Jan. 16, 1945. A. E. KROGH ET AL 2,367,359

CONTROL SYSTEM

Filed July 26, 1940 2 Sheets-Sheet 1

FIG. 1.

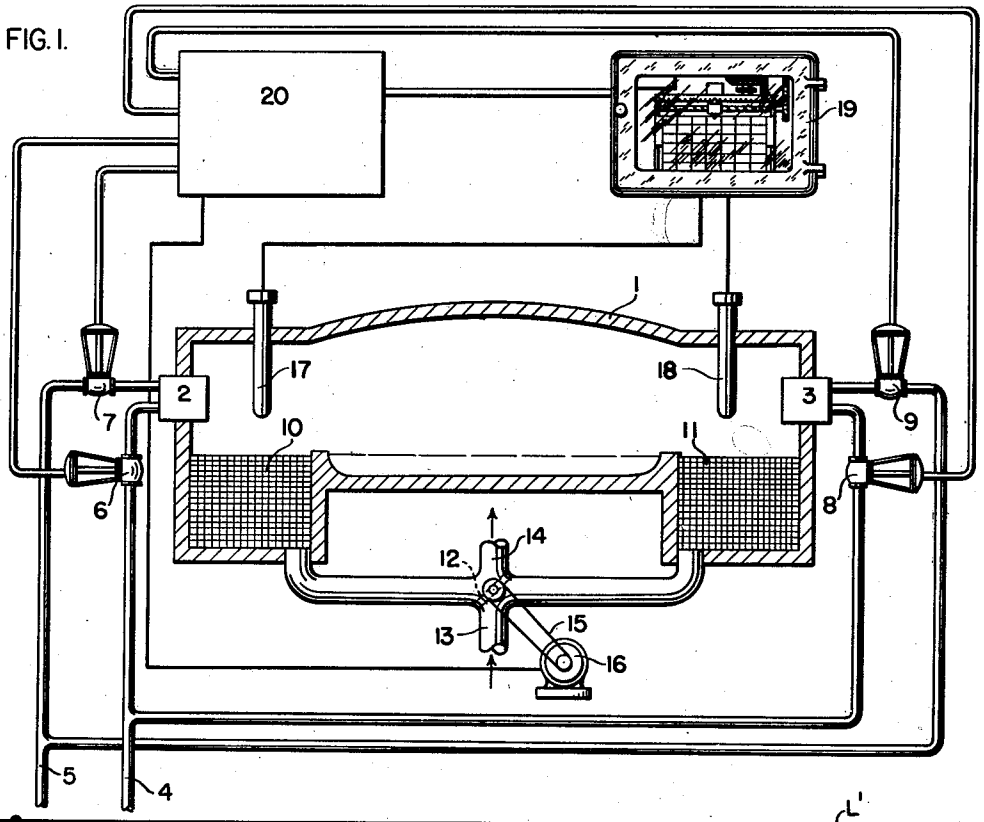
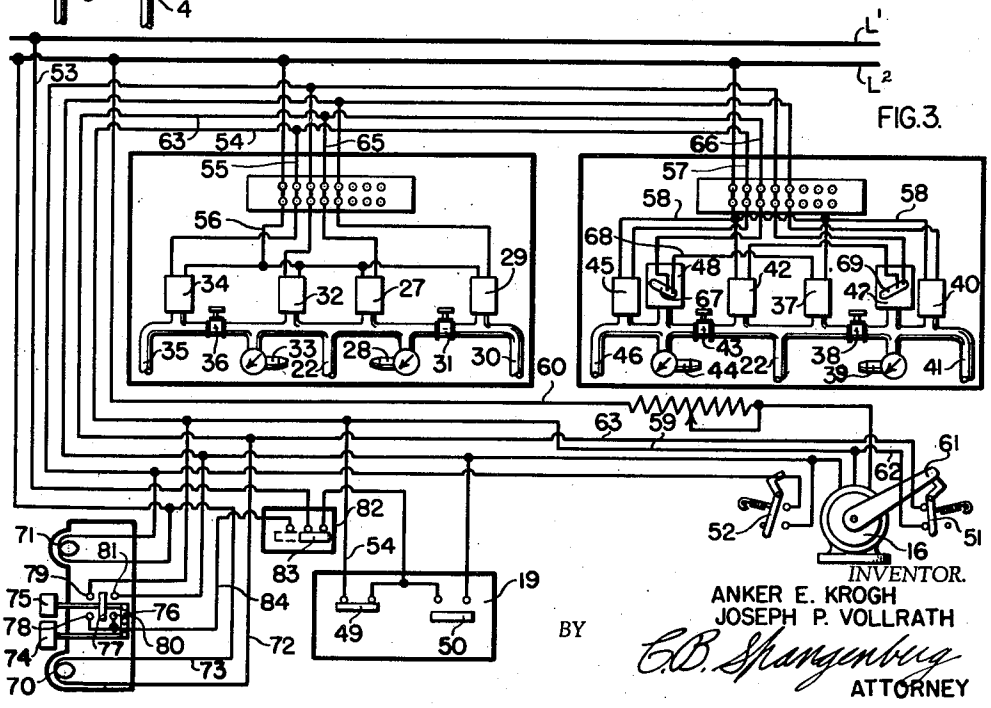


