July 3, 1934. C. H. SMOOT 1,964,774

FURNACE REGULATION

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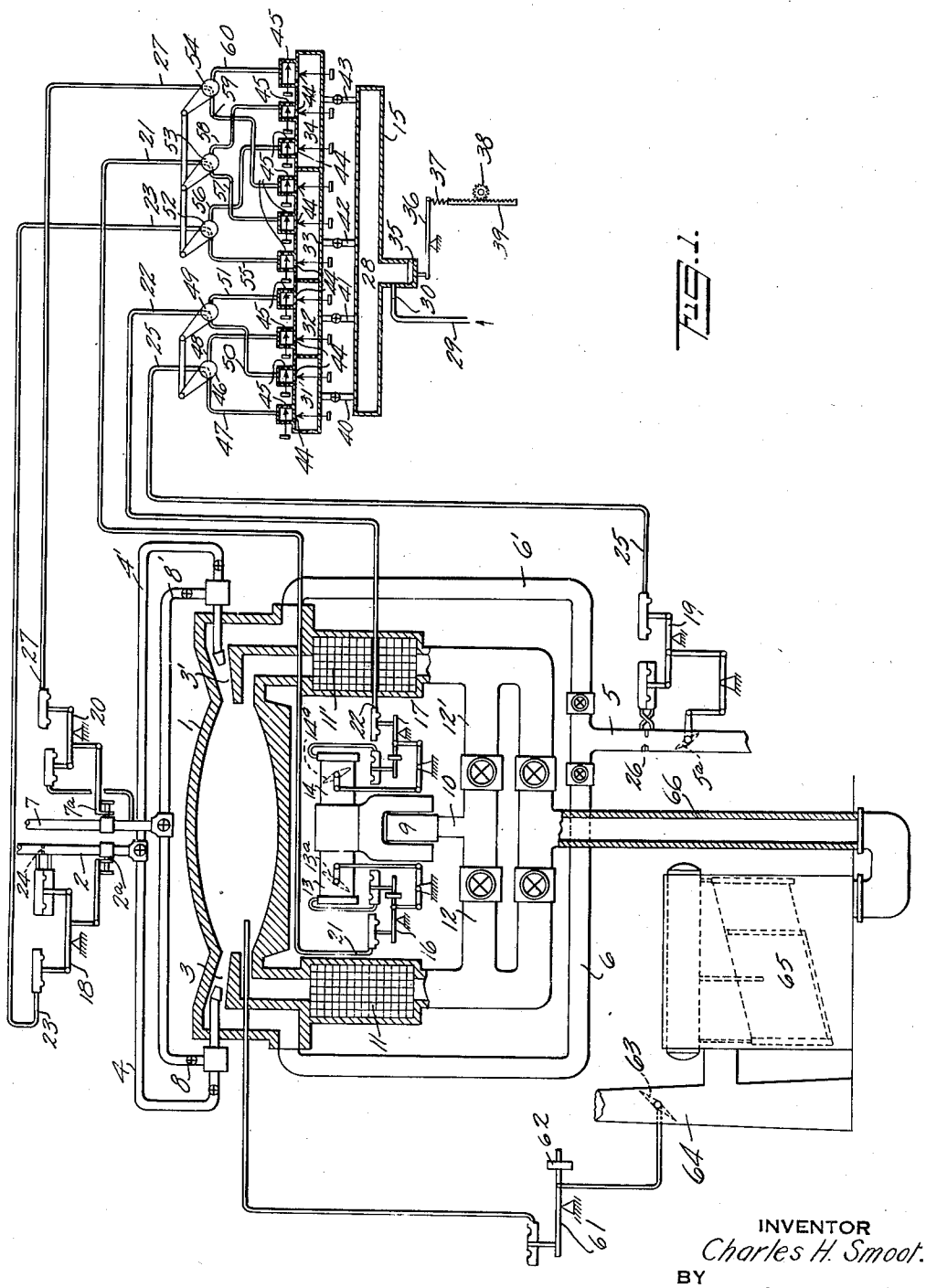


FIG. 1.

