

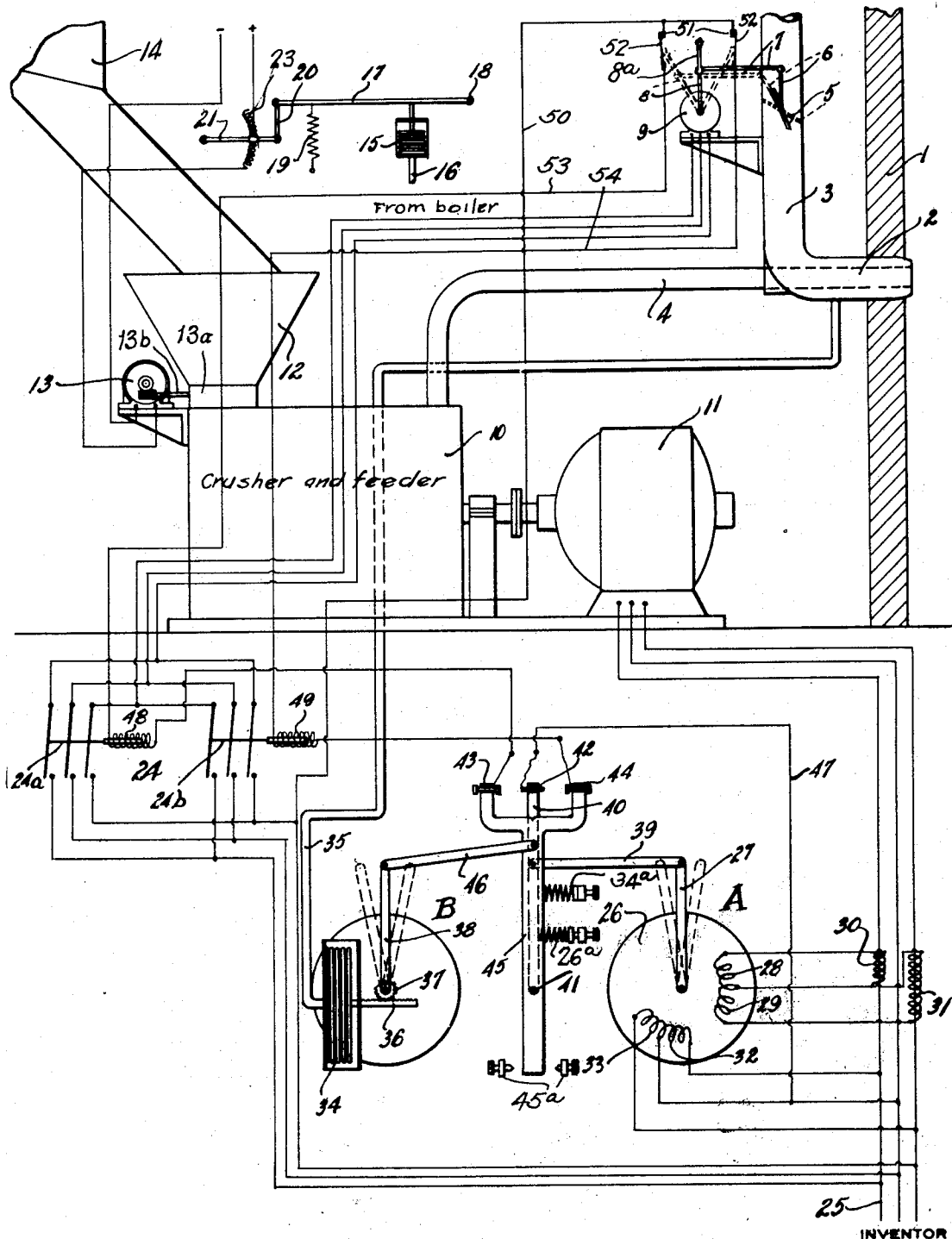
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FUEL CONTROL SYSTEM

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FUEL CONTROL SYSTEM

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4 Claims. (Cl. 110-103)

This invention relates to the control of the supplies of both fuel and air to a furnace operated with pulverized coal or other similar fuel. In such furnaces the raw coal, in the form of slack or larger sizes, is often pulverized just before it enters the furnace and it has been customary to control both the air supply and the fuel supply in accordance with variations in steam pressure, for the purpose of maintaining uniform steam pressure.

