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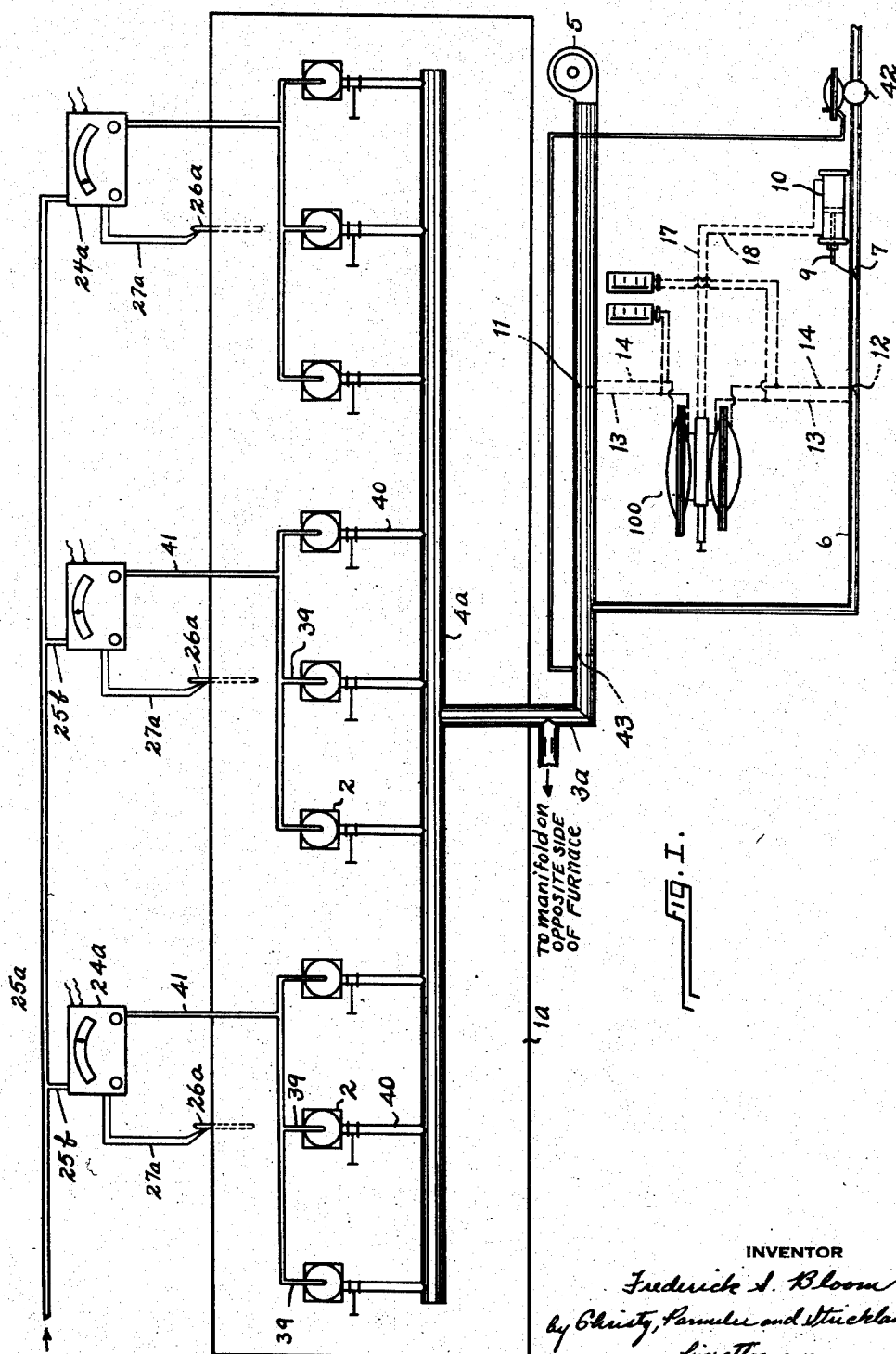
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INDUSTRIAL FURNACE AND FIRING APPARATUS

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INDUSTRIAL FURNACE AND FIRING APPARATUS

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10 Claims. (Cl. 236—15)

My invention relates to industrial furnaces, and consists in an improved apparatus or system for firing one or more of such furnaces with pre-mixed air and fuel. (The application for this patent consisted in a continuation in part of application Serial No. 278,520, filed by me June 10, 1939.)