INVENTOR
Charles H. Smoot.
BY
Barrill, Eyre, Scott & Kool
ATTORNEYS

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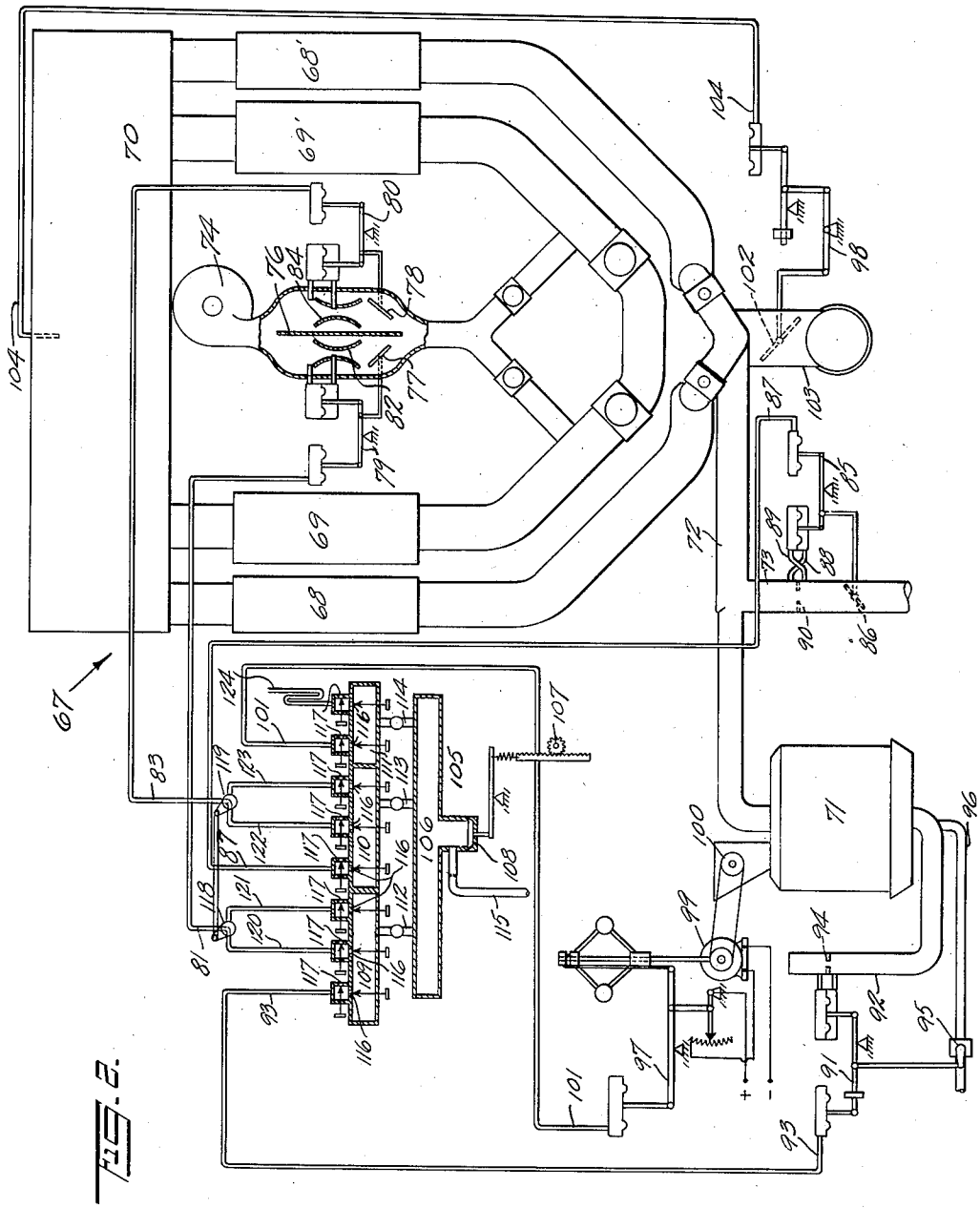


Fig. 2.

INVENTOR
Charles H Smoot.
BY
Bartlett, Eyre, Scott & Keel
ATTORNEYS

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FURNACE REGULATION

Charles H. Smoot, Maplewood, N. J.; Katherine Smoot, executrix of said Charles H. Smoot, deceased, assignor to Katherine Smoot

Application September 26, 1930, Serial No. 484,685

8 Claims. (Cl. 158—1)

My present invention relates to furnace regulation and comprises a method of remote control of the supplies of fuel and air to a furnace to maintain any desired atmosphere in the furnace, whether oxidizing or reducing, and includes apparatus adapted to carry out the method. My invention is particularly concerned with the control of the fuel and air to furnaces burning more than one kind of fuel and when applied to such type of furnace involves the division of the air supply into a plurality of flows corresponding to the number of different fuels utilized and the control of each air flow in any desired ratio to the rate of supply of one of the fuels; the proportioning of the fuels to the separate air flows being controllable from a central point in the plant to obtain the desired atmosphere in the furnace or furnaces.