The object of the present invention is to provide an improved control system in which, upon variation in some factor of boiler operation desirably maintained uniform, such as steam pressure, a correcting influence is imparted to the control system and the effect thereof is transmitted to the devices for governing the delivery of both air and coal to the furnace, so that the supplies thereof are varied more nearly in strict proportionality in such manner as to maintain proper and efficient combustion conditions under all circumstances, thereby avoiding, particularly during a change in feeding conditions, either over-supply of coal as compared with air and the consequent production of smoke and CO and loss of efficiency on the one hand, or, oppositely, an under-supply of coal as compared with air and the consequent loss of efficiency, as well as the possibility of blowing out the fire on the other hand.

Further objects of the invention are in part obvious and in part will appear more in detail hereinafter.

In the drawing, the view represents somewhat diagrammatically one embodiment of apparatus embodying the invention.

A portion of the wall of the combustion chamber of the furnace is conventionally indicated at 1. Through it extend one or more burners 2 communicating both with the air supply conduit 3 and with a conduit 4 through which is conducted the pulverized fuel, which is usually accomplished by the blowing effect of what is called the primary air. Any number of burners may be employed, but the drawing shows one for simplicity of illustration. The air supply through the conduit 3 is governed in any suitable manner, such as by a damper 5 having an arm 6 actuated through a link connection 7 by an arm 8 on a reversible electric motor 9. The fuel supply, in pulverized form, comes through the conduit 4 from a suitable crushing device conventionally indicated at 10, the crushing mechanism therein (not shown) being operated by a motor 11. Raw coal, in the form of slack or even larger sizes, is

fed to the crusher 10 from a hopper 12 by a fuel feeding motor 13, which can operate any sort of feeding device 13a of such character that the rate of inflow of coal from the hopper 12 to the crusher 10 depends upon the speed of operation of motor 13. As shown, the motor shaft 13, through worm gearing, operates a drive shaft 13b connected to operate the feeder 13a. Coal is fed to hopper 12 from bunker 14 in any suitable manner.

It is customary, in the operation of systems of this kind, to utilize some device subject to pressure of steam in the boiler, for controlling both the device, such as damper 5, which regulates the air supply, and the device, such as motor 13, which regulates the feed of coal from the hopper 12 to the crusher, but such systems are not fully satisfactory. The reason is that upon an increase in the steam pressure, such as demands a reduction in fuel and air supplies, both the damper 5 and motor 13 are immediately and simultaneously adjusted to produce a new condition. Adjustment of the damper 5 does actually immediately vary the air supply. Adjustment of motor 13 to decrease its speed, however, does not immediately reduce the inflow of pulverized fuel to the furnace, due to the fact that the crusher 10 already contains not only the fuel already pulverized, but a supply in the process of being pulverized and ready for such action, so that even after speed of motor 13 is actually reduced the response is not felt in the furnace chamber until some time later, due to the necessity for first consuming the excess of fuel on hand in the crusher. As a result, for some time there is an excess of fuel over air, with a consequent production of CO and black smoke and the loss of efficiency. Likewise, upon a reduction in steam pressure, which should be met with an increase in the amounts of both air and fuel, the air supply is actually changed immediately, but the coal supply entering the furnace chamber does not experience an increase until some time later, because increasing the speed of the motor 13 does not immediately increase the amount of fuel passing from the pulverizer to the furnace. As a result, under these conditions there is an excess of air over fuel, with the usual loss of efficiency and the possibility of actually blowing out the fire.

My invention aims to overcome the objections to these prior control systems by subjecting the devices for controlling the supplies of both air and fuel to the influence of a device sensitive to that factor of furnace operation which it is de-

sired to maintain uniform, such as steam pressure, but at the same time to correlate the two sets of feed controlling devices, to wit, the air supply controlling device on the one hand and the fuel supply controlling device on the other hand, so that the quantities of air and fuel are always in proper proportion to each other. That is to say, upon either an increase or a decrease in steam pressure the quantities of both air and fuel are decreased, but always in step with each other, so that the relative proportions of the two do not vary even while conditions are changing. This I accomplish by making the control system sensitive to a factor which is more nearly, or indeed, may be said to be almost exactly proportional to the actual rate of flow of fuel from the crusher to the furnace chamber. The factor chosen for this purpose is the load on the motor or driver for the crushing mechanism. As a consequence, when the quantity of fuel being crushed in the pulverizer is large, the load on the crusher motor is heavy, and when the crusher contains a smaller amount of fuel the load on said motor is reduced, and in all cases, whatever be the conditions existing or demanded, the rate of air supply is maintained at a value in step with the load on the crusher motor.