FIG. 3.



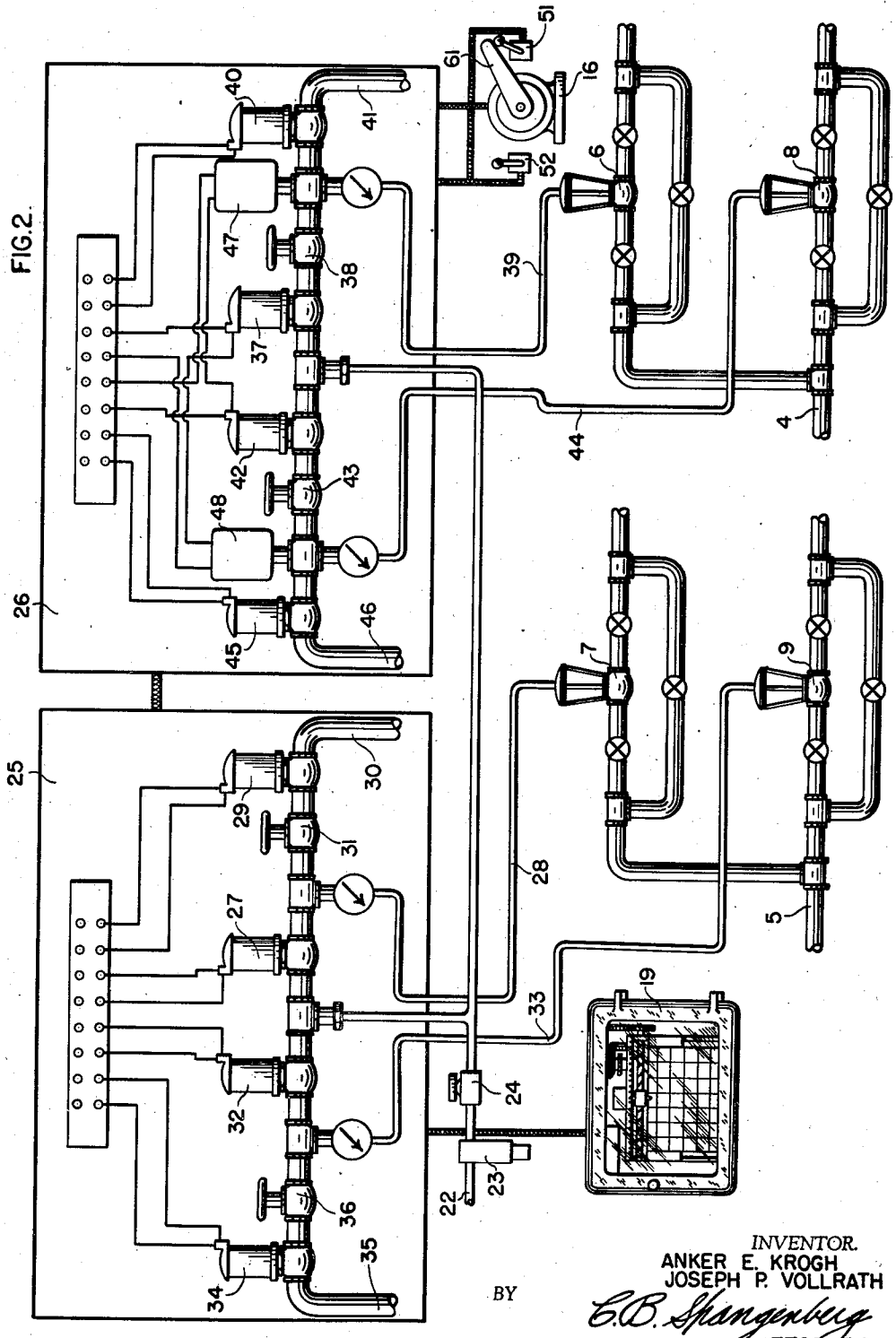
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FIG. 2.