For a better understanding of my invention, reference may be had to the accompanying drawings of which,—

Fig. 1 illustrates one embodiment of the invention applied to the regulation of a furnace burning both oil and coke oven gas; and

Fig. 2 illustrates another embodiment of the invention as applied to a furnace burning blast furnace gas and gas produced in a gas producer associated with the furnace.

Referring to Fig. 1, a furnace 1, shown specifically as an open hearth furnace, is supplied with fuel oil through a conduit 2 connected to the burners 3 and 3' by means of branch conduits 4 and 4' and with coke oven gas through a main 5 and branch pipes 6 and 6' connected with the burners 3 and 3' respectively. Regulating valves 2*a* and 5*a* in the conduit 2 and main 5 respectively control the fuel supplies to the furnace 1. Steam under pressure for atomizing the fuel oil is supplied through a pipe 7 provided with a regulating valve 7*a* and connected by means of branch pipes 8 and 8' with the branch conduits 4 and 4' respectively. Air is supplied to the furnace from a blower 9 through a conduit 10 connected to the checker brick passages 11 and 11' by means of conduits 12 and 12', respectively. Suitable valves in the branch conduits for the fuel, steam and air are provided, as usual, for reversing the dirction of flow through the furnace. According to the invention, the air supply is divided into two portions corresponding to the number of fuels employed and the volume of air flow of one portion is maintained in proportion to the flow of oil to the furnace and that of the other portion is maintained in proportion to the flow of coke oven gas to the furnace. In the particular embodiment illustrated the division of the air supply is effected by dividing the air inlet to the blower 9 into two channels 13 and 14 in which are located the dampers 13*a* and 14*a* respectively controlled by means now to be described. These means comprise a master controller 15, air regulators 16 and 17 associated respectively with the dampers 13*a* and 14*a*, and regulators 18, 19 and 20 associated respectively with regulating valves 2*a*, 5*a* and 7*a*.

Each of the various regulators above enumerated is diagrammatically illustrated for simplicity as comprising a balancing lever arranged for direct control of the associated damper or valve in response to forces varying as a function of the element controlled and in response to a force transmitted to the lever by the master controller. Preferably these regulators would be of the anti-hunting balanced type employing auxiliary power fluid for operating the controlled elements. As such regulators are now well known in the art it is not believed necessary to illustrate or describe the same in detail. For example these regulators may take the form illustrated in Fig. 2 of my Reissue Patent No. 16,507, dated December 21, 1926. Regulator 16 is arranged to be responsive to the suction in channel 13 in advance of the damper 13*a* and to a master control force transmitted through a pipe 21. Regulator 16 operates the damper 13*a* to maintain a fixed relation between the force transmitted through pipe 21 and the differential pressure between that of the atmosphere and the suction in channel 13, which differential is a measure of the volume of air flowing through the channel. Similarly regulator 17 is arranged to operate damper 14*a* to maintain a fixed relation between a master force transmitted through a pipe 22 to the balance lever of the regulator and the volume of air flowing through the channel 14 as measured by the differential pressure between the atmosphere and the suction in advance of the damper 14*a*. Regulator 18 is arranged to control valve 2*a* to maintain a predetermined relation between a master force transmitted through a pipe 23 to the balance lever of the regulator and the volume of fuel oil flowing through the main 2 as measured by the differential in pressure across an orifice 24 in the main 2. Similarly regulator 19 is arranged to control damper 5*a* to maintain a predetermined relation between a master force transmitted through pipe 25 and the volume of coke oven gas as measured by the pressure differential across a constriction 26 in the gas main 5. Regulator 20 is arranged to control the steam valve 7*a* to main-

tain a predetermined relation between a master force transmitted through pipe 27 and the pressure of the steam at a point between the valve 7*a* and the burners 3 and 3'.

