oppositely acting coils 118 and 119 which control the operation of an armature or core 120. The armature or core 120 is connected by a spring 121 to a pivoted switch arm 122. Cooperating with the pivoted switch arm 122 are spaced contacts 123 and 124 so that when the coils 118 and 119 are equally energized, the switch arm 122 is spaced midway between the contacts 123 and 124. When the coil 119 is energized more than the coil 118, the switch arm 122 is moved into engagement with the contact 124 and when the coil 118 is energized more than the coil 119, the switch arm 122 is moved into engagement with the contact 123.

One end of secondary 110 of the step-down transformer 109 is connected by wires 130 and 131 to one end of the coil 112. In a like manner, the other end of secondary 110 is connected by wires 132 and 133 to one end of coil 111. One end of coil 119 is connected by a wire 134 to the junction of wires 130 and 131 and one end of the coil 118 is connected by a wire 135 to the junction of wires 132 and 133. The junction of wires 130, 131 and 134 is connected by a wire 136, a protective resistance 137 and a wire 138 to the right hand end of resistance coil 95. The junction of wires 132, 133 and 135 is connected by a protective resistance 139 and wires 140 and 141 to the left hand end of the resistance coil 95. The junction of oppositely acting coils 111 and 112 is connected by wires 142 and 143 to the slider 94. The switch arm 115 is connected by a wire 144 to the junction of oppositely acting coils 118 and 119. The contact 116 associated with the switch arm 115 is connected by a wire 145 to a small number of turns of coil 111 and in a like manner, the contact 117 is connected by a wire 146 to a small number of turns of coil 112. The left hand end of the resistance coil 105 of the pressure regulator 50 is connected by a wire 147 to the junction of wires 140 and 141 and the right hand end of resistance coil 105 is connected by a wire 148 to the junction of protective resistance 147 and the wire 138. The slider 104 associated with the resistance coil 105 is connected by a wire 149 to the junction of wires 142 and 143.

The switch arm 122 is connected by a wire 150 to the wire 64. The contact 123 associated with the switch arm 122 is connected by a wire 151 to the limit switch 85 and the contact 124 is connected by a wire 152 to the limit switch 84. The limit switch 85 is connected by a wire 153 to one end of field winding 81 and the limit switch 84 is connected by a wire 154 to one end of the field winding 80. The field windings 80 and 81 are connected together and to a wire 155 which in turn is connected to the wire 63.

From the above related wiring connections, it is seen that the upper end of the secondary 110, the right hand end of the coil 112, the right hand end of resistance coil 95, and the right hand end of resistance coil 105 are connected together. Likewise, it is seen that the lower end of secondary 110, the left hand end of coil 111, the left hand end of resistance coil 95 and the left hand end of resistance coil 105 are connected together. It is also seen that the junction of coils 111 and 112, the slider 94 and the slider 104 are connected together. It is therefore seen that the secondary 110, the coils 111 and 112, the resistance coil 95 and the resistance coil 105 are connected in parallel.