The object of the invention is to provide a firing system for industrial furnaces, in which a mixture of air and fuel is fed from a common supply to the furnace ports or burners, with the ratio of air to fuel in the supply mixture automatically maintained at optimum value, and with elimination of the danger of back-firing and explosion of the mixture either within the burners or elsewhere in the system.

It is further my object to provide a burner that is particularly effective in safeguarding such a firing system, particularly when the system operates over a wide range of combustion control.

Still another object is to provide means whereby the individual burners, or selected groups of burners, may be controlled independently and automatically in accordance with temperature conditions within the furnace, and to provide for the ready alteration of the grouping of the burners, best to meet the requirements in each installation.

In the accompanying drawings

Fig. I is a view in side elevation of an industrial furnace equipped with a firing system embodying the invention, it being noted that certain portions of the apparatus included in the system are illustrated diagrammatically;

Fig. II is a view in vertical section of one of the burners of the firing system, mounted in position of service upon the side wall of the furnace, which wall is shown fragmentarily;

And Fig. III is a view comparable with Fig. II, illustrating a modification in the burner structure.

Referring to the drawings, the reference numeral 1a is applied to a furnace, which may be a batch furnace, or a continuous furnace, or a lehr, for heating or heat-treating articles formed of metal, glass, or other material. A line of burners 2 is mounted on each of the opposite side walls of the furnace, and in service these burners are adapted to project burning columns of fuel and air into the furnace chamber. A supply duct 3a delivers a combustible mixture of air and fuel (the fuel in this case being a combustible gas) into a manifold 4a, and from the manifold the mixture is fed through branch pipes 4b to the burners. More specifically, gaseous fuel is

delivered, under superatmospheric pressure, from a pipe 6 into the duct 3a, and air is supplied to the duct, by means of a blower or fan 5, and the mixed air and fuel are delivered from the duct 3a to the burner-feeding manifolds 4a on the opposite sides of the furnace.

In the firing or combustion system of the invention, I provide means for establishing and automatically maintaining at predetermined value the ratio of air to fuel in the mixture, and such means, including a piece of apparatus 100 obtainable on the open market under the name Askania ratio regulator, are fully described in my said application, Serial No. 278,520. To those skilled in the art it will suffice to say that the duct leading from the blower 5 includes an orifice plate 11, and the fuel line 6 an orifice plate 12; that leads 13 and 14 establish communication between the regulator 100 and the pipes 3a and 6 at points on opposite sides of the orifice plates, as shown; that a butterfly valve 7 is arranged in the fuel pipe 6 on the upstream side of the orifice plate 12; that the plunger 9 of a pneumatic cylinder 10 is connected to swing such valve; and that leads 17 and 18 extend from the regulator to the opposite ends of said cylinder. The regulator 100 operates in known way to vary pneumatic pressures in the two leads 17 and 18 in accordance with variations in the pressure differential between the fuel and the air supplied to the duct 3a, and, as the difference between the pressures in said leads rises and falls, the plunger 9 shifts in the cylinder 10 in one direction or the other, correspondingly swinging the valve 7 in the fuel line 6 towards open or closed position. In such manner the ratio of air to fuel in the mixture in duct 3a is established and maintained at optimum value, regardless of fluctuations in the supply pressures of the air and fuel, and irrespective of the usual variations in the demands or requirements of the furnace. The air and fuel are thus mixed in proportions that will afford highest efficiency of combustion and greatest fuel economy, but it will be understood that such a mixture within a closed firing system is highly explosive and hitherto has been dangerous.

In accordance with the invention, I bring into association with the instrumentalities, above described, means for preventing in the system, and in each of the burners included therein, the explosive back-firing of the pre-mixed air and fuel. Such means include an automatic valve in each of the several burners of the system, a valve adapted entirely to close the mouth of the asso-

plate burner when the pressure or velocity of the delivered mixture of gas and air falls to the danger point. With this situation in mind, the construction of the burners will now be considered in detail.

Referring to Fig. II, each burner consists in a metal body 28 that includes a valve-chest or chamber 32. The burner is adapted to be mounted on the side wall of the furnace, as shown, with the outlet orifice or mouth 29 of the burner in registry with the outer and smaller end of a conical passage 30 in a refractory port-block 31 which is, as usual, embodied in the furnace side wall. The combustible mixture of fuel and air enters the chest 32 by way of one of the branch pipes 40, leading from manifold 4a, and within the chest a valve 32 is arranged to control the mouth or orifice 29.