The master controller 15, while constructed along the same general principles as the master controllers heretofore disclosed in various of my prior applications and patents and shown best, perhaps, in the reissue patent above referred to, comprises an improved structure particularly arranged to permit the ready control of the atmosphere of the furnace and to provide means for rapid change thereof from oxidizing to reducing or vice versa. In the improved construction illustrated, the controller includes a main chamber 28 to which fluid under pressure is supplied from any suitable source (not shown) through a pipe 29 provided with a restricted orifice 30, and auxiliary chambers 31, 32, 33 and 34. The pressure of the fluid in chamber 28 is maintained at any desired value by means of a cup valve 35 normally permitting a slight leakage of fluid from the chamber. A pivoted lever 36 carries cup valve 35 at one end and is connected at its other end to one end of a spring 37 the tension of which is adjustable by means of a hand-operated gear 38 meshing with a rack 39 attached to the lower end of the spring.

For each setting of the hand gear 38, valve 35 will thus maintain a predetermined pressure in chamber 28, which pressure will be such that the downward force thereof acting upon valve 35 will just equalize upon lever 36 the effect of the tension of spring 37. Fluid under pressure passes from chamber 28 into auxiliary chambers 31, 32, 33 and 34 by way of pipes 40, 41, 42 and 43 respectively and bleeds from these auxiliary chambers to the atmosphere through pairs of valve controlled orifices indicated in the drawings by the reference numerals 44 and 45; chambers 31 and 32 each being connected to the atmosphere through two pair of orifices 44 and 45, and chambers 33 and 34 each being connected to the atmosphere through three pair of orifices 44 and 45. Pipe 25 is adapted to be connected to a point intermediate one pair of orifices 44 and 45 associated with chamber 31 or to a point intermediate one pair of orifices 44 and 45 associated with chamber 32 depending upon the position of a throw-over valve 46 to which are connected branch pipes 47 and 48. Similarly pipe 22 may be connected with either chamber 31 or 32 intermediate the other pair of orifices 44 and 45 associated with these chambers by manipulation of a throw-over valve 49 to which are connected branch pipes 50 and 51. Pipes 23, 21 and 27 may be connected with either of chambers 33 or 34 by suitable manipulation of throw-over valves 52, 53 or 54 to which pairs of branch pipes 55—56, 57—58, and 59—60 are respectively connected. Preferably valves 46 and 49 are arranged, as shown, for joint operation, as are valves 52, 53 and 54. The various branch connections to the master controller, in combination with the throw-over valves and pairs of manually adjustable leakage ports 44 and 45 permit of the widest possible flexibility of the system. It will be noted that the pressures in chambers 31, 32, 33 and 34 will be less than that in chamber 28 and that each may be independently adjusted by means of the valves in the connecting pipes 40, 41, 42 and 43 respectively. With the throw-over valves in the position shown, that is, with pipes 25 and 22 connected to chamber 31 and with pipes 23, 21 and 27 connected to chamber 33, the relative proportion of coke oven gas to fuel oil is adjusted by manipulation of the valve in pipes 40 and 42. The valves controlling the ports 44 and 45 associated with branch pipes 47 and 50 are then adjusted for the desired ratio of gas to air for the furnace atmosphere desired and similarly the valves controlling the ports 44 and 45 associated with branch pipes 55, 57 and 59 are adjusted for the ratio of fuel oil to air and for the preferred atomizing steam pressure. Assuming that the above adjustments have been made with a view of maintaining an oxidizing atmosphere in the furnace, then the valves controlling the leakage ports 44 and 45 associated with chambers 32 and 34 may be adjusted for such proportions of fuel to air as will give a reducing atmosphere in the furnace, while the relative proportions of gas to fuel oil may be kept the same as before or adjusted to a new value by the valves in pipes 41 and 43. With the improved master controller above described and with the divided air supplies to the furnace, it will be apparent that an operator can vary the relative amounts of the two fuels employed or may vary the furnace rating without upsetting the proportions of air to fuel as previously adjusted and that he may, without readjustment, readily shift from one set of fuel air proportions to a second by simple manipulation of throw-over valves.

In operation should it be desired to increase the furnace rating, it is only necessary for the operator to manipulate gear 38 in a direction to increase the tension of spring 37 and to thereby cause an increase in pressure in chamber 28 with corresponding proportionate increases in pressures in all the auxiliary chambers and in the master lines 25, 22, 23, 21 and 27. The increased pressures in these lines upsets the balance of each of the regulators associated therewith and causes operation thereof to increase the gas and oil flows proportionately to the increased master pressures and to open the dampers 13*a* and 14*a* and the steam valve 7*a* to correspondingly increase the air flows and the steam pressure. Conversely, operation of the gear 38 in a direction to reduce the tension of spring 37 causes proportionate reduction of each of the fuel, air and steam supplies.