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Patented Jan. 16, 1945 2,367,359

UNITED STATES PATENT OFFICE

2,367,359

CONTROL SYSTEM

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Application July 26, 1940, Serial No. 347,776

8 Claims. (Cl. 158—7.5)

The present invention relates to regenerative furnaces, and more particularly to a system for reversing the flow of fuel and air to furnaces of this type in an approved and theoretically correct manner.

In regenerative furnaces the oil or other fuel is injected into the furnace by steam and oil pressure and air for supporting combustion is blown in through a checker work at the end of the furnace adjacent the oil supply nozzle. The combustion gases come in contact with the furnace charge to be heated and pass out through a checker work at the opposite end of the furnace. At variable periods the flow of air and combustion gases is reversed so that the air supply may be preheated by passing through the checker work that was formerly used for exhaust. The other checker is then reheated. When this reversal occurs it is necessary that the oil supply nozzle on one side of the furnace be completely purged of oil before the oil on the other side is turned on and it is necessary that a damper which is used to control the reversal of the air supply be moved to its final position before the oil is turned on.

These and other necessary operations have previously been performed manually with a great loss of time and fuel or have been performed electrically. When an electric control system was used the necessary interlock connections between the various control units created an ungainly and highly complicated system. Even then it was extremely difficult if not impossible to vary the relative rates at which the various valves were opened and closed.

It is an object of our invention to overcome the difficulties encountered in and the short comings of the previous control systems by providing an electrical control system for pneumatically operated valves. These valves are used to control the supply of fuel oil and atomizing steam to the furnace and are interlocked with each other and with the air reversing damper.

It is a further object of our invention to so interconnect the actuating elements of the various valves that a theoretically perfect reversal system is obtained for a regenerative furnace. It is a further object of the invention to reverse a regenerative furnace quickly and efficiently with each of the operations performed automatically in the proper sequence from the closure of a single switch. It is a further object of the invention to provide a simple and reliable means to vary the speed with which the various valves of the system operate. It is a further object of the invention to provide a system in which an open hearth, or other regenerative furnace, may be reversed automatically from a manual push-button station or may be reversed from any desired control instrument.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects obtained with its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described a preferred embodiment of the invention.

In the drawings:

Fig. 1 is a diagrammatic representation of an openhearth furnace and its control connections;

Fig. 2 is a detail view of the piping and valve connections; and

Fig. 3 is a wiring diagram of the control system.

There is shown in Figure 1, an open hearth furnace 1 which may be fired from either end by burners 2 or 3. Each of these burners is supplied with fuel, preferably oil, through pipe line 4 and with steam or other suitable fluid that is used to inject and atomize the oil into the furnace under high pressure, through a pipe line 5. The pipe lines supplying oil and steam to the burner 2 are respectively provided with pneumatically operated valves 6 and 7, which valves are normally maintained in their closed position and are opened by means of air supplied to their diaphragms. In a like manner pipe lines 4 and 5 supplying oil and steam to the burner 3 are provided with similar pneumatic valves 8 and 9. Air to support combustion in the furnace is supplied to the end having the burner 2 through a checker work 10 and the end of the furnace having the burner 3 through a checker work 11. The arrangement is such that when air is being forced in through one end the combustion gases passing through the other end will heat that checker work so that the air for combustion, when the furnace is reversed, will be preheated. A damper 12 directs air from the supply 13 to one of the checkers and directs the exhaust gases from the other checker through the stack 14. The damper is driven in opposite directions to reverse the air and exhaust flow by means of a chain drive 15 from a reversible motor 16.

The temperature of the checkers is measured by temperature responsive elements 17 and 18 which are connected to a potentiometer 19. This potentiometer is generally of a self balancing type

and comprises a control switch which acts to reverse the furnace in some predetermined manner. The measuring devices 17 and 18 may be thermocouples or radiation or optical pyrometers and they serve to operate the potentiometer 19 in any well known manner. The measurement of the temperatures as made by the potentiometer 19 can be used to reverse the furnace in any standard manner such as from maximum temperature of the roof or of the checkers or of a temperature difference between the measuring devices 17 and 18. When the switches in the potentiometer 19 are closed they energize a reversing mchanism which is enclosed in a cabinet 20 the details of which will be described below. This reversing mechanism is used to operate the reversing valves in a predetermined sequence in order to change the furnace from firing through burner 2 so that it will fire through burner 3 or vice versa.

