Sept. 24, 1946. N. J. URQUHART 2,408,114

FURNACE ATMOSPHERE CONTROL

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FIG. I.

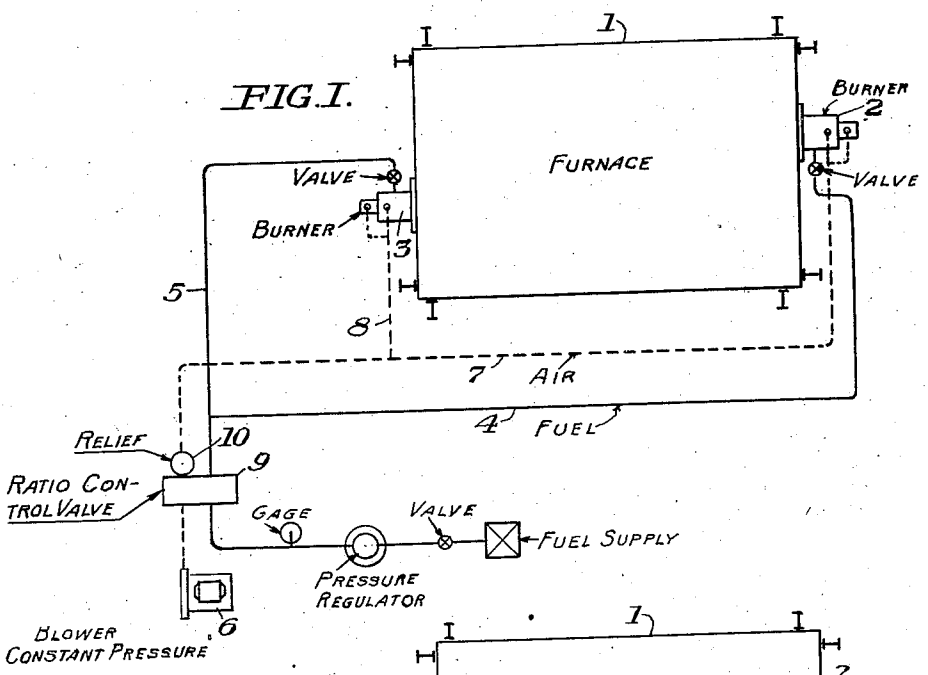
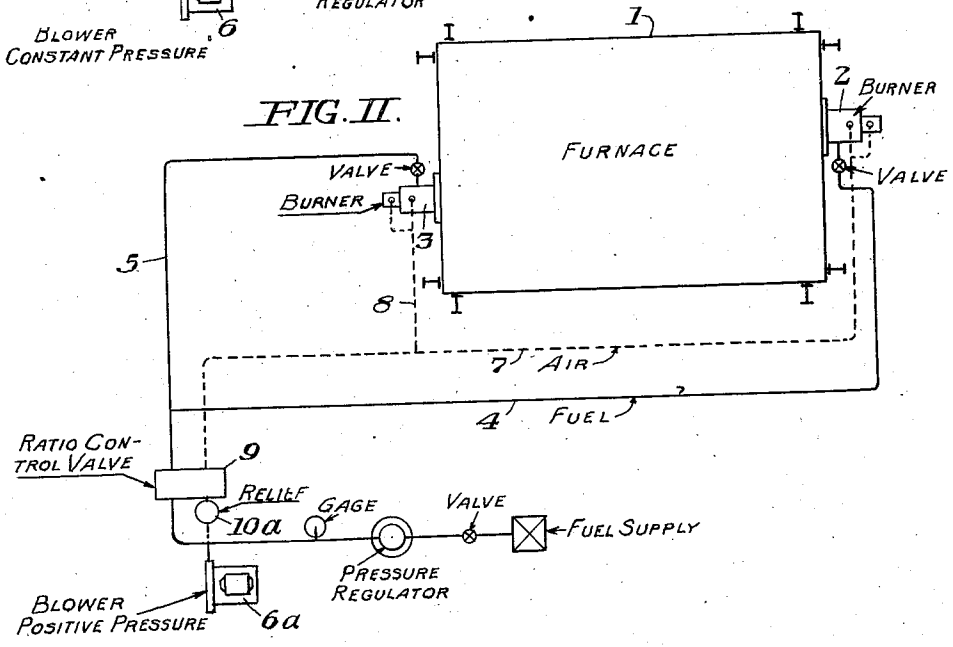


FIG. II.



