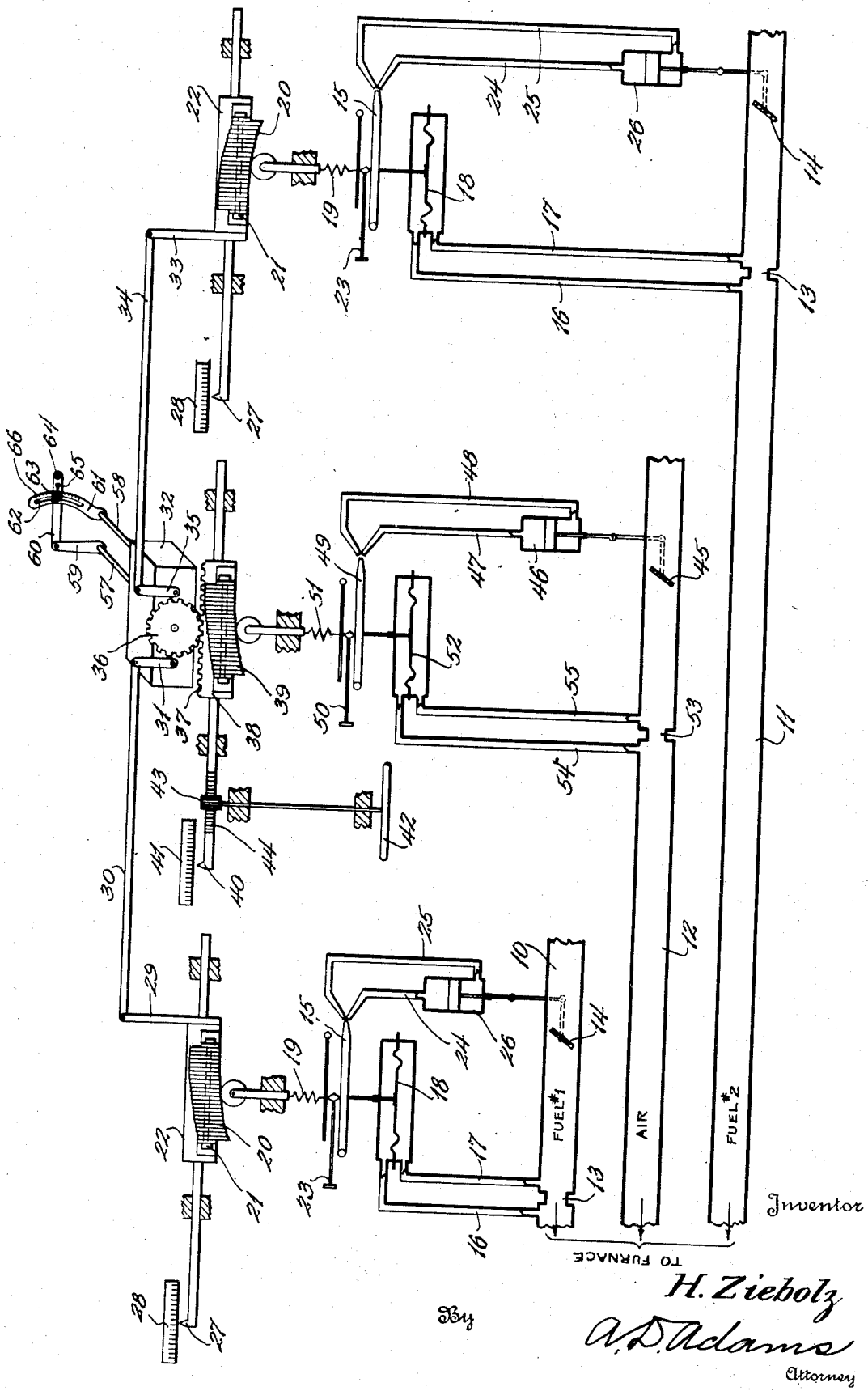
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FLOW PROPORTIONING APPARATUS

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FLOW PROPORTIONING APPARATUS

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6 Claims. (Cl. 137—164)

This invention relates to improved apparatus for controlling and proportioning the flows of separate fuels having different air requirements and heating values to the adjusted total controlled supply of combustion air delivered through a single conduit. The main idea is to provide summarizing and control means so constructed and arranged that the adjusted total controlled supply of air may be manually controlled in accordance with any desired heat input in a furnace and the ratio of the fuels relative to each other or the percentage of one fuel may be changed manually to produce the most efficient combustion or to insure consumption of a maximum quantity of one fuel.