Referring to Figure 2 there are shown two panels 25 and 26 each of which is located in the control box 20 and each of which has mounted upon it the necessary valves and piping to control the steam and the oil, respectively.

Air is supplied under high pressure through pipe 22, in which is located a filter 23 and a pressure regulator 24, to each of the panels 25 and 26. A normally closed solenoid valve 27 controls the flow of air under pressure from the pipe 22 to the pipe 28, which connects with a chamber above the diaphragm of valve 7. When this valve 27 is energized air may flow from pipe 22 to pipe 28 to open valve 7 and this air is exhausted to permit valve 7 to close when a normally closed solenoid valve 29 is energized so that air can escape through pipe 30. The rate at which the air escapes through this pipe, and therefore, the rate at which the valve 7 is closed to shut off the steam supplied therethru is determined by the setting of a variable restriction 31 located between pipe 28 and valve 29.

In a similar manner air under high pressure from pipe 22 can be supplied to the diaphragm of valve 9 when the normally closed solenoid valve 32 is energized and the air is permitted to escape from the valve 9 when a normally energized solenoil valve 34 is energized so that the air can exhaust thru pipe 35. Located between the valve pipe 33 and the solenoid valve 34 is a variable restriction 36 which is used to control the rate at which the air escapes and, therefore, the rate at which valve 9 closes.

In a somewhat similar manner the oil valves are opened and shut. The oil valve 6 is opened when a normally closed solenoid valve 37 is energized to permit air to flow from the pipe 22 through a variable restriction 38 to the pipe 39. This valve 6 is permitted to close when the solenoid valve 40 is opened so that air can escape from pipe 39 through exhaust pipe 41. In a similar manner oil valve 8 is opened when the solenoid valve 42 is energized so that air can flow from the pipe 22 through the variable restriction 43 into the pipe 44. The valve 8 is permitted to close when solenoid valve 45 is energized so that air can escape through exhaust pipe 46. Each of the pipes 39 and 44 is provided with a pressure responsive instrument 47 and 48, respectively. These instruments are provided with mercury switches that are closed when the pressure in pipes 39 and 44 approaches atmospheric or when the valves 6 and 8 are closed. The manner in which the mercury switch operates will be described below.

Located in the potentiometer 19 are a pair of alternately closed switches 49 and 50 (Fig. 3) which are operated when it is necessary to reverse the furnace. These switches serve to initiate the reversal operation. It is also noted the motor 16 is provided with switches 51 and 52 that are alternately operated by the motor as the damper 12 reaches its limit positions.

In describing the operation of the device reference is made in Figure 3. Suppose, for example, the furnace has been firing from burner 3 and the instrument 19 calls for a reversal. In such a case the switch 49 in that instrument will be closed to simultaneously perform these operations. First, energize solenoid 34 from line L1 over conductor 53, switch 83, switch 49, conductors 54 and 55, solenoid 34 and conductor 56 to L2; second, energize solenoid 45 over conductor 53, switch 83, switch 49, conductors 54 and 57, solenoid 45 and conductor 58; and third, energize motor 16 through conductor 53, switch 83, switch 49, conductors 54, 59, motor 16 and conductor 60 to L2. This, through solenoid valve 45, permits valve 8 to quickly close to cut off the supply of fuel and opens the solenoid valve 34 to slowly bleed the air from valve 9 to cut off the steam. Also the motor 16 is started to reverse the position of damper 12. As the motor starts to rotate a switch arm 61 moves to permit the switch 52 to open. This simultaneously breaks the circuit to solenoid valves 42 and 32 to cut off the supply of air to valves 8 and 9 and prevent any possibility of the air supply opening these valves.

Thus the oil is quickly cut off from the burner 3 and the steam is slowly cut off so that the burner may be purged prior to the time that the opposite burner is started. It is noted that a resistance is located in the motor line 60 so that the speed of operation of the motor 16 may be adjusted if desired.

Since, as above stated, the switches 49 and 50 are alternately opened, the switch 50 was opened when 49 was closed. Opening of switch 50, through circuits similar to those above traced deenergizes solenoid valves 40 and 29 to close the exhaust ports for the valves 6 and 7 so that those valves may be opened when the air supply for them is turned on.