It will be understood that in service the combustion of the gaseous mixture streaming through orifice 29 and port-block 31 into the furnace is initiated in the conical passage 30 in the port-block, and that so long as the velocity of the streaming gases is above a critical value, there is no danger of the flame burning back through the orifice 29 and causing premature combustion and explosion in the burner body 28, or in branch pipe 40. With this circumstance in mind, it is to be understood that my burner structure includes, advantageously, means for adjusting the valve 32 in accordance with variations in the pressure of the combustible mixture supplied to the burner, so that, regardless of the pressure at which the combustible mixture enters the burner, the velocity of flow through the orifice 29 will either be held above critical value, or the valve 32 will shift into position entirely to close the orifice or mouth of the burner.

Such means may, as shown in Fig. II, consist in a flexible diaphragm 33, to which the stem 34 of valve 32 is secured. A spring 35, whose effective force may be adjusted by means of a screw 36, bears upon one side of the diaphragm, and tends to shift the rod 34 in right-to-left direction and to move the valve 32 towards closed position, while the pressure of the combustible mixture, transmitted through a passage 66 in a partition 37 in the valve-chest, is effective on the opposite side of the diaphragm, and, opposing the force of spring 35, tends to move the valve away from the mouth or orifice 29. As in service the pressure of the combustible mixture supplied to the chest rises or falls (other things being equal), the valve 32 is shifted to the right or to the left, and accordingly increases or decreases the effective area of the orifice 29, with the consequence that the velocity of the gases flowing through the port-block 31 is maintained above critical value—above the value at which the flame can work back through the orifice 29 and cause an explosion in the burner body 28.

If the pressure of the combustible mixture should drop to a value at which a safe velocity through orifice 29 cannot be maintained, the valve 32, under the urging of spring 35, moves into fully closed position, and in such position the valve is effective to prevent explosive back-firing. It is merely a matter of properly adjusting the effective force of spring 35 to insure that the valve shall close before the danger point is reached. The body of the valve, it is to be noted, includes one or more small passages 38, which, when the valve is in closed position, permit the flow of a slight but sufficient quantity of the

combustible mixture into the throat 30 of the port-block, to sustain a pilot flame.

It is important to note that the valve 32 is arranged to control the flow of the combustible mixture, not at some point in the line of flow removed a substantial interval from the inlet end of the passage 29, 30, but immediately at the inlet end of such passage, and preferably immediately at the inlet end 30a of the conical throat of the port-block 31.

A pipe 39 opens through the burner wall, and through such pipe (as presently will appear) air or other fluid under pressure is supplied to the diaphragm chamber within the burner, on opposite side of the diaphragm 33 from that upon which the pneumatic pressure of the combustible mixture is effective. By regulation of the pressure of the air in line 39, the position of the valve 32 may be adjusted, the pneumatic pressure thus established on the right-hand side of the diaphragm supplementing the pressure of the spring 35. Indeed, in some cases the spring may be dispensed with, leaving the valve-shifting diaphragm responsive solely to pneumatic pressures.

Other known pressure-operated devices than flexible diaphragms may be arranged to shift the burner valves in the desired manner, and in Fig. III a Sylphon or metal bellows 33a is shown as exemplary of such alternate devices. The inner head 33b of the Sylphon is secured and sealed to the valve-stem 34a, and the outer head 33c includes a threaded plug 36a (the counterpart of the screw 36 of the above-described burner) which is adapted to adjust the force of a compression spring 35a arranged within the Sylphon and bearing against the inner face of the Sylphon head 33b. In known way the Sylphon expands and contracts with variations in the pressure of the gaseous mixture to which it is exposed within the burner body 28a, and in consequence the valve 32a operates in the same general manner as the valve 32. An air line 39a, communicating with the interior of the bellows, is in the modified structure of Fig. III of the same utility as the air line 39 of the burner of Fig. II.

The rate of combustion is regulated in such manner as to maintain the desired temperature conditions within the furnace. In my above-noted copending application, I describe means, for example a master valve, for controlling the flow of the mixed air and fuel from the supply duct to the manifold on each side of the furnace. The flow-controlling position of the master valve is determined by an electric motor, and the energizing of such motor is controlled by an electric pyrometer that is subject in its operation to a thermocouple within the furnace. In the apparatus herein disclosed the rate of combustion is controlled by the same valve 32 as serve to safeguard the burners from back-firing, means being provided for shifting the valves towards or away from their seats 29 according as the temperature within the furnace rises or falls from a critical or predetermined value. Advantageously, if not essentially, the means for so shifting the valves are pneumatic, and are adapted automatically to vary the differential pressure on the valve-shifting members 33 within the burners.