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FIG. III.

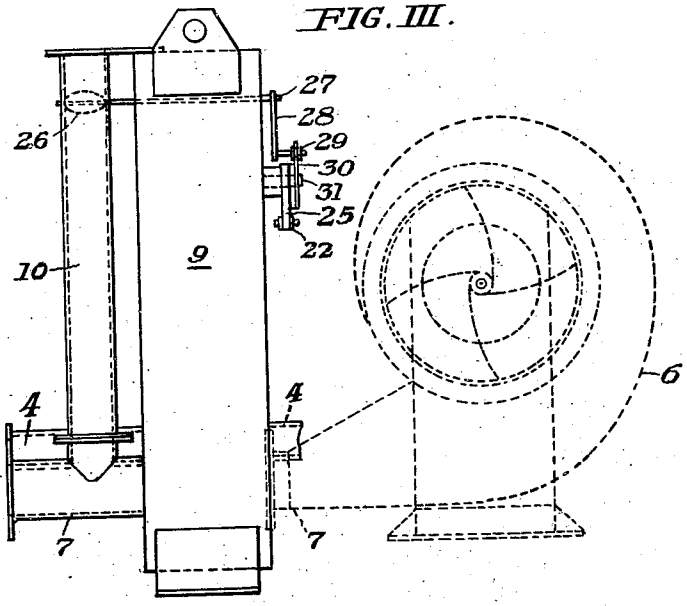
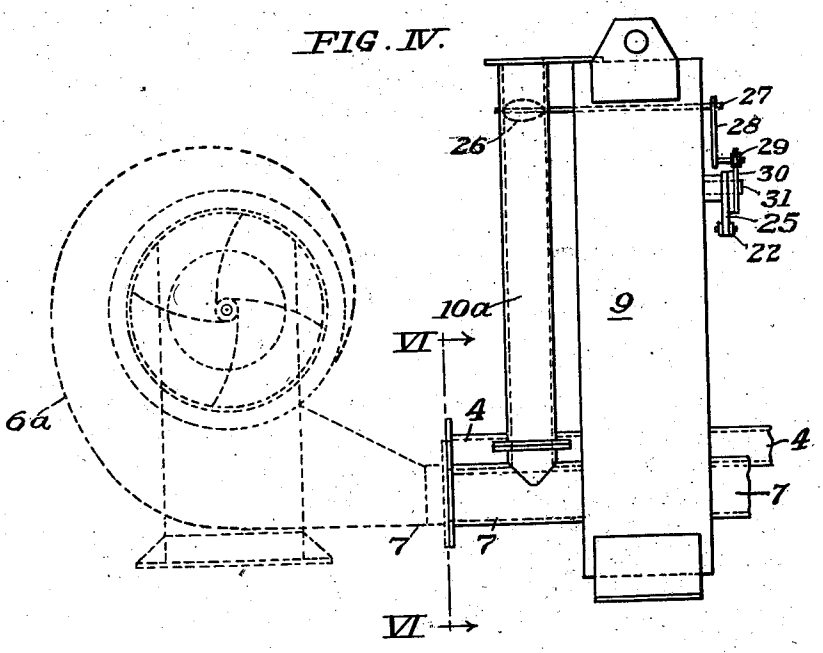


FIG. IV.



