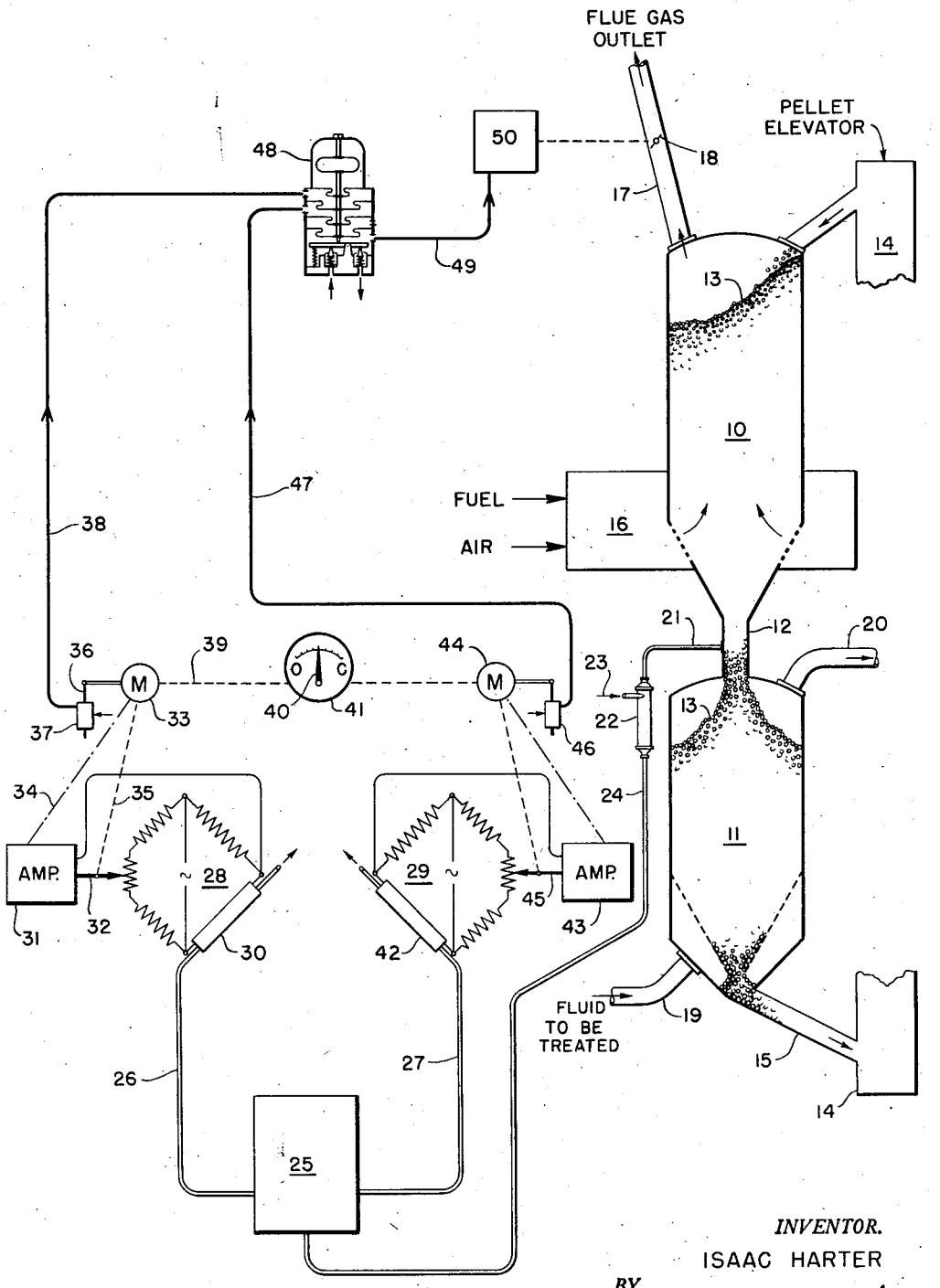
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FLUID HEATER CONTROL SYSTEM

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FLUID HEATER CONTROL SYSTEM

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My present invention relates in general to the operation and control of fluid heaters of the type in which the heat transfer medium consists of a fluent gas-pervious mass of refractory material which is first heated by the passage of a heating fluid in heat transfer relation therewith and is then cooled by contact with fluid to be heated; and more particularly to fluid heaters of the character illustrated and described in which the mass of heat transfer material in the form of pellets moves by gravity downwardly through a series of superposed heating and cooling chambers or zones connected by one or more throats of reduced flow area but structurally unobstructed, and the pellets are elevated to a point above the upper chamber, and again allowed to move by gravity through the several chambers.

The heater may comprise a multiplicity of superposed refractory lined chambers, one or more of which may be adapted for the continuous heating of refractory pellets while one or more of the chambers is adapted for the heating of fluids by contact with the descending stream of hot pellets. The refractory pellets are arranged for gravity flow through the chambers and connected throat sections and then for external return from the lowermost chamber to the uppermost chamber. Certain arrangements of control apparatus and the operation of such a heater form particular features of my present invention.