Heretofore, it has been suggested that rates of fuel flow be summarized by means of fuel flow meters or by pilot air flows which are directly proportional to the individual B. t. u. rates of fuel flow and the total air proportioned to the sum of the individual fuel flows in terms of their heating values. The design of such mechanisms is based on the fact that a definite amount of air is required for theoretically complete combustion of a given quantity of fuel in terms of its B. t. u. value. In the operation of industrial furnaces or boiler furnaces a number of factors must be taken into consideration which render the supply of the calculated or exact amount of air necessary for theoretically complete combustion, improper. Such factors do not vary as a direct function of the rate of fuel flow but present different values at different rates of fuel flow. Some of these factors are, for example, air used to atomize liquid fuels or primary air used for conveying pulverized fuel, which air is not subject to control by the well known air control apparatus. Such factors may be termed "burner factors." The calculated amount of air, which would be supplied by the control apparatus to support theoretically complete combustion of a single fuel, modified by the amount of air which finds its way into the burner installation by reason of these factors, is referred to herein as "compensated air requirements" of that fuel. If more than one fuel is supplied, the calculated amount of air which would be supplied by the control apparatus to support theoretically complete combustion of the plurality of fuels, modified by the amount of air which finds its way into the burner installation, as a result of the feeding of more than one fuel, is referred to herein as "totalized compensated air requirements" for the fuels. Further correction factors may be necessary in any furnace installation to take into account infiltration of air into the furnace, other sources of air of determinable amounts admitted to the furnace, or the desired condition of the furnace atmosphere. All of these factors are subject to variations which are not direct functions of the rate of total fuel supply. They may be termed furnace factors. These furnace factors may require further adjustment in the "total compensated air requirements" called for by the fuels. The total compensated air requirements, thus modified by these furnace factors, is herein termed "adjusted total air requirements."

The "adjusted total air requirements" may be modified so as to produce a deficiency or excess of combustion air in the furnace. The "adjusted total air requirements" as thus modified may be termed "adjusted total controlled air" or the actual amount of controlled air supplied to the furnace.

It is therefore a further and more specific object of this invention to provide means for proportioning the supplies of at least two fuels, both controlled to flow at constant rates, in accordance with their respective compensated air requirements necessary to support complete combustion and means for manually controlling the air supply at a constant rate in accordance with adjusted total amount of air necessary to be supplied to a furnace at the different, total fuel loads.

This invention involves important improvements over my copending application Ser. No. 401,666, filed July 9, 1941.

Other aims and advantages of the invention will appear in the specification, when considered in connection with the accompanying drawing, wherein:

The figure is a diagrammatic illustration of one form of apparatus embodying the invention applied to the control of air and two fluid fuels.

Referring particularly to the drawing, the illustrated apparatus is especially designed to be manually adjusted and to so regulate the supplies of adjusted total controlled air and the respective fuels that any predetermined ratio of the fuels is maintained for the desired heat input in a furnace. Also, provision is made to maintain the adjusted total controlled supply of air constant after the apparatus is adjusted. In steel furnaces, for example, it is sometimes desirable to regulate the supply of a primary fuel, such as coke oven gas, so that it represents a definite proportion or percentage of the total heat input. In the simple form of apparatus shown, the sup-

plies of two fuels, one of which may be primary fuel and the other a secondary fuel, are automatically controlled in accordance with the manual setting of an air supply regulator and the ratio of the fuels relative to each other is capable of being changed by the manual adjustment of a summarizer.