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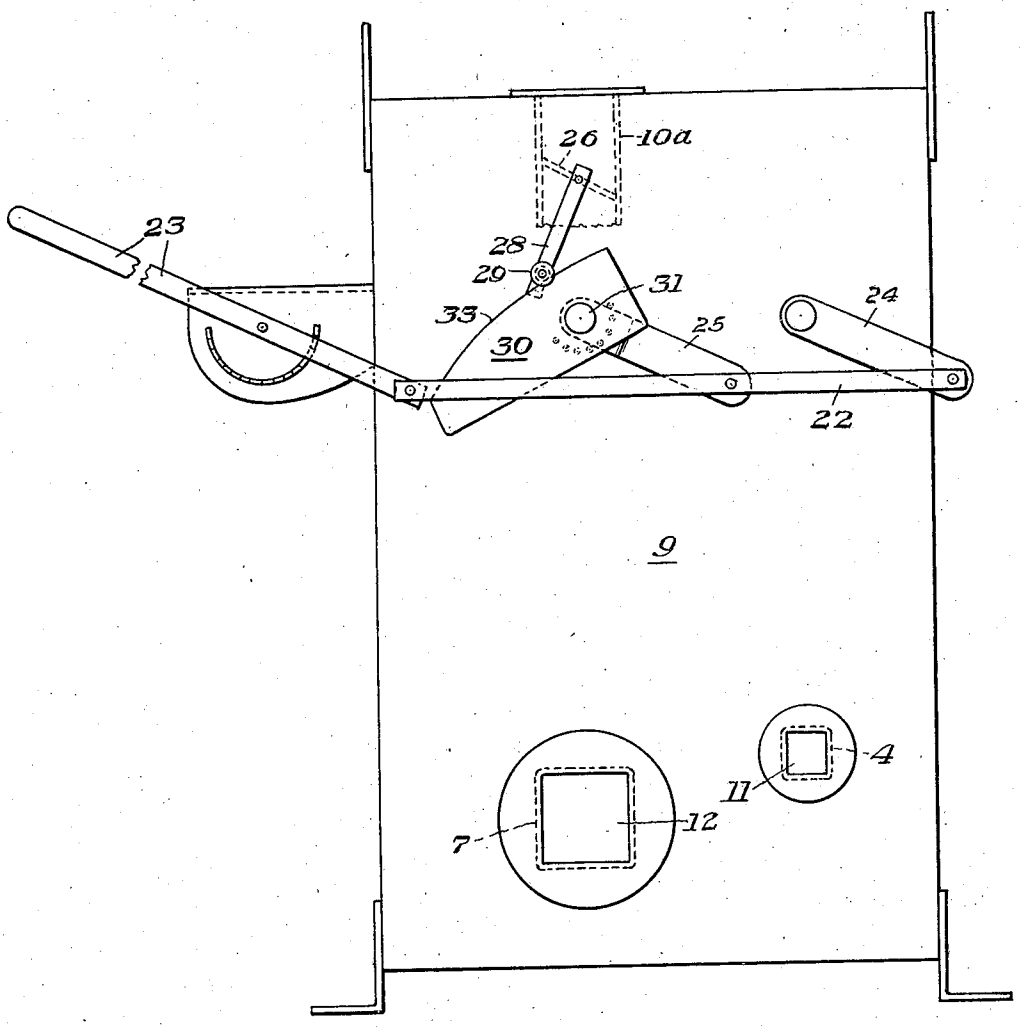
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FURNACE ATMOSPHERE CONTROL

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FIG. V.