Returning to Fig. I, the air-control pipe 39 of each burner is connected by a lead 41 to a pyrometer 24a, which is in turn connected by a lead 25b to a pipe 25a that leads from a supply of compressed air (not shown). A thermo-

couple 26a, exposed to the temperature within the furnace, is connected to the pyrometer. In the illustrated furnace it is desirable to provide different temperatures at various points in the length of the furnace, and in such an installation, I arrange the burners in groups longitudinally of the furnace, and provide a pyrometer 24a and a thermo-couple 26a for each group. The burners 2 of the furnace 1a are shown to be arranged in three groups of three burners each, and the pneumatic control pipes 39 of the burners in each group are connected in common to the control pipe 41 of a pyrometer 24a. The pyrometers include valves (not shown) that open and close in response to the increase and decrease of the thermo-electric currents in circuits 27a, and, as such valves in the pyrometers open and close, the fluid pressure in pipes 41 leading to the valve-controlling diaphragms 33 (which diaphragms are exemplary of the several types of pneumatic motors that may be used) correspondingly rises and falls; that is to say, as the temperatures rise or fall (in the regions of the furnace into which thermo-couples 26a extend) the pressures on the right-hand faces of the burner diaphragms (cf. Fig. II) increase or decrease relatively to the pressure of the combustible mixture on the left-hand faces of the diaphragms, and in consequence the burner valves are shifted either towards closed positions or into more widely opened positions. Thus the quantity of the fuel and air mixture delivered into the furnace is regulated. In organizing the burners in groups severally controlled by pyrometers that are individually responsive to thermo-couples arranged at successive points longitudinally of the furnace, the temperatures at such points or regions of the furnace may be accurately maintained, and the desired temperature gradient in the furnace may be established and held.

The apparatus admits of great versatility in the matter of temperature regulation. The grouping of the burners may be quickly altered to provide the desired temperature gradient from one end of the furnace to the other; one burner on each side of the furnace may be connected to one pyrometer, and five burners on each side may be connected to another, and so on; indeed, all of the burners may be connected to a single pyrometer, if the conditions should require a single control. This interchangeability of burner grouping is made practical and economical, due to the ease with which the small tubing 39, 41 may be taken apart and re-connected in such way as to provide the desired burner grouping.

While, as already described, the valves and their associate parts within the burners are effective to prevent back-firing and explosion within the system, the provision of an additional safeguard is within the contemplation of the invention. Specifically, an automatic valve 42 is arranged in the fuel supply line 6. If for any reason the pressure of the air, or of the combustible mixture, should fall to the danger point the valve 42 closes and completely shuts off the supply of fuel. The fan 5 will continue in operation, and in such case will scavenge the lines 3a and 4a of the combustible mixture therein. Accordingly, if one or more of the burner valves should fail to close when the pressure of the mixture falls below critical value, the valve 42 closes and provides a safeguard against explosion. I have shown the valve 42 as a

known type of pneumatically operated valve, adapted in known way to close the fuel line when the pressure of the gases in pipe 3a falls below critical value.

If for any reason it should prove desirable to close down a burner, other than through the operation of the automatic means described, the attendant may do it. That is to say, I provide a branch 43 from the air line 39 of each burner (cf. Fig. II), and this branch is connected to a supply of air or other fluid under a predominating pressure. The branch includes a valve 44 shown in Fig. II adjacent to the burner, but it will be understood that this valve may, if desired, be located at a remote control station. The valve is normally closed, and the burner functions in the system, as explained. However, if it becomes desirable to shut the burner down, the attendant merely opens the valve, and a predominating pressure is immediately established on the right-hand face of the diaphragm. The valve 32 is instantly closed. Thus it is that the air line 43 and valve 44 comprise auxiliary means for quickly varying the relative value of the pressures acting on the valve-controlling diaphragm. It will be perceived that the branches 43 of all of the burners of the furnace may be connected through a single valve to the predominating pressure supply, whereby the burners will respond simultaneously to the control of the attendant. In still further refinement the attendant's valve or valves may be automatically operated in response to certain critical pressures or temperatures in the installation, but I shall not involve this specification with this or other refinements and modifications that the engineer may supply within the scope of the invention claimed.