The drawing shows conventionally one control system for this purpose. As before, some means is provided by which a change in a factor of boiler operation desirably maintained uniform, such as steam pressure, for example, varies the speed of the fuel feeding motor 13. Many commercial control devices are obtainable in the open market to produce this effect. The drawing shows conventionally for the purpose an expansible bellows 15 which expands or contracts according to variations in boiler pressure conveyed to it through the conduit 16. The movable portion of the bellows is connected to actuate a lever 17 pivoted at 18 and biased toward the bellows by a tension spring 19, the movable end of said lever being suitably connected, as by a link 20, to the arm 21 of a rheostat 23 in the circuit from the supply leads to motor 13. Upon an increase in steam pressure lever 17 rises and shifts the position of rheostat arm 21 and decreases the speed of motor 13, thereby reducing the rate of supply of coal from hopper 12 to crusher 10. Ultimately, when the influence of the change is felt at the boiler, the steam pressure falls and a reverse influence is reflected back through the control system. The parts act like a governor, with the lever 17 always tending to return to a neutral position.

It will be observed that so far the only effect of rising steam pressure is to decrease the speed of the feeder motor 13. No immediate effect is produced upon the supplies of either air or fuel entering the furnace, but these are adjusted or changed in step with each other later on, as will appear.

Motor 9 is a reversible motor which is operated by the reversing switch mechanism generally indicated at 24. Motor 9 is normally stationary and is operated in one direction or the other to adjust the damper 5 toward open or closed position.

The new position of the damper produces a change in pressure at the bellows 34, with a consequent opening of the appropriate pair of contacts 42 and 43 on the one hand, or 42 and 44 on the other hand, as the case may be, thus ultimately stopping motor 9 and damper 5 in a new position. The switch mechanism 24 is made sensitive to the flows of both air and fuel by a suitable relay mechanism for the purpose. This re-

lay mechanism includes two instruments, one of which is sensitive or responsive to the load on the crusher or the driver for the crusher and the other of which is sensitive or responsive to variations in the air supply on the furnace side of the damper 5.

As to the first of said instruments,—that responsive to the crusher or crusher driver,—said instrument will of course be of a character depending upon the type of driver used for the crusher. For example, if the crusher driver is a steam turbine, the first instrument of the relay mechanism would be made responsive to steam flow to the turbine, as will be readily understood. In the drawing, however, the crusher driver is an electric motor 11, so that the first instrument of the relay mechanism is of electrical character. The relay mechanism includes a suitable support (not shown) on which are mounted the said electrical instrument A sensitive or responsive to the power taken by the motor 11 from the electric supply leads 25. This electrical instrument of course will be of a character suitable to the kind of current required for motor 11. For an A. C. system it will be similar to a polyphase or single phase watt meter. For a D. C. system it may be similar to a D. C. watt meter. In the arrangement shown, which is A. C. as regards motor 11, the electrical instrument A includes a disc 26 carrying an arm 27 and influenced by coils 28, 29 supplied by current transformers 30, 31 associated with leads from the main line to motor 11, and also two potential coils 32, 33 suitably connected to the line. The torque developed by the disc 26 is proportional to the amount of power taken from the supply leads 25 by the motor 11, and is balanced against the usual adjustable loading spring 26a.

The instrument B includes an expansible bellows 34 made to expand and contract according to the pressure conducted to it by the pipe 35 communicating with the air supply pipe 3 on the furnace side of the damper 5. The movable part of the bellows actuates a rack 36 connected to a pinion 37 with which rotates an oscillating arm 38, the bellows pressure being balanced against the usual adjustable loading spring 34a.

Arm 27 of instrument A is connected by a link 39 to arm 40 pivoted at 41 and carrying a double ended contact member 42 cooperating with two adjustable contacts 43, 44 on the arms of a yoke carried by a lever 45 also pivoted at 41 and working between the usual limit stops 45a and connected by link 46 to be operated by arm 38.

The center contact 42 is connected by a wire 47 to the center one of the supply leads, while the contacts 43, 44 are connected through coils 48, 49 of the reversing switch 24 to the other two wires of the system. These two coils 48, 49 separately actuate the switch parts 24a, 24b which connect the motor 9 up to the main leads 25, so as to cause rotation of the motor 9 in one direction or the other according to which switch part is closed.