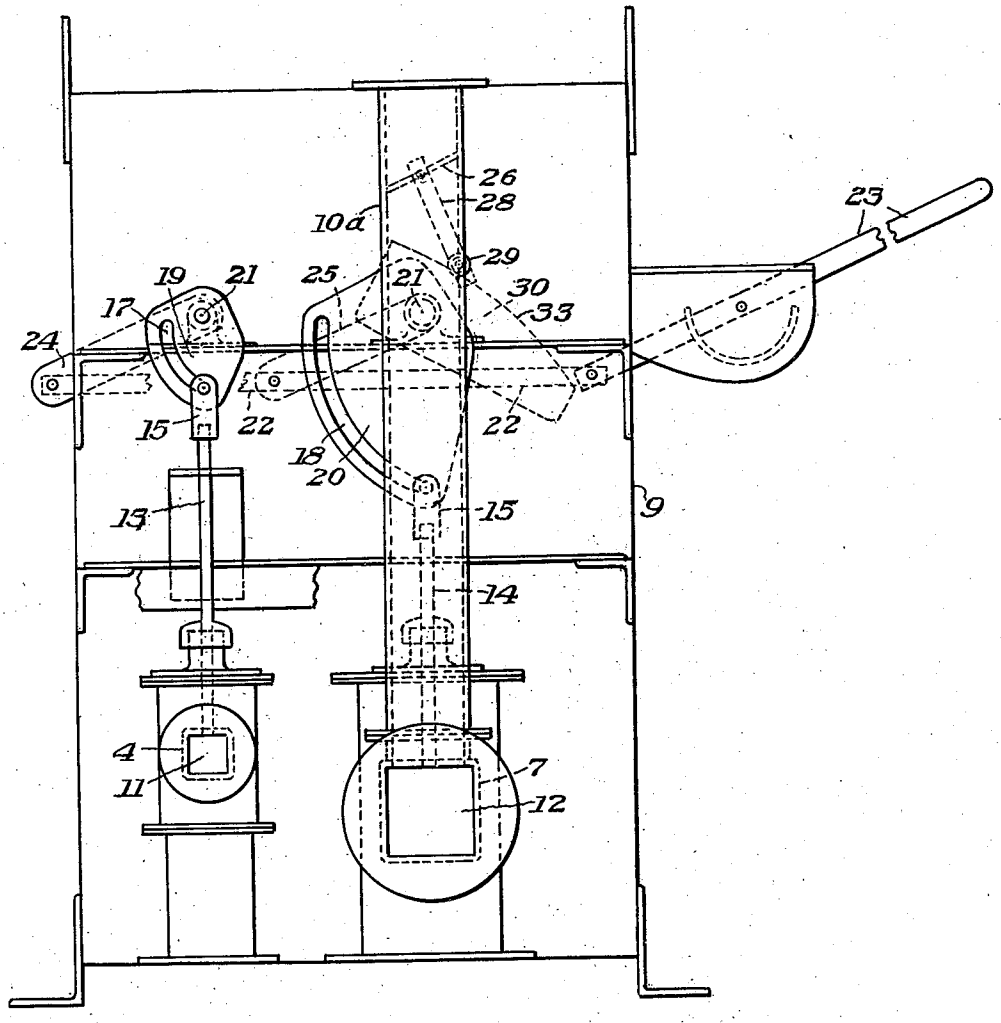
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FURNACE ATMOSPHERE CONTROL

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FIG. VI.



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UNITED STATES PATENT OFFICE

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FURNACE ATMOSPHERE CONTROL

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Application August 14, 1944, Serial No. 549,396

4 Claims. (Cl. 158—119)

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This invention relates to a ratio control valve for furnaces.

It is highly desirable in operating metallurgical furnaces of all sorts that the furnace atmosphere be maintained uniform during selected periods of furnace operation and in spite of changes in the combustion rate. It is an inherent condition in furnace installations that in supplying air and fuel such as gas, oil, powdered coal or coke, to the furnace any ratio fixed by valves in the delivery lines for the combustion air and for the fuel is not accurately effective at the burner or burners of the furnace. This primarily is because there is always variant frictional resistance and usually other conditions tending to destroy accurately proportioned flow in the connections between the air and fuel valves and the burner or burners of the furnace, so that a valve setting effective to give the desired air and fuel ratio at one combustion rate becomes inaccurate with increase or decrease in the rate of combustion as the volumes of air and fuel both are increased or decreased. Whereas, therefore, the pressure and volume at which both the combustion air and the fuel pass their valves may respond to an accurate determined ratio to give a desired condition of the furnace atmosphere if it were effective at the furnace burner or burners, there will be sufficient variance from that ratio at the burner or burners themselves substantially to vary the ratio of combustion air and fuel, and thus to vary the gaseous components in the furnace chamber sufficiently to give a substantially different furnace atmosphere from that from which the initial ratio is determined. In the heat treating and melting of metals and typically in the heat treating and melting of iron and steel this is a matter of great importance.