When the motor 16 has rotated sufficiently to shift the damper 12 to its new position it will be stopped by the opening of a suitable limit switch (not shown) and the arm 61 will have closed the switch 51. As the switch 51 is closed two operations will be simultaneously performed: first, a circuit will be closed through conductor 53, switch 83, switch 49, conductors 54, 59 and 62, switch 51, conductors 63, and 65, valve 27 and conductor 56 to L2; and second, a circuit will be closed through the same conductors up to 63 and through conductor 66, switch 67 in pressure responsive instrument 48, conductor 68, valve 37 and conductor 58 to L2. Thus the valve 27 will be opened to permit air to flow from pipe 22 to pipe 28 and quickly open steam valve 7. At the same time air can flow from pipe 22 to pipe 39 through valve 37 at a rate determined by restriction 38 to slowly open oil valve 6. The switch 67, and a similar switch 69 in the pressure responsive instrument 47, serve as safety switches to prevent the oil from being turned on in one burner until the oil in the opposite burner is completely turned off.

When it is again time to reverse the furnace the switch 50 will be closed while switch 49 is opened. The valves will be oppositely actuated by

circuits similar to those just described and which it is not believed necessary to trace in detail. It will, therefore, be seen that when the instrument 19 calls for a reversal to take place the oil on the side that is firing is quickly cut off and the atomizing steam is slowly cut off while the damper 12 is being shifted. When 12 is completely shifted the atomizing steam is quickly started on the opposite side of the furnace and the fuel oil is slowly turned on when the fuel on the recently firing side has been completely turned off.

Signal lamps 70 and 71 are provided so that an operator may know which end of the furnace is firing. These lamps are so connected that neither one will be lighted while reversal is taking place, but one or the other will be lighted while the furnace is firing. For example, when the switch 51 is closed, during the reversal just described, a circuit will also be completed from line L_1 as described, to conductor 63 and from there through conductor 72, lamp 70 and conductor 73 to L2. In a similar manner the signal lamp 71 will be lighted when switch 52 is closed.

There is also provided a push button station that is provided with switches which parallel the switches 49 and 50, so that the furnace may be manually reversed at any time. Push buttons 74 and 75 are connected by a lever 76 and carry a contact bridging member 77. The arrangement is such that when button 74 is pushed the membe 77 will bridge contacts 78 and 79 to complete a circuit that parallels switch 49 to perform the reversal just described. In a like manner, if the button 75 is pushed the member 77 will bridge contacts 80 and 81 to complete a circuit that parallels instrument switch 50.

In order to prevent the manual push buttons from being operated when the automatic switches 49 and 50 are operated and thereby the possibility of firing the furnace from both ends at once a manual automatic switch station 82 is provided. When a switch member 83 in this station is in its full line position the conductor 53 from line L_1 is connected to the switches 49 and 50. When, however, the switch 83 is in its dotted line position, line L_1 is connected by conductors 53 and 84 to contacts 79 and 80. For convenience, the signal lights, push button station and the switch 82 may all be mounted together on a single panel.

The applicants wish to stress the importance of providing restrictions in the exhaust air line for the steam valves and the air supply pipe to the oil valves. It has been found that if any oil remains in a burner after the oil supply has been turned off a harmful burning thereof may occur when the reversal takes place. If the oil is shut off quickly and the steam slowly, then the steam will force any remaining oil out into the furnace to be burnt. By providing the restrictions 31 and 36 the amount of steam needed for the purging of the burners after the oil has been cut off may be adjusted. When the furnace is reversed the steam must immediately be turned on to help force the oil into the furnace and the oil must be turned on slowly so that it will ignite properly. If the oil is turned on too quickly all of it will not burn and smoke will be produced. The lack of smoke and the evenness with which the flame picks up are standards by which a furnace reversing system is judged. The restrictions 38 and 43 allow the speed of opening of the oil valves to be adjusted to any desired value while insuring that the oil valves will be quickly turned off. The applicants apparatus completely does away with the complicated gearing or motor speed regulating apparatus that has previously been used.

From the above description it will be seen that we have provided an efficient and simple apparatus for reversing a regenerative furnace. The apparatus is versatile enough so that any desired or necessary speeds of opening and closing of the valves may be obtained as well as any desired sequence of valve opening. While we have described our invention as being used on an open-hearth furnace it will be obvious that it may be used for any application in which a series of valves must be opened and closed in a predetermined sequence. In the specification and claims the fluid in pipe 5 has been described as steam, but it is to be understood that any other desirable fluid may be used. For example, the two pipes 4 and 5 may carry different types of combustible gas.