With the parts in the positions shown in Fig. 2, the slider 94 is midway of its resistance coil 95, the slider 104 is midway of its coil 105, the switch arms 115 and 122 are midway of their contacts and the coils 111, 112, 118 and 119 are equally energized whereby the damper 21 is maintained in a mid position which position allows the correct rate of flow of combustion gases through the boiler 10 for a given boiler steam pressure. When the boiler steam pressure decreases, the lever 88 is rotated in a clockwise direction to move the slider 94 to the right with respect to its coil 95. By reason of the parallel relationship set out above, movement of slider 94 to the right causes shunting or short-circuiting of the coil 112 to increase the energization of coil 111 and decrease the energization of coil 112. This unbalanced relationship of coils 111 and 112 causes movement of switch arm 115 into engagement with the contact 116, movement of switch arm 115 into engagement with the contact 116 completes a circuit from the secondary 110 through wires 132 and 133, a small number of turns of the coil 111, wire 145, contact 116, switch arm 115, wire 144, coil 119, and wires 134 and 130 back to the secondary 110. Completion of this circuit causes short circuiting or shunting of coil 118 to decrease the energization of coil 118 and increase the energization of coil 119 to move the switch arm 122 into engagement with the contact 124. Movement of switch arm 122 into engagement with contact 124 completes a circuit from line wire 62, through wires 64 and 150, switch arm 122, contact 124, wire 152, limit switch 84, wire 154, field winding 80, and wires 155 and 63 back to the other line wire 61. Completion of this circuit causes energization of field winding 80 to rotate the shaft 75 to move the damper 21 towards an open position. Movement of damper 21 towards an open position increases the rate of flow of combustion gases through the boiler 10 and causes downward movement of the inverted bell 99 of the pressure regulator 50 to move the slider 104 thereof to the left with respect to its resistance coil 105. Due to the parallel relationship of the various coils, as pointed out above, movement of the slider 104 to the left of coil 105 causes shunting or short circuiting of the coil 111 to increase the energization of the coil 112 and decrease the energization of the coil 111. When the rate of flow of the gases of combustion through the boiler 10 has been increased in response to the opening of damper 21 to a value which corresponds to the new low stream pressure value, the slider 104 will be moved sufficiently far to the left with respect to its coil 105 to rebalance the coils 111 and 112 to move the switch arm 115 out of engagement with its contact 116 and into mid position as shown in Fig. 2. Movement of switch arm 116 out of engagement with the contact 116 breaks the above short circuit through the coil 119 equally energize the coils 118 and 119 to move the switch arm 122 out of engagement with the contact 124. This causes deenergization of field winding 80 to stop rotation of the shaft 75 to maintain the damper 21 in its newly adjusted position whereby the draft through the boiler 10 is maintained in accordance with the value of the boiler steam pressure.

When the boiler steam pressure increases, the lever 88 of the pressure controller 47 is rotated in a counter-clockwise direction to move the slider 94 to the left with respect to the resistance coil 95. This left hand movement of slider 94 causes shunting or short-circuiting of the coil 111 to increase the energization of coil 112 and decreases the energization of coil 111. This causes movement of switch arm 115 into engagement with the contact 117 to complete a circuit from the secondary 110, through wires 130 and 131, a small number of turns of coil 112, wire 146, contact 117, switch arm 115, wire 144, coil 118 and wires 135 and 132 back to the secondary 110. This causes short circuiting or shunting of the coil 119 to increase the energization of coil 118 and decrease the energization of coil 119 to move the switch arm 122 into engagement with the contact 123 to complete a circuit from the line wire 62, through wires 64 and 150, switch arm 122, contact 123, wire 151, limit switch 85, wire 153, field winding 81 and wires 155 and 63 back to the other line wire 61. This causes energization of field winding 81 to move the shaft 75 in the opposite direction to move the damper 21 towards a closed position. Movement of damper 21 towards a closed position decreases the rate of flow of the combustion gases through the boiler 10 and in response to this decrease in the rate of flow, the inverted bell 99 of the pressure regulator 50 is raised by the adjustable tension spring 100. This upward movement of the inverted bell 99 causes right hand movement of slider 104 with respect to the coil 105 and this right hand movement shunts or shorts out the coil 112 to increase the energization of the coil 111 and decreased the energization of the coil 112. When the rate of flow of gases of combustion through the boiler 10 have decreased to a value corresponding to the new increased boiler steam pressure value, the coils 111 and 112 will become equally energized to move the switch arm 115 out of engagement with the contact 117 and into mid position shown in the drawings. This causes equal energization of the coils 118 and 119 and consequent movement of the switch arm 122 out of engagement with the contact 123 and into the mid position shown in the drawings. This causes equal energization of the coils 118 and 119 and consequent movement of the switch arm 122 out of engagement with the contact 123 and into the mid position shown in the drawings. This causes deenergization of field winding 81 to stop rotation of shaft 75 to maintain the draft damper 21 in its newly adjusted position.