It is impossible accurately and in apportioned relation to predetermine the variation in flow through connections to the burner or burners of a furnace for all rates of combustion, that is for all rates of air and fuel consumption. There have been many ratio valves designed and used approximately to adjust at the air and fuel valves for variant conditions in the connections beyond those valves at different combustion rates. Such regulation or adjustment commonly has involved the use of valves having specially designed orifices and/or proportional mechanical valve-operating means, functioning to expose variant relative orifice areas as the valves are operated to increase or decrease the air-fuel supply, to give at the air and fuel valves compensation for variation in flow through the connections beyond the

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valves. As above noted, the conditions in the air and fuel connections which give rise to such difference in the coefficients of friction render accurate adjustment for the difference impossible in practice. There is also another condition associated with the adjusting or compensating means which introduces an additional variant in the adjusting means themselves. This is in the fact that with change in the relative dimensions of the orifices in the fuel and air valves in compensating for variations beyond the valves, the change in the areas of the orifices themselves introduces an additional frictional resistance variant which is inherent and direct compensation for which cannot be had.

In the view above, I have conceived a novel principle of ratio control for the fuel and air which is effective to maintain a ratio which gives a uniform furnace atmosphere under all changes in the rate of combustion. This, I accomplish by basing my control on the desired end in view, namely upon uniformity in the furnace atmosphere throughout progressive alteration in the volume of air-fuel supply, and by providing mechanism concordant with the desired condition of the furnace atmosphere functioning to impose upon the air-fuel supply in any progressively increased or decreased volume thereof correction, or rectification, empirically determined from the furnace atmosphere itself. This, I do by determining the desired furnace atmosphere for any particular furnace operation and setting the air and fuel valves to give that atmosphere at any one selected volume of air-fuel supply. The valve setting is effected by making observations of the furnace atmosphere by means of suitable instruments which give either a chemical analysis or a gravity analysis of the furnace gases. Then, while increasing or decreasing the volume of air-fuel supply to increase or decrease the combustion rate, I repeatedly make such analysis of the furnace atmosphere and record the adjustment or correction required to maintain that atmosphere, as the combustion rate is changed. In so doing, I calibrate a control or rectifying element, desirably in the form of a cam, to that ratio with respect to, and only with respect to, the volume of air passing through the connections leading from the air valve to the burner. Then supplying both air and fuel each at its own constant pressure under which the empirical determinations and calibrations have been made, I supply a normal excess, or deficiency, of air over the maximum required for the desired air-fuel ratio at the burner. Usually, a

regulated proportion of this air is then wasted under the influence of the rectifying element calibrated to maintain under all combustion conditions the desired determined furnace atmosphere. When, however, the operation is such that the tendency is to create a suction effect in the connections and thus to draw air into the system rather than to waste it, the same regulating means which normally waste air tends to limit the volume of air which is inspirated to a proportion which will maintain the desired furnace atmosphere.

It is to be repeated that in my furnace atmosphere control the means for rectifying the air supply with relation to the fuel supply at the burners of the furnace is directly related to the desired furnace atmosphere, so that the control or correction cares for all variations which occur. It also should be understood that the control or corrections made by a specific rectifying element is appropriate only to a particular furnace, to a particular installation of connections leading to the furnace burners and to a particular furnace operation. Taking a specific furnace with its connections, the calibrated control or correction element applies to the desired furnace atmosphere for some particular operation, and if another operation is to be performed in the furnace another rectifying element designed for the desired furnace atmosphere in that particular operation should be substituted. Change in the shape or dimensions of the furnace chamber or in the length or dimensions of the connections to the furnace burners require different rectifying controls designed to maintain the desired furnace atmosphere for the several operations which are to be performed in the altered furnace installation.