The drawing in full lines shows all parts of the apparatus in neutral position, with the boiler operating at normal pressure. Assuming an increase of boiler pressure, the first effect is at the bellows 15, which expands and elevates lever arm 17 pivoted at 18 to increase the resistance of rheostat 23, thereby decreasing the speed of motor 13. As before stated, motor 13, through a shaft 13b, operates a conventional type of feeder so constructed as to vary the amount of coal fed from hopper 12 into the crusher 10 in proportion to the rate of speed of motor 13. Therefore, reduc-

tion in speed of motor 13, produced in the manner stated, reduces the rate of supply of fuel from the hopper 12 to the crusher and feeder 10. In conventional combustion controls, as generally used, the quantity of air admitted to duct 3 is varied in step with variations in speed of motor 13, with the result that when the speed of motor 13 is reduced too little air is admitted to the combustion space for efficient combustion, because it requires the elapse of a material length of time for a decrease in the quantity of coal supplied to the crusher to produce a decrease in the rate of flow of coal through duct 4 to the combustion space. In the present system, when the speed of motor 13 is reduced in the manner stated, no immediate change is produced in the rate of air supplied to the combustion space. Such air supply is not reduced in quantity until the load on the driving motor 11 is reduced. The load on the driving motor 11 is utilized as a controlling factor for the air supply because it has been found from experience that the power taken by motor 11 is very nearly proportional to the flow of fuel and carrier air through duct 4 to the combustion space. In the example now being described, steam pressure has risen beyond the desired normal and the speed of motor 13 has been reduced. As soon as motor 11 feels the effect of the reduced quantity of coal being supplied to the crusher and feeder 10, and therefore takes less power from the feed lines 25, the watt-meter element A with its disc 26 exerts reduced torque upon arm 27 about the center of disc 26, allowing spring 34a to pull lever 40 to the right, closing contacts 42, 44, and energizing coil 49 of the reversing magnetic switch 24. The consequence is the closing of the switch parts 24b, connecting motor 9 to the line in such manner that it slowly rotates lever 8 to the left in the drawing, moving damper 5 toward closed position, thus reducing the air pressure in the duct 3 and the communicating pipe 35 and bellows 34. Bellows 34 therefore partially collapses and, through rack 36 and pinion 37, moves arm 38 to the right, causing arm 45 and the contact 44 mounted thereon also to move to the right, thus opening contacts 42, 44 and de-energizing coil 49 of magnetic switch 24, opening the switch parts 24b and stopping further rotation of motor 9. Thus it will be observed that the element B, sensitive or responsive to the air supplied to the combustion chamber, acts as a restoring device or, more accurately, to terminate the regulating or control operation with contacts 42, 44 open and the motor 9 stopped.

If steam pressure again rises, or rises further, the same cycle is repeated or continued until finally the parts come to rest in a position in which the rate of supply of fuel has been reduced at the feeder 13a and the damper 5 has been moved toward closed position, both to an amount sufficient to off-set the rise in boiler pressure. In the case of a decrease in boiler pressure opposite effects are produced in the sense that the first effect is a reduction in pressure at the bellows 15 with a lowering by spring 19 of the lever 17, a reduction in the resistance of rheostat 13 and a consequent increase in the speed of motor 13. This immediately increases the rate of supply of fuel by the feeding device 13a to the crusher and feeder 10, but the effect of this increased rate of fuel supply is not felt at the motor 11 for a material period of time. Consequently, at first, there is no immediate adjustment of damper 5. However, when the load on motor 11 increases, due to the increased duty of said motor in coping

with the heavier load on the crusher and feeder, the wattmeter element A responds with an increased torque effect upon arm 27, moving it to the left in the drawing and also moving arm 40 to the left, ultimately closing switch contacts 42, 43. Closing of these contacts energizes coil 48, closes switch elements 24a and again connects the motor 9 to the line, but in a manner to rotate it in the opposite direction from before, or in such manner as to rotate arm 8 to the right and moving damper 5 toward open position. This increases the air pressure in the duct 3, in conduit 35 and in bellows 34, resulting in arms 38 and 45 being moved to the left, thus opening contacts 42 and 43 against the tension of spring 26a. This terminates the control operation which, in the meantime, has adjusted both the fuel supply and the air supply sufficiently to meet the assumed decrease in boiler pressure.