In this instance, the fuels are supplied through individual conduits 10 and 11 and the adjusted total controlled combustion air is supplied for both fuels through a single conduit 12, the conduits leading to a furnace, not shown. The fuels may be fuel oil or blast furnace gas and coke oven gas, the flows of which are each maintained constant by means of a regulator of any suitable type. The conduits 10 and 11 are each shown as having a constriction 13 and a butterfly control valve 14. The position of the valve is adapted to be automatically varied and the flow maintained by a jet pipe regulator 15, here shown as being of the well known hydraulic type. A pair of pipes 16 and 17 are connected to opposite sides of the constriction and lead to opposite sides of a diaphragm 18 connected to act on one side of the pivoted jet pipe 15. The force exerted by the diaphragm acts in opposition to a spring 19, the compression of which is controlled by a movable loading cam 20 of variable contour. The cam is shown as being composed of a multiplicity of relatively adjustable, slotted pieces clamped together by a bolt 21 secured to a carriage 22 which is slidably mounted in fixed bearings. The contour of each cam is adjusted to take into account the variable burner factors, so that its loading movement is directly proportional to the compensated air requirements to support complete combustion of the respective fuels at any rate of fuel flow. In this instance, the contours differ slightly from that of an ordinary square root cam.

Each regulator has a ratio slider 23 which may be employed to vary the ratio of the compensated air requirements for the respective fuel in accordance with variations in the density, chemical analysis and viscosity of the fuels, as well as other factors affecting the B. t. u. content of the fuels. The force exerted on the jet pipe by the diaphragm, due to the differential pressure on opposite sides of the constriction 13, is always counterbalanced by the force of the spring to restore the jet pipe to neutral position and maintain the flow of fuel constant.

The position or movement of each cam 20 relative to a fixed or zero point corresponding to zero flow of fuel corresponds with the compensated air flow requirements for the respective fuels supplied at any desired constant rate and the rate of flow of the fuel is maintained by the regulator, the jet pipe of which acts through a pair of pipes 24 and 25 on the piston of a servomotor 26 connected to the butterfly valve to maintain the position of the valve constant when the pressure differential across the restriction is constant. The position of the cam is indicated by means a pointer 27 cooperating with a scale 28 reading in terms of the compensated air requirements for the fuel at its controlled rate of flow. The left hand carriage is shown as being connected by means of an arm 29 and link 30 to a crank arm 31 mounted on one shaft of a movement proportioning means or differential gear 32 similar to that disclosed in my copending application Serial No. 401,666, filed July 9, 1941. The right hand carriage is also shown as being connected by means of an arm 33 and link 34 to a crank arm 35 mounted on a second shaft of the differential gear 32. An ordinary or simple form of differential gear is shown in detail in the aforesaid copending application. As explained in the aforesaid application, it has a spur gear 36 which meshes with a rack 37 on a slidable carriage 38, similar to the carriages 22. The carriage 38 also carries an adjustable cam 39 made like cams 20 and shaped to control the supply of air in accordance with its adjusted position, taking into account air infiltration in the furnace. That is to say, the contour of this cam is so adjusted that its manual adjusting movements are directly proportional to adjusted total amounts of air delivered through the air conduit, taking into account variable furnace factors. The carriage operates a pointer 40 cooperating with a scale 41, to indicate the adjusted total air flow, representing the desired heat input. In may be adjusted by any suitable means, such as hand wheel 42 operating a pinion 43 meshing with a rack 44 connected to the carriage. It will be seen that the adjusting movement of the carriage imparts movements to both of the cams 20, being the sum of their movements.

Now, the flow of the air in conduit 12 is shown as being controlled by a butterfly valve 45 which is actuated by a piston type servo-motor 46. The servo-motor is connected by pipes 47 and 48 to be operated by a jet pipe regulator 49, also having a ratio slider 50, whereby the ratio between the cam movements and the rate of air flow may be changed at will. The cam 41 acts on one side of the jet pipe through a spring 51 in opposition to a diaphragm 52 on the opposite side of the jet pipe, and the position of the diaphragm is controlled by the pressure differential across a constriction 53 in the air conduit 12, acting through pipes 54 and 55 on opposite sides of the diaphragm.

In this instance, the adjusting movement of the loading cam 39 of the air regulator not only imparts proportioning movements to the fuel cams 20, but the differential gearing has associated means to change the ratio of the fuel cam movements relative to each other. The fuel ratios may be changed by selecting suitable gears to operate the fuel cams in conjunction with the differential gearing. For illustrative purposes, the main shaft 57, carrying the spur gear 36 is shown as being positively connected to operate one fuel shaft 58 by a simple form of ratio changing linkage. For this purpose, the shaft 57 is shown as extending rearwardly and carries a crank arm 59 to which is pivoted a ratio link 60 also adjustably pivoted to a crank arm 61 on the secondary fuel shaft 58. The crank arm 61 has an arcuate slot 62 in which a pivot pin 63 is slidably adjusted by means of a handle or knob 64 on the ratio link. It will be understood by those skilled in the art that this linkage takes the place of a pair of spur gears on the shafts 57 and 58 in the housing of an ordinary differential gear like that shown in my aforesaid copending application Ser. No. 401,666. To enable an operator to adjust the ratio, as desired, the ratio link may have a pointer 65 cooperating with a scale 66 on the arm 61. By shifting the ratio link, the movement imparted to the secondary fuel cam is increased or decreased, as desired; while the balance of the summarizing movements is transmitted to the primary fuel cam. This adjustment should be made while the air