In the accompanying drawings

Fig. I is a diagrammatic view showing the arrangement of the furnace having burners associated therewith, air and fuel connections leading to the furnace burners, and showing in the air and fuel lines a ratio control valve comprising the rectifying organization of my invention. In this figure of the drawings air is supplied through the ratio control valve to the burners of the furnace by means of a constant pressure blower.

Fig. II is a diagrammatic view similar to Fig. I, but illustrating the slight difference in arrangement of elements of the rectifying assembly of my invention in accommodation to the use of a positive pressure blower for supplying air through the ratio control valve to the furnace burners.

Fig. III is a side elevation of the ratio control valve assembly showing the valve box in side elevation in conjunction with a constant pressure blower, and in conjunction with the elements of the rectifying assembly.

Fig. IV is a similar view, but showing a positive pressure blower and a position of that blower with respect to the elements of the rectifying assembly different from the position of the blower shown in Fig. III.

Fig. V is a front elevation of the ratio control valve box and its associated rectifying elements looking toward the left in Fig. IV.

Fig. VI is a rear elevational view of the ratio control valve box looking to the right in Fig. IV, with the wall of the box removed and omitting the blower shown in Fig. IV.

Referring first to Figs. I and II of the drawings, those figures illustrate what may be considered normal supply connections to the burners of a heating furnace, such as those used in metallurgical work, illustrating that there commonly are connections of relatively extended length between a valve organization provided to control the supplied ratio of fuel and air to the burners, and illustrating that the fuel and air supply connections from the ratio control valve to the several burners of the furnace may be of different length. In both these figures of the drawings the furnace is designated by the reference numeral **1**, and its burners are designated respectively by reference numerals **2** and **3**. A fuel line **4** from a source of fuel supply, and equipped with the usual valves and pressure regulating and indicating means, leads to burner **2** and has a branch connection **5** leading to burner **3**. Referring particularly to Fig. I of the drawings, air is supplied under moderate pressure by a constant pressure blower **6**, the air line **7** of which leads to burner **2** and has a branch connection **8** leading to burner **3**. Both fuel line **4** and air line **7** pass through a ratio control valve box **9** and the air line is shown in communication with air relief duct **10**.

In Fig. II of the drawings the arrangement and the elements are identical with the showing of Fig. I, except that the constant pressure blower **6** is replaced by a positive pressure blower **6*a*** connected with air line **7**, and except that air relief duct **10*a*** is positioned on the blower side of the ratio control valve box **9** instead of on the furnace side of such box as in Fig. I.

Referring now particularly to Figs. V and VI of the drawings, fuel line **4** and air line **7** are shown as valved in the control box **9**. Because a great number of variant forms of valve may be used, the specific valve structure being immaterial with respect to my invention, the valve **11** for the fuel line and valve **12** for the air line are diagrammatically indicated. The valve operating connections which are themselves of well known form are, however, shown in detail because of their cooperative action with the rectifying organization of the valve assembly. Such valve operating means comprise valve operating plunger rods **13** and **14** for the fuel valve **11** and the air valve **12** respectively. At their upper ends plunger rods **13** and **14** are equipped with forks **15** carrying pintles which lie in the curved cam slots **17** and **18** of cam plates **19** and **20**. These valve-operating cam plates **19** and **20** have eccentric pivots **21** about which the plates swing. Simultaneous swinging movement of the cam plates is caused by longitudinal movement of cam-actuating rod **22** extended horizontally along the front of valve box **9**, which is mounted for sliding movement and which has an operating handle **23** pivotally connected at one end thereof. Toggle arms **24** and **25** transmit movement of cam actuating rod **22** to the cam plates **19** and **20**, which by the action of their slots **17** and **18** actuate valve-operating rods **13** and **14** simultaneously to produce opening or closing movement of valves **11** and **12** in predetermined relation to each other. The form and setting of slotted cam plates **19** and **20** thus controls the ratio between fuel and air passing to the connections which lead to the furnace burner.