Thus, the system is automatically accommodating or self-adjusting to either increases or decreases in boiler pressure, in each case first adjusting the fuel supply and then, after the passage of a material period of time, also adjusting the air supply to meet the new condition.

Preferably, the electrical circuits to the motor 9 include travel limit switch devices which automatically open the circuits to said motor when the limit positions, open or closed, of the damper 5 are reached. As illustrated, a wire 50 coming from one of the supply leads 25, is connected to the stationary contacts 51 of the two limit switches, each of which includes a spring contact 52, one of which is connected by a wire 53 to the coil 48 and the other by a wire 54 to the coil 49. The spring contacts are operated by an extension 8a of the motor arm 8. The arrangement is such that when the arm 8 approaches either limit of its motion the extension 8a engages one or the other of the spring contacts 52 and thereby opens the motor circuit. This arrangement is a simple expedient to automatically open the motor circuit and limit its operation under any circumstances, particularly under unusual conditions, as when the circuit to the motor 11 is opened for any reason, thereby deenergizing all of the coils 28, 29, 33 and 32, so that no influence of motor 11 can be effective in the control of motor 9.

As a result of all of the foregoing, the several control devices conjointly function as a governor, each change of steam pressure producing an operation of the rheostat 23 which controls motor 13, so as to change its speed and consequently to change the rate of supply of coal to the crusher 10, and the air damper or controlling device is later adjusted in step with the change of power required for crushing and hence with the change in the rate of feed of coal to the furnace, so that ultimately the rates of supply of both air and fuel to the furnace are adjusted proportionately in such manner as to restore the steam pressure to the original value at which it should be maintained. This avoids any lack of proportionality between air and fuel and maintains efficient combustion conditions at all times.

While the drawing shows the damper 5 arranged to control the flow of air to the furnace through a conduit 3 which is separate from that communicating with the crusher, it should be understood that such illustration is conventional and should not be considered in any sense of limitation, because any arrangement which controls the supply of air to the furnace is satisfactory. In these furnaces, the air supply is taken care

of in various ways. In some cases, such as shown in the drawing, a part of the air,—the smaller part,—flows through the crusher and travels with the pulverized fuel to the furnace and because this
 5 air is limited in quantity a proper control of the total air supply may be effected at the conduit 3. However, in other cases, all of the air for the furnace, or at least for the one unit thereof, may pass through the crusher, and such air supply is
 10 therefore regulated by a proper damper or other means at the air inlet to the crusher. Other arrangements are possible, but in any event, the system herein described will include a motor 9 whose function it is to properly control the
 15 quantity of air supplied to the furnace, wherever or whatever the air regulating device may be.

What I claim is:

1. In combination, a boiler furnace, fuel crushing and feeding means communicating therewith,
 20 fuel supply means for said fuel crushing and feeding means, air supply means for the furnace, means responsive to variations in a factor of boiler operation desirably maintained uniform for controlling said fuel supply means, and means responsive to the operating load of the fuel crushing
 25 means for controlling the air supply means.

2. In combination, a boiler furnace, fuel crushing and feeding means communicating therewith, fuel supply means for said fuel crushing and
 30 feeding means, air supply means for the furnace,

means responsive to variations in a factor of boiler operation desirably maintained uniform for controlling said fuel supply means, and means responsive both to the operating load of the fuel crushing means and to said air supply for controlling the air supply means.

3. In combination, a boiler furnace, fuel crushing and feeding means communicating therewith, variably operating fuel supply means for said fuel crushing and feeding means, a regulator therefor,
 10 air supply means for the furnace, a regulator therefor, means responsive to variations in a factor of boiler operation desirably maintained uniform for controlling the regulator for said fuel supply means, and means responsive to the operating
 15 load of the fuel crushing means for controlling the regulator for the air supply means.

4. In combination, a boiler furnace, fuel crushing and feeding means communicating therewith, variably operating fuel supply means for said
 20 fuel crushing and feeding means, a regulator therefor, air supply means for the furnace, a regulator therefor, means responsive to variations in a factor of boiler operation desirably maintained uniform for controlling the regulator
 25 for said fuel supply means, and means responsive both to the operating load of the fuel crushing means and to said air supply for controlling the regulator for the air supply means.

FRANK O. WALLENE. 30