It is noted that the circuits completed by the movement of switch arm 115 into engagement with either contact 116 or 117 include a small number of turns of coils 111 and 112 which increases the holding effort of the coils to prevent chattering between the switch arm 115 and the contacts 116 and 117. The limit switches 84 and 85 are opened when the motor is moved to either of its extreme positions to break the circuit to the field windings 80 and 81 whereby over-travel of the motor 23 in either direction is prevented.

It is well-known that the draft and the rate of flow of gases of combustion in the boiler are affected by outdoor atmospheric conditions, including outdoor temperatures and wind so that for a given position of a draft damper, the rate of flow of gases of combustion through the boiler will vary in accordance with the variations in the outdoor atmospheric conditions. Therefore, with a draft damper that is merely positioned in accordance with some condition without any compensating effect under the control of the draft or rate of flow of combustion gases through the boiler will not afford an accurate control. By having my pressure regulator 50 perform the balancing function in the manner above described, this compensating effect is accomplished and for a given condition of steam pressure or demand on the boiler, the rate of flow of the gases of combustion through the boiler 10 is maintained at a given value regardless of outdoor atmospheric conditions. Therefore, it is seen that I have provided means whereby the rate of flow of gases of combustion through the boiler 10 is controlled by a floating motor in response to the boiler steam pressure or demand on the boiler and the rate of flow of gases of combustion through the boiler 10.

The proportioning motor 32 which controls the steam valve 31 of the steam engine 28 is also controlled by the pressure controller 47 through the medium of the relay 58. The slider 92 and the associated resistance coil 93 of the pressure regulator 47 as disclosed in Fig. 2 therefore performs the control function of the proportioning motor 32. The relay 58 associated with the proportioning motor 32 is in all respects identical to the relay 57 disclosed in Fig. 2 and the proportioning motor 32 is likewise identical to the floating motor 23 disclosed in Fig. 2 with the exception that the balancing potentiometer is controlled by the motor instead of by the changes in the condition produced by the motor in a manner disclosed in my copending application S. N. 673,236 filed May 27, 1933. To illustrate this, reference is made to Fig. 2 wherein slider 104′ is moved in accordance with the position of the proportioning motor 32. The slider 104′ is adapted to slide across the resistance coil 105′ and one end of resistance coil 105′ is connected by a wire 147′ to the junction of wires 140 and 141 while the other end of the resistance coil 105′ is connected by a wire 148′ to the junction of the protective resistance 137 and wire 138. The slider 104′ is connected by a wire 149′ to the junction of wires 142 and 143. When a proportioning motor such as 32 is used, the resistance coil 105′, the slider 104′, and the wires 147′, 148′ and 149′ are substituted for the resistance coil 105, the slider 104 and the wires 147, 148, and 149, respectively. In Fig. 1, the wiring connections are indicated to correspond to the wiring connections disclosed in Fig. 2.

Upon a decrease in steam pressure or upon an increase in the demand upon boiler 10 the proportioning motor 32 is placed in operation through the relay 58 to move throttle valve 31 toward an open position to increase the speed of operation of the chain-grate stoker to supply more fuel to the boiler 10. When the throttle valve 31 has been moved to a position corresponding to the decreased steam pressure, the balancing potentiometer operated by the proportioning motor 32 stops operation of the proportioning motor **32** and maintains the throttle valve **31** in its newly adjusted position whereby fuel is supplied to the boiler **10** in proportion to the demand for steam or in inverse proportion to the boiler steam pressure.