The rectifying assembly of my invention is associated functionally with the means for operating the fuel and air valves, to give different combustion rates in the furnace, and desirably is connected physically with the means for operating those valves so that the rectifying action for each change in the combustion rate takes

place simultaneously with and under the direct influence of such change.

The assembly for rectifying the proportions of fuel and air in accordance with the desired furnace atmosphere is shown as comprising an air relief duct 10 (with reference to the form of Fig. IV), extended vertically from the air line 7. In the air relief duct there is a butterfly valve 26 arranged to control passage of air from and to the air line. The pintle of butterfly valve 26 is extended as a shaft 27, which is equipped terminally with an arm 28 carrying a roller 29 arranged to ride on the upper surface of cam 30, which is the calibrated control element of the rectifying assembly. This is shown as pivotally mounted on box 9 by a short shaft 31 which forms the pivot point 21 for valve operating cam 20 and which is swung by arm 25 connected with cam-actuating rod 22, which rod also actuates cam plate 19 through arm 24.

As cam-actuating rod 22 is moved to increase or decrease the port areas of the air and fuel valves, cam 30 is thus moved and its movement is transmitted to relief butterfly 26 to act on that valve in accordance with the effective form of cam surface 33 on which roller 29 rides. Initially, therefore, the cam surface is shaped, or calibrated, to the proper opening of the relief valve for closely spaced positions of cam 30. As has been indicated, the various positions of cam 30 are, by common use of cam-actuating rod 22, related directly to the opening or closing of the fuel and air valves to increase or decrease the total volume of combustible mixture passed into the connections leading to the furnace burners. Thus butterfly valve 26 is operated to vary the escape of air therethrough, or to vary the limiting effect of the valve in controlling aspiration of air into the system as the case may be, under the influence of cam 30 and in accordance with the design of its surface 33.

It has been stated that the calibration of the cam, that is with the sort of cam shown the formation of its effective surface 33, is in accordance with the desired furnace atmosphere under all rates of supply of fuel and combustion air to the furnace. This is done by operating the furnace in accordance with the temperature conditions which are to exist throughout the entire desired operation, with actuation of the fuel and air valves to give the required temperature cycle. In making the calibration the cam is designed by marking a blank for the cam with relation to the proper setting of the buterfly valve which rectifies the fuel and air ratio to give the desired furnace atmosphere. Thus with each change in the setting of the air and fuel valves 11 and 12 an analysis of the furnace atmosphere is made and the butterfly valve is operated by hand to a point at which analysis shows the desired atmosphere, this point being marked on the cam blank. When, therefore, the operation is repeated with the finished cam serving as a rectifying control element, the rectification is automatically effected by operation of the butterfly valve under the influence of the rectifying control cam with each movement of the common actuating means for that cam and the fuel and air valves, as the intended temperature curve of the furnace is followed. In this way the furnace atmosphere is kept uniform throughout the entire operation.

It is to be emphasized that each individual furnace has its own appropriate set of cams, and that each cam is made for an operation of a particular sort. For example a furnace has one

cam made for the heat treatment of bars in accordance with one specification, another cam made for the heat treatment of iron and steel castings in accordance with another specification, and various other cams each for a particular operation. Any desired set of cams may be provided for interchange as the furnace is used for different operations, and additions to such set may be made from time to time as the occasion arises. For this reason the cam 30 of the drawings is shown as relatively unspecialized in the contour of its effective surface 33, any particular contour being empirically determined in the manner above described.

In operation, the preferred procedure is to supply an excess of air from a suitable source, such as one of the blowers shown in the drawings. A certain proportion of that air normally is wasted through the relief duct under the control of the rectifying valve. It is possible, though not usual to utilize an initial deficiency of air, and to supplement the air supply by inspiration through the air relief duct. In such case the cam 30 makes adjustment of rectifying valve 26 on the same empirical basis as has been above described, the only difference being that the rectification is concerned with the limitation of incoming air instead of outgoing air.