In combination with the apparatus above described, means are preferably provided for maintaining the pressure in the furnace chamber equal to that of the atmosphere irrespective of the furnace rating or of the proportions of fuel to air. These means may comprise a regulator, such as 61, responsive to the pressure within the furnace and to a constant force, such as the weight 62, arranged to control a damper 63 in the stack 64 of a waste heat boiler 65 associated with the open hearth furnace 1. Alternatively, the regulator 61 could be arranged to directly control a damper or exhauster in the conduit 66 through which the waste gases are withdrawn from the furnace.

In Fig. 2, I have illustrated a control system substantially similar to that above described with reference to Fig. 1 but applied to the joint control of a gas producer and a furnace burning a mixture of the gas produced in the producer and blast furnace gas. As in Fig. 1, the control system includes a master controller arranged to control the supplies of fuel and air to the furnace and to permit of ready adjustment of the nature of the atmosphere therein. The master controller of Fig. 2, however, differs in some respects from that shown in Fig. 1, being in some respects simpler of construction.

In Fig. 2, an open hearth reversing furnace is designated by the reference numeral 67 and is shown as including gas and air checker brick passages 68, 68' and 69, 69' respectively leading to burners (not shown) within the furnace chamber 70. A gas producer 71 supplies gas to a conduit 72 connected through suitable reversing valves with either checker brick passage 68 or 68'. Blast furnace gas supplied through a conduit 73 is mixed with the gas from the producer in conduit 72 and supplied therewith to the furnace. A blower 74 delivers air to the furnace through a conduit connected through suitable reversing valves with passages 69 and 69'. As in the system disclosed in Fig. 1 the air supply is divided into two parts, each separately controllable and each maintained in proportion to the flow of one of the fuels supplied to the furnace. The division of the air supply in the regulating system now under discussion comprises a partition 76 within the conduit 75 arranged to cause the air from blower 74 to pass in two parallel streams during at least a part of its travel through conduit 75. Dampers 77 and 78 are provided for independent adjustment of the two air streams under control of regulators 79 and 80 respectively. Regulator 79 is responsive to a master pressure transmitted through a pipe 81 and to the volume of air passing damper 77 as measured by a pressure differential taken for example from the maximum and minimum pressure points of a short Venturi section 82 inserted in this stream; regulator 79 operating to maintain a predetermined relation between the master pressure in pipe 81 and the volume of air passing damper 77. Similarly regulator 80 is arranged to control damper 78 to maintain a predetermined relation between a master pressure transmitted through a pipe 83 and the volume of air passing damper 78 as measured by the pressure differential between the maximum and minimum pressure points of a Venturi section 84 located in the stream of air passing damper 78.

The fuel control to the furnace comprises a regulator 85 which adjusts a damper 86 in the conduit 73 to maintain a predetermined relation between a master pressure transmitted through a pipe 87 and the volume of blast furnace gas as measured by pipes 88 and 89 connected to pipe 73 at either side of a constriction 90 and a regulator 91 arranged to control the flow of air through a conduit 92 to the gas producer 71 and to control, therefore, the volume of producer gas generated therein and flowing to the furnace. Regulator 91, responsive to a master pressure transmitted through a pipe 93 and to the volume of air flowing through conduit 92 as measured by the differential in pressure across a construction 94 in the conduit 92, adjusts a valve 95 in a pipe 96 conveying steam to the producer for injection of air on the carburetor principle.

In the particular embodiment of the invention illustrated in Fig. 2, means are provided for regulating the feed of fuel to the gas producer 71 and the pressure of the gases in the furnace chamber 70 of the open hearth furnace 67. These means comprise the regulators 97 and 98; the former of which varies electrical resistance in the circuit of a motor 99 driving the fuel feeder 100 of the producer in response to a master force transmitted through a pipe 101 and to the speed of the motor 99 and the latter of which controls a damper 102 in the stack 103 of the furnace 67 in response to the pressure in the chamber 70 as measured by a pipe 104.