The pressure regulator **54** responding to over-fire pressure is identical to the pressure regulator **50** disclosed in Fig. 2 but instead of performing a balancing function as is done by the pressure regulator **50**, the pressure regulator **54** performs a controlling function. The pressure regulator **54** is therefore connected by wires **138**, **141** and **143** to the relay **59** which relay controls the operation of the proportioning motor **41**. The proportioning motor **41** operates a balancing potentiometer in the same manner as proportioning motor **32** so that the motor **41** is positioned in accordance with the control of the pressure regulator **54**. When the over-fire pressure decreases, the pressure regulator **54** operates through the relay **59** and the proportioning motor **41** to move the air supply damper **40** towards an open position to supply more air for purposes of combustion and to restore the over-fire pressure to normal. In a like manner, when the over-fire pressure increases above its normal value, the pressure regulator **54** operates through the relay **59** and the proportioning motor **41** to move the air supply damper **40** towards a closed position to decrease the supply of air for combustion and restore the over-fire pressure to its normal value. Therefore, the over-fire pressure is maintained constant regardless of the effects of the outdoor atmospheric conditions and of the condition of the fuel bed.

Summarizing the mode of operation of the entire control system as disclosed in Fig. 1, upon a decrease in steam pressure or upon an increase in the demand for steam, the draft damper **21** is opened to increase the rate of flow of the gases of combustion through the boiler **10** and by reason of the balancing function afforded by the pressure regulator **50** this rate of flow of the gases of combustion is maintained at the desired value regardless of outside atmospheric conditions. This increase in the rate of flow of the combustion gases through the boiler increases the heat supplied to the water in the water tubes **11** to generate more steam and bring the steam pressure in the supply pipe **14** back up to normal. Increasing the rate of the flow of combustion gases through the boiler **10** would tend to decrease the over-fire pressure but by reason of the pressure regulator **54**, controlling the air supply damper **40**, the over-fire pressure is maintained constant regardless of changes in the rate of flow of gases of combustion. This increase in the rate of flow of gases of combustion causes faster burning of the fuel and requires more fuel to be fed to the fire bed. This is taken care of by means of the pressure controller **47** responding to the steam pressure or to the demand for steam to supply more fuel to the boiler **10** where the steam pressure decreases to again restore the steam pressure back to normal. In a like manner, when the steam pressure rises above normal, the rate of flow of gases of combustion through the boiler **10** is decreased regardless of the outdoor atmospheric conditions. The over-fire pressure is maintained constant even though the decrease in the rate of flow of gases of combustion tend to increase the over-fire pressure and the amount of fuel supplied to the boiler **10** is decreased.

From the above it is seen that I have provided a combustion control system which is extremely accurate and reliable in its operation and which is not effected by varying conditions such as outdoor atmospheric conditions and fuel bed conditions.

Although I have disclosed one form of my invention other forms may become apparent to those skilled in the art and this invention is to be limited only by the scope of the appended claim and prior art.

I claim as my invention:

In a combustion control system for a furnace having means for feeding fuel to the fuel bed of the furnace, means for supplying combustion supporting air and a stack for inducing draft through the furnace, the combination of, means responsive to the load on the furnace for controlling the rate of fuel supply to the fuel bed of the furnace, a damper associated with the stack for controlling the draft through the furnace, a reversible electric motor for positioning said damper, a relay including a plurality of coils for controlling the operation of the electric motor, a first adjustable potentiometer, means responsive to variations in the load on the furnace for adjusting said potentiometer, a second adjustable potentiometer, means responsive to variations in the draft through the furnace for adjusting the second potentiometer, circuit connections between the potentiometers and the coils of the relay to position the damper in accordance with the load on the furnace and the draft through the furnace for maintaining the draft through the furnace at predetermined values as determined by the load on the furnace regardless of changes in the draft inducing effect of the stack, a second reversible electric motor for controlling the rate of supply of combustion supporting air by the supplying means, a relay including a plurality of coils for controlling the operation of the second electric motor, a third adjustable potentiometer, means responsive to over-fire pressure for adjusting said potentiometer, a fourth adjustable potentiometer, means responsive to a condition indicative of the position of the second electric motor for adjusting the fourth potentiometer, and circuit connections between the third and fourth potentiometers and the coils of the last mentioned relay to position the second electric motor and hence control the rate of supply of combustion supporting air to maintain the over-fire pressure substantially constant regardless of changes in the load on the furnace, changes in the condition of the fuel bed or changes in the draft through the furnace.

LEWIS L. CUNNINGHAM.