While in accordance with the provisions of the statutes, we have illustrated and described the best form of our invention now known to us, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of our invention as set forth in the appended claims, and that in some cases certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

Having now described our invention, what we claim as new and desire to secure by Letters Patent is:

1. In a reversing system for a furnace of a type supplied with fuel and air at either end and exhausting products of combustion at the opposite end, a fuel and an injector medium valve at each end, means to supply air to each end of the furnace, damper means to reverse said air supply from one end of the furnace to the other, pneumatic means to operate said fuel and injector medium valves, electrical means to control said pneumatic means and said damper means, means to operate said electrical means and means to delay operation of a portion of said electrical means until said damper has been operated.

2. In a control system for a furnace of a type fired alternately from either end, a fuel pipe and an air supply duct for each end of the furnace, a damper to reverse the supply of air from one duct to the other, valves in said fuel pipes, operating means to close the valve in the pipe supplying fuel and open the other valve and to reverse the damper, means to delay the opening of one fuel valve until the other is closed and said damper has completed its movement, and means to vary the speed of operation of said fuel valves.

3. In a fuel control system, for a supply of fuel and a supply of injection fluid, a fluid operated valve to control the supply of fuel, a fluid operated valve to control the supply of injection fluid, intake and exhaust passages leading to each of said fluid operated valves, a supply of fluid under pressure to operate said valves, electrically operated means to control the application of fluid to each of said valves, means in the intake passage to said fuel valve and means in the exhaust passage from said injection fluid valve to retard the flow of pressure fluid through said passages, and control means for said electrically operated means operative to simultaneously open said inlet and exhaust passages.

4. A control system for a regenerative furnace comprising means to supply fuel and injection steam to opposite ends of said furnace, means to supply combustion air to said opposite ends of said furnace, the supply of fuel, steam and air to said opposite ends of said furnace being alternate, means to reverse said supplies from one end of the furnace to the other including means to quickly shut off the supply of fuel, means to slowly cut off the injection steam, means to direct the supply of air from the end from which the fuel and injection steam have been cut off to the opposite end, means to quickly turn on the supply of injection steam to the end of the furnace to which air is now directed and means to slowly turn on the fuel supply to said end of the furnace.

5. In a control system, a pair of fluid actuated valves to be alternately operated, a supply passage for each valve through which fluid to operate the valve may be passed, an exhaust passage for each valve through which valve actuating fluid may be exhausted, an electrically operated means in each passage operative to control the flow of the valve actuating fluid in that passage, restricting means in each of said inlet passages operative to slow down the flow of valve operating fluid in said passages, pressure responsive means responsive to the valve operating fluid applied to each valve, means to actuate said electrically operated means in a predetermined sequence to permit valve actuating fluid to be applied to and exhausted from said valves, and means operated by said pressure responsive means to prevent the operation of the electrically operated means in the supply passage to one valve when pressure above a predetermined value is applied to the other valve.

6. In a control system for a furnace of a type fired alternately from either end, a fuel pipe and an air supply duct for each end of the furnace, a damper to reverse the air from one duct to the other, a valve in each fuel pipe, means to control the operation of each valve, other means to control the reversing action of said damper, means to simultaneously operate the control means for the valve through which fuel has been flowing to close that valve and start operation of said other control means to start a reversing operation of said damper, and means operative upon completion of the said reversing operation to operate the control means for the valve which was closed to open the same and permit the flow of fuel therethrough.

7. In a control system for the supply of fuel to a furnace, the combination of a plurality of fluid operated valves operating to supply fuel and an injection medium to the furnace, a supply passage for valve actuating fluid extending to each of said valves, an exhaust passage for fluid leaving each of said valves, electrically operated means in each of said supply and exhaust passages to control the supply of valve operating fluid to said valves, flow retarding means in at least one of said supply and exhaust passages to each valve to retard the flow of valve actuating fluid in said passage, and means to actuate said electrically operated means in a predetermined sequence.

8. In a fuel supply system for a furnace, the combination of a fluid operated valve through which fuel is supplied to the furnace, a supply passage for actuating fluid for said fuel valve, an exhaust passage for actuating fluid exhausted from said fuel valve, electrically operated means to control the flow of valve actuating fluid in said passages to and from said fuel valve, a restriction in said supply passage operative to slow up the flow of fluid therethrough whereby the valve actuating fluid will be applied to said fuel valve slower than it can be exhausted from said fuel valve to thereby turn on the fuel supply to the furnace slowly and turn it off quickly, and means to actuate said electrically operated means.

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