The master controller 105, controlling the regulators 79, 80, 85, 91 and 97, is substantially similar to that disclosed in Fig. 1. It comprises the main chamber 106 in which the pressure is manually adjustable by the hand gear 107 controlling the opposing force applied to cup valve 108, and three auxiliary chambers 109, 110 and 111 in communication with the main chamber by means of the throttled connecting pipes 112, 113 and 114 respectively. Fluid under pressure supplied through a pipe 115 to chamber 106 bleeds from each of chambers 109 and 110 through three pair of valve controlled orifices 116—117 and from chamber 111 through two pair of valve controlled orifices 116—117. Pipes 93 and 87 are connected to chambers 109 and 110 respectively intermediate one pair of orifices 116—117 and pipes 81 and 83 are adapted to be connected intermediate either of the other two pair of orifices associated with chambers 109 and 110 respectively by manipulation of throw-over valves 118 and 119 respectively; valve 118 being connected to chamber 109 by means of branch pipes 120 and 121 and valve 119 being connected to chamber 110 by means of branch pipes 122 and 123. Preferably valves 118 and 119 are linked together, as shown, to permit joint operation thereof by the operator.

Pipe 101, leading to the fuel regulator for the gas producer is connected to chamber 111 intermediate one pair of orifices 117—118 and a pressure gauge 124 is connected to this chamber intermediate the other pair of orifices. Obviously additional gauges could be provided if desired, to indicate to the operator the various master forces and to guide him in their adjustment.

The operation of the apparatus of Fig. 2 will be comparatively clear from the above description and from that already given in connection with the system of Fig. 1. The pressures in chambers 109 and 110 are adjusted by means of the valves in pipes 112 and 113 in accordance with the desired ratio between the two fuel supplies; the pressure in chamber 109 being increased relatively to that in chamber 110 when an excess of producer gas over blast furnace gas is desired, and being relatively reduced when an excess of blast furnace gas is desired. The valves controlling the leakage ports 116—117 associated with branch pipes 120 and 122 are adjusted for such volumes of air compared with the respective gases as will maintain an oxidizing atmosphere in the furnace and the valves controlling the leakage ports 116—117 associated with branch pipes 121 and 123 are adjusted for such volumes of air compared with the respective gases as will maintain a reducing atmosphere in the furnace. Shifting of the throw-over valves 118 and 119 from the position shown to connect pipes 81 and 83 with branch pipes 121 and 123 respectively thus causes operation of the regulators 79 and 80 in a direction to close dampers 77 and 78 to reduce the air supplied to the furnace 70 relative to the fuel supply. A return of valves 118 and 119 to the position shown in the drawings, restores the pressures in pipes 81 and 83 to their respective former valves and causes operation of regulators 79 and 80 to increase the air flows to the furnace by opening of dampers 77 and 78 and to thereby restore oxidizing conditions within the furnace.

Should it be desired to increase the supply of blast furnace gas relative to that of the gas from

the producer, it is only necessary to manipulate the valve in pipe 113 to increase the flow of pressure fluid therethrough. This increases the pressure in chamber 110 and therefore the pressures in pipes 83 and 87 as well, thus simultaneously and proportionately increasing the flow of blast furnace gas and that portion of the air supply which is correlated therewith.

Normally the feed of fuel to the gas producer need not be varied in exact correspondence with the air supply thereto; it being sufficient for most purposes to maintain the fuel feed at a constant rate. Adjustment of the valves controlling leakage ports 116—117 associated with pipe 101 is effective however to cause regulator 97 to vary the fuel feed whenever desired, and the arrangement at the master is such that adjustment of hand gear 107 to vary the total rating of the furnace will proportionately vary the fuel feed to the producer. Should closer correspondence between the fuel and air supplied to the producer be desired, it is only necessary to so construct the master controller as to combine chambers 109 and 111, or, without change in construction, merely operate jointly the valves in pipes 112 and 114.

I have now described two embodiments of my invention as applied to furnaces supplied with fuel from two different sources. In each embodiment of the invention the air supply to the furnace is divided into two parts each maintained in predetermined relation with one fuel supply. In each embodiment the component air flows are combined into a common stream prior to admittance to the furnace whereby, in the case of regenerative furnaces of the type illustrated, a single regenerative passage serves to preheat the total air supply and the total fuel and air supply may be mixed with the total fuel supply at the burners within the furnace while still insuring the proper regulation of the air in proportion to the various fuels. In each embodiment of the invention means are provided for readily varying the conditions in the furnace chamber from oxidizing to reducing, and vice versa, while maintaining furnace operation at any desired rating. Although the invention is particularly adapted for use in connection with the control of open hearth furnaces and has been so shown and described, certain features thereof may be advantageously employed in the control of boiler, or other furnaces, particularly when such furnaces utilize a plurality of fuels.