I claim as my invention:

1. A pre-mix firing system for industrial furnaces comprising a burner including a valve-chest and a mouth opening therefrom, a supply of pre-mixed air and fuel in communication with said valve-chest in the burner, ducts for delivering air and fuel to said supply, apparatus for establishing and automatically maintaining the ratio of air to fuel in said supply at substantially constant value, a valve arranged in the valve-chest of the burner adjacent to said mouth thereof to control the rate of flow of the mixture of air and fuel from said burner, a diaphragm connected to said valve, said diaphragm exposed on its left-hand face to the pressure of said mixture of air and fuel and on its right-hand face to a fluid under pressure, means including a thermo-couple exposed to furnace temperature for varying the pressure of said fluid, with the effect that said diaphragm, yielding to variations in the differential value of such pressures, is adapted to adjust the flow-controlling position of said valve in accordance with variations in furnace temperature, said diaphragm being effective, upon a drop in the pressure of said mixture in said chest to critical value, to close said valve in said burner mouth and thereby safeguard the system from back-firing of said mixture of air and fuel.

2. A pre-mix firing system for industrial furnaces comprising a burner including a valve-chest and a mouth opening therefrom, a supply of pre-mixed air and fuel in communication with said valve-chest in the burner, ducts for delivering air and fuel to said supply, apparatus for establishing and automatically maintaining the ratio of air to fuel in said supply at substantially

constant value, a valve arranged in the valve-chest of the burner adjacent to said mouth thereof to control the rate of flow of the mixture of air and fuel from said burner, a diaphragm connected to said valve, said diaphragm exposed on its left-hand face to the pressure of said mixture of air and fuel and on its right-hand face to a fluid under pressure, means including a thermo-couple exposed to furnace temperature for varying the pressure of said fluid, with the effect that said diaphragm, yielding to variations in the differential value of such pressures, is adapted to adjust the flow-controlling position of said valve in accordance with variations in furnace temperature, said diaphragm being effective, upon a drop in the pressure of said mixture in said chest to critical value, to close said valve in said burner mouth and thereby safeguard the system from the back-firing of said mixture of air and fuel, and a normally open automatic valve in said fuel line adapted to close under dangerous pressure conditions in said system, substantially as described.

3. A pre-mix firing system for industrial furnaces comprising a burner including a valve-chest and a mouth opening therefrom, a supply of pre-mixed air and fuel in communication with said valve-chest in the burner, ducts for delivering air and fuel to said supply, apparatus for establishing and automatically maintaining the ratio of air to fuel in said supply at substantially constant value, a valve arranged in the valve-chest of the burner adjacent to said mouth thereof to control the rate of flow of the mixture of air and fuel from said burner, a diaphragm connected to said valve, said diaphragm exposed on its left-hand face to the pressure of said mixture of air and fuel and on its right-hand face to a fluid under pressure, means including a thermo-couple exposed to furnace temperature for varying the pressure of said fluid, with the effect that said diaphragm, yielding to variations in the differential value of such pressures, is adapted to adjust the flow-controlling position of said valve in accordance with variations in furnace temperature, and means subject to independent control for applying fluid at predominating pressure to the said right-hand face of the diaphragm to effect the closing of said valve, said diaphragm being effective, upon a drop in the pressure of said mixture in said chest to critical value, to close said valve in said burner mouth and thereby safeguard the system from the back-firing of said mixture of air and fuel.

4. A pre-mix firing system for an industrial furnace including a burner, a valve-chest in said burner, an outlet opening from such chest, means for supplying a combustible mixture under pressure to said chest, a valve movable relatively to said outlet, a diaphragm connected to said valve and adapted to yield in response to difference in pressure on its opposite faces for shifting said valve relatively to said outlet, the pressure of said combustible mixture being effective on one side of said diaphragm, means for supplying fluid under pressure to the opposite side of said diaphragm, and means responsive to variations in furnace temperature for automatically regulating the pressure of such fluid effective on the diaphragm relatively to the pressure of the combustible mixture.