cam is in its zero position, so that hand setting movement of the hand wheel will impart the desired proportional movements to the respective fuel cams.

When the air cam is set and the fuel ratio is determined, all of the regulators will maintain constant flows in the respective conduits. Thus, a furnace may be operated continuously at its maximum efficiency and the consumption of the respective fuels is controlled in accordance with their availability and/or cost.

It will be understood that the regulators, servomotors and the cams may be mounted on any suitable support, such as a table. The cams may be guided for straight line movement in any convenient manner, for example, by wheeled carriages or the like. Moreover, the indicators may be either mechanical or electrical and all of them may be located at any convenient point. As explained in the aforesaid copending application, the apparatus may be employed to control any number of fuels by using an additional differential gear for each additional fuel.

Obviously, the present invention is not restricted to the particular embodiment thereof herein shown and described. Moreover, it is not indispensable that all the features of the invention be used conjointly, since they may be employed advantageously in various combinations and subcombinations.

What is claimed is:

1. Apparatus for controlling and proportioning the supply of at least two separate fuels to the adjusted total controlled supply of combustion air delivered to a furnace, comprising, in combination, individual conduits for the air and the respective fuels; a regulator connected to the air conduit constructed and arranged to control and maintain the adjusted total controlled supply of air constant and having manual setting means to provide a predetermined air flow representing the controlled air requirements of the furnace; a fuel proportioning device, including gearing connected to be operated and set by said manual setting means; flow controlling regulators connected to the respective fuel conduits constructed and arranged to maintain the flows of the fuels constant; movable control devices associated with said fuel regulators so constructed and arranged that their movements relative to a zero point corresponding to zero fuel flow and proportional to the compensated air requirements of the respective fuels to thereby call for predetermined rates of flow of the fuels; and operating elements connecting said movable control devices to said proportioning device, whereby manual adjusting movements of the setting means are imparted to each of said movable control devices and the fuel flows are proportioned in accordance with the adjusted total controlled air requirements of the furnace.

2. Apparatus for controlling and proportioning the supply of at least two separate fuels to the adjusted total controlled supply of combustion air delivered to a furnace, comprising, in combination, individual conduits for the air and the respective fuels; a regulator connected to the air conduit constructed and arranged to control and maintain the supply of air constant and having manual setting means to provide a predetermined air flow representing the controlled air requirements of the furnace; a fuel proportioning device, including gearing connected to be operated and set by said manual setting means; flow controlling regulators connected to the respective fuel conduits constructed and arranged to maintain the flows of the fuels constant; movable control devices associated with said fuel regulators so constructed and arranged that their movements relative to a zero point corresponding to zero fuel flow and proportional to the compensated air requirements of the respective fuels to thereby call for predetermined rates of flow of the fuels; operating elements connecting said movable control devices to said proportioning means; and ratio varying mechanism associated with said gearing and so constructed and arranged that the proportioning movements which are imparted by said manual setting means to said control devices of the respective fuel regulators may be adjusted to produce any desired fuel ratio.

3. Apparatus, as set forth in claim 2, wherein the fuel regulators are of the hydraulic type and their control devices comprise loading cams of adjusted contour.

4. Apparatus, as set forth in claim 2, wherein the air flow regulator is of the hydraulic type and the manual setting means comprises a cam of adjusted contour.

5. Apparatus, as set forth in claim 2, wherein all of the regulators are of the hydraulic type and the setting means, as well as the movable control devices comprise loading cams for the respective regulators, and each of said loading cams operates an associated indicator reading in terms of quantities of air.

6. Apparatus, as set forth in claim 2, wherein, each of said regulators has a ratio varying element.

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