I claim:

1. In combination with a reversing furnace burning a plurality of fuels and provided with a pair of regenerative passages for preheating the air upon reversal of the furnace, a control system comprising a plurality of air ducts equal in number to the number of fuels burned in the furnace and adapted to be connected in parallel with each other and in series with either of said passages, means for supplying air to each of said ducts, a plurality of regulators one associated with each duct for controlling the flow of air therethrough, a plurality of fuel supplying means, regulators for controlling the supply of fuel from each of said means, and means cooperating with said last mentioned regulators and with said air flow regulators for maintaining a predetermined ratio between the flow of one of the fuels and the flow of air through one of said air ducts and between the flow of another one of said fuels and the flow of air through another one of said ducts whereby when the total fuel supply is varied predetermined ratios between each fuel flow and its coordinated airflow are maintained.

2. In combination with an open hearth furnace provided with fuel from two different sources and with air for burning the fuel, a control system comprising in combination means for supplying the air to the furnace in two separately controllable components, a regulator for each component, a regulator for each fuel supply, and means, including a master controller for one of said fuel supplies to maintain a predetermined relation between that component air flow and the rate of supply of that fuel and for adjusting the regulators for the other component and for the other fuel supply to maintain a predetermined relation between the last mentioned component air flow and the rate of supply of the last mentioned fuel.

3. The combination according to claim 2 wherein said master controller includes means for causing operation of all of said regulators to vary the total fuel and air supplies and for causing said regulators to vary said ratios while maintaining the total fuel supply constant.

4. In combination with a gas producer provided with fuel and air supplying means and with a furnace supplied with gas produced in said producer and provided with additional fuel supplying means and air for burning the gas and additional fuel, a control system for said producer and furnace comprising in combination a master controller, means for supplying the air to said furnace in two component flows, a regulator for each of said component flows, a regulator for the air supplied to the producer, a regulator for the additional fuel supplied to the furnace, connections between said master controller and each of said regulators, and means at the master controller for transmitting controlling forces through said connections to cause said regulators to maintain a predetermined ratio between one of said component air flows to the furnace and the air supplied to the producer and to maintain a predetermined ratio between the other of said component air flows to the furnace and the rate of supply of said additional fuel to the furnace.

5. The combination according to claim 4 wherein throw over valves are provided in said connections at said master controller for readily varying said ratios from one value to a second value whereby the furnace atmosphere may be changed from oxidizing to reducing and vice versa.

6. The combination according to claim 4 including a regulator for the fuel supplying means for the producer connected to said master controller for control thereby and a regulator for the pressure in said furnace independent of said master controller to maintain said pressure constant irrespective of the furnace rating or of the ratio between the component air flows and the respective rates of fuel supply.

7. A control system for furnaces provided with fuel and air supplying means and with regulators therefor comprising in combination a master controller, and connections between said master controller and said regulators for transmitting control forces therethrough; said master controller including means for independently and jointly adjusting the control forces delivered through said connections and including throw over valves which in one position so control said connections as to cause delivery of one set of control forces to said regulators and in another position so change said connections as to cause delivery of another set of control forces to said regu-

lators whereby upon suitable adjustment of the control forces at the master controller by said means, the furnace atmosphere may be readily changed from oxidizing to reducing at said master controller by manipulation of said valves.

8. A control system for furnaces burning a plurality of fuels and provided with air supplying means for burning the same, comprising in combination means for supplying the air to the furnace in a plurality of component flows equal in number to the number of different fuels to be burned, a regulator for each fuel supply, a regulator for each of said component air flows, a master controller provided with alternate connections to said regulators for delivery of control forces thereto to control all of said regulators in unison to vary the furnace rating, and throw over valves at said master controller controlling the alternate connections between said controller and said regulators, said valves when thrown from one position to another serving to change the connections between said regulators and said controller for delivery of different sets of control forces to said regulators whereby when said valves are in one position one set of ratios between the fuel supplies and the individual component air flows is maintained and when said valves are in another position a different set of ratios between the fuel supplies and the component air flows is maintained.

CHARLES H. SMOOT.