5. A pre-mix firing system for an industrial furnace including a burner, a valve-chest in said burner, an outlet opening from such chest, means for supplying a combustible mixture under pres-

sure to said chest, a valve movable relatively to said outlet, a diaphragm connected to said valve and adapted to yield in response to difference in pressure on its opposite faces for shifting said valve relatively to said outlet, the pressure of said combustible mixture being effective on one side of said diaphragm, means for supplying fluid under pressure to the opposite side of said diaphragm, and means responsive to variations in furnace temperature for automatically regulating the pressure of such fluid effective on the diaphragm relatively to the pressure of the combustible mixture, and auxiliary fluid pressure means for varying the differential value of the pressures acting on the opposite faces of said diaphragm.

6. A pre-mix firing system for a furnace installation including a furnace provided with a plurality of burners adapted to project burning columns of gases into the combustion chamber of the furnace, a duct communicating with said burners, means including a fuel line for supplying a pre-mixed combustible mixture of air and fluid fuel at superatmospheric pressure to said duct, apparatus for controlling the ratio of air to fuel in said mixture, means including valves severally arranged in said burners and a thermo-couple exposed to furnace temperature for controlling the flow of said mixture from the duct, through the burners, and into said combustion chamber of the furnace, means effective to close said burner valves in response to a decrease in the pressure of the air-and-fuel mixture to a value at which there is danger of back-firing in said burners, a normally open shut-off valve arranged in said fuel line, and means organized with said last valve and responsive to the pressure of said mixture for closing such fuel valve when the pressure of said mixture falls below a critical value.

7. A pre-mix firing system for a furnace installation including a furnace provided with a plurality of burners adapted to direct burning columns of gases into the combustion chamber of the furnace, means for supplying a pre-mixed combustion-sustaining mixture of air and fluid fuel under pressure to said burners, each of said burners including a flow-controlling valve and a pneumatic device subject to two opposing pneumatic pressures and adapted to adjust the position of said valve in accordance with variations in the differential value of such pressures, one of such pressures being the pressure of said combustible mixture, and means including a thermo-couple exposed to furnace temperature and an instrumentality responsive to thermo-electric currents generated by said thermocouple for regulating the other of said pressures in accordance with the value of furnace temperature.

8. A pre-mix firing system for a furnace installation including a plurality of burners provided severally with back-fire arresting devices, a duct for supplying a pre-mixed combustible mixture of air and fuel at super-atmospheric pressure to said burners, means for supplying a mixture of air and fuel to said duct; said means including an air-delivering passage and a fuel-supplying line, together with apparatus for automatically regulating the ratio of air to fuel in the mixture supplied to said duct, a normally open shut-off valve in said fuel passage, and means organized with said valve and responsive to a drop in the pressure of the mixture of fuel and air to a critical value for closing said valve,

while leaving the air-delivering passage open to a scavenging flow of air.

9. In a pre-mix firing system for an industrial furnace installation including a plurality of burners, a supply of pre-mixed air and fuel in communication with said burners, means for delivering air and fluid fuel to said supply, apparatus for establishing and automatically maintaining the ratio of air to fuel in said supply at substantially constant value, a valve arranged with each burner to control the flow of the combustible mixture delivered thereto, means for shifting the burner valves, said means including valve-operating members that are severally organized with said valves, that are severally exposed to oppositely directed pressures, and that are severally movable to shift the valves in response to variations in the differential value of such oppositely directed pressures, and means for varying the differential value of such oppositely directed pressures in accordance with variations in the furnace temperatures of said installation; the improvement herein described that consists in auxiliary means for varying said differential value of said pressures, said last means comprising a lead for fluid that extends from each valve-operating means to a remote control station which includes means for varying the pressure of the

fluid in said leads and thereby varying the differential value of said oppositely directed pressures, with the effect that said valves may be shifted in unison to closed positions.

10. A pre-mix firing system for a furnace installation including a furnace provided with a plurality of burners adapted to project burning columns of gases into the combustion chamber of the furnace, apparatus for supplying a pre-mixed combustible mixture of air and fluid fuel at super-atmospheric pressure to said burners, apparatus for controlling the ratio of air to fuel in said mixture, a valve and a valve-shifting device in each burner, means including a thermocouple exposed to furnace temperature for actuating said devices to shift said valves and regulate the flow of said mixture through the burners and into the combustion chamber of the furnace, the valve-shifting device of each burner being effective to close its associate valve in response to a decrease in the pressure of the air-and-fuel mixture in the burner to a value at which there is danger of backfiring, and leads for connecting the valve-shifting devices of several burners in common to a remote control, whereby the valves of the several burners may be simultaneously shifted independently of said means.

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