In order to have a full understanding of the operation of my apparatus, it should be borne in mind that whatever the air source be, that is whether it be from a constant pressure blower, a positive pressure blower, or from some other source from which air is delivered under positive or negative pressure, the pressure at which the air is delivered is so controlled as to be constant, or uniform, throughout both the calibration of the rectifying control element and the functioning of the control valve during the operation of the furnace. The same is true of the fuel, which is delivered at its own constant or uniform pressure throughout both the calibration of the control element and the operation of the furnace. Because of the basis on which the rectification is made, the fuel may be delivered from a plurality of sources, each supplying fuel under its own constant pressure without decreasing the effectiveness of the rectification. The fuel from such different sources also may itself be different, as oil supplied by one valved line and gas supplied by another valved line, also without impairing the effectiveness of the rectification.

Having shown and described one apparatus embodiment of my invention, it is to be understood that the invention is not to be strictly limited thereby, but that such equivalent structure as falls within the definition of my appended claims comes also within the scope of my invention.

I claim as my invention:

1. In combination with valved fuel and air lines arranged to convey a proportioned supply of fuel and air under controlled pressure to a furnace, and interconnected valve-operating means arranged to be actuated proportionally to open and close the valves of said fuel and air lines for different rates of air-fuel supply, a rectifying assembly comprising an air relief duct in communication with the said air line, a rectifying valve controlling air flow through said relief duct, and a rectifying control element mechanically connected with said rectifying valve and having means for moving it proportionally with movement of the said interconnected valve-operating means, said control element being cali-

brated to a desired furnace atmosphere with respect to related positions of the valves of the fuel and air lines and the said rectifying valve, to give at the furnace a proportion of air to fuel rectified to the desired furnace atmosphere at the different rates of air-fuel supply.

2. In combination with valved fuel and air lines arranged to convey a proportioned supply of fuel and air under controlled pressure to a furnace, and interconnected valve-operating means arranged to be actuated proportionally to open and close the valves of said fuel and air lines for different rates of air-fuel supply; a rectifying assembly comprising an air relief duct in communication with the said air line, a rectifying valve controlling air flow through said relief duct, and mechanical connections between said interconnected valve-operating means and the said rectifying valve comprising a rectifying control element calibrated to a desired furnace atmosphere with respect to related positions of the valves of the fuel and air lines and the said rectifying valve, to give at the furnace a proportion of air to fuel rectified to the desired furnace atmosphere at the different rates of air-fuel supply.

3. In combination with valved fuel and air lines arranged to convey a proportioned supply of fuel and air under controlled pressure to a furnace, and interconnected valve-operating means arranged to be actuated proportionally to open and close the valves of said fuel and air lines for different rates of air-fuel supply, a rectifying assembly comprising an air relief duct

in communication with the said air line, a rectifying valve controlling air flow through said relief duct, and a rectifying control cam mechanically connected with said rectifying valve and having means for moving it proportionally with movement of the said interconnected valve-operating means, said control cam being calibrated to a desired furnace atmosphere with respect to related positions of the valves of the fuel and air lines and the said rectifying valve, to give at the furnace a proportion of air to fuel rectified to the desired furnace at the different rates of air-fuel supply.

4. In combination with valved fuel and air lines arranged to convey a proportioned supply of fuel and air under controlled pressure to a furnace, and interconnected valve-operating means arranged to be actuated proportionally to open and close the valves of said fuel and air lines for different rates of air-fuel supply; a rectifying assembly comprising an air relief duct in communication with the said air line, a rectifying valve controlling air flow through said relief duct, and mechanical connections between said interconnected valve-operating means and the said rectifying valve comprising a rectifying control cam calibrated to a desired furnace atmosphere with respect to related positions of the valves of the fuel and air lines and the said rectifying valve, to give at the furnace a proportion of air to fuel rectified to the desired furnace atmosphere at the different rates of air-fuel supply.

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