In the present example, pellets are heated in an upper chamber by contact with a countercurrent stream of hot combustion gases after which they pass by gravity into a treating chamber where they treat the fluid which is to be processed. In some instances a third chamber is positioned below the treating chamber to effect a pre-heating of the air for combustion purposes in connection with the pellet heating chamber and to cool the pellets further. In the present embodiment two chambers are shown, connected by an unobstructed throat, and the invention relates particularly to the controlling of pressure conditions within the chambers and throat to prevent intermingling of the fluids between the chambers by passage of one or the other fluid from one chamber to the other through the throat. The invention is equally applicable to an arrangement having more than two chambers where any two of the chambers are connected by such a throat section desirably to be maintained under a pressure condition such as to minimize fluid passage therethrough. Thus, in a three chamber installation, my present invention is applicable in relation to the throat between the uppermost and middle chamber or to the throat between the middle chamber and lowermost chamber. By way of example however I have chosen for the sake of simplicity to show a two chamber heat exchanger.

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The general object of my invention is the provision of a method of and apparatus for operating and controlling fluid heating apparatus of the character disclosed for continuously heating a fluid under pressure at high capacity to a uniform final temperature in a range whose upper temperature limit is dependent only upon the physical properties, such as the fusing temperature, of the refractory materials employed with little or no contamination of the fluid being heated by the heating fluid employed and vice versa. The invention is carried out without subjecting any included metallic parts present to unsafe operating temperature or requiring special corrosion and heat resistant alloys for metal operating temperatures over 900 F. and with a relatively high overall thermal efficiency.

A particular object is to provide a control system for the apparatus described which is characterized by its ability to maintain balanced fluid pressures within the apparatus to prevent intermingling of the fluids from one chamber to another.

I have chosen to describe my invention in connection with the heating, to an elevated temperature, of a combustible gas or vapor, such as a hydrocarbon, where such a fluid to be heated is composed predominantly of a combustible material. The fluid to be heated may of course be a liquid, or a mixture of liquid and gas or vapor, where the heating of such a fluid will result in an increased percentage of gaseous or vaporous components. Desirably, such a fluid should not be diluted by the intermingling therewith of combustion gases from the chamber in which the pellets are being heated. Likewise the fluid to be heated should not be wasted by allowing any portion of it to pass into the pebble heating chamber where the valuable fluid would be burned or lost.

The throat interconnecting such chambers is preferably of a cross section reduced in area as compared to the cross section of the chambers but unobstructed structurally so that there is a free gravity flow of heated pellets between the chambers. My invention is directed particularly to a method of and apparatus for maintaining a balance in pressures between the two chambers, across the throat, to prevent passage of fluid

from either chamber through the throat to the other.

In the drawing the single figure is a diagrammatic showing, in elevation, of a two chamber heater to which one arrangement of my control system has been applied. It appears unnecessary to complicate this showing by details of the construction of the heat exchanger or of the elevator system for returning the pellets from the exit of the lowermost chamber to the inlet to the uppermost chamber. Such constructions are known in the art and form no part of the present invention. Thus the showing of the drawing is entirely diagrammatic insofar as the size, shape and general constructional arrangement of the principal apparatus is concerned. The apparatus which is concerned with the control of operation of such a heater unit and to which my invention is particularly directed will be explained in detail.

While I have chosen as an illustrative embodiment of my invention to describe the operation in connection with the heating of a combustible hydrocarbon gas or vapor it will be understood that the fluid to be heated may be naphtha, sulphur, or many varieties of fluids including air or steam to be superheated. Furthermore, the pellet heating chamber may contain a flowing fluid other than the gaseous products of combustion. To employ my invention however it is only essential that the fluid in the throat connected chambers be sufficiently dissimilar that certain distinguishing characteristics may be ascertained.

While I speak of the fluent gas-pervious mass of solid heat contact material as being in the form of pellets which may be of refractory material and in the nature of ¼ to ½" in diameter it will be understood that the actual size and character of such material is not limiting to the invention and in fact the material may be of particle size or form such as is commonly utilized in the catalytic treatment of hydrocarbon and other fluids in present day practice.

Furthermore I do not intend that my invention be limited to use with a treating system depending entirely upon heat transfer for the fluid treatment. It is equally applicable to systems for the catalytic or other form of fluid treatment resulting from the passage of particle form material from one chamber to another, through an open unobstructed connecting throat section, and where it is essential that neither of the fluids be allowed to bleed through the throat from one chamber to another.

The heating unit illustrated in the drawing is constructed and designed for the use of vapors or gaseous heating and heated fluids under pressure and as shown comprises as its main part an upper heating chamber **10** normally substantially filled with a downwardly moving fluent gas-pervious mass of refractory heat transfer material **13** to be heated by high temperature gases passing therethrough. There is shown a connected subjacent heat absorbing or reaction chamber **11** arranged to receive and normally substantially completely filled with heated refractory material **13** from the upper chamber and in which the heated refractory material is utilized for heating a second fluid, in the present embodiment a gaseous or vaporous fluid such as a hydrocarbon, to a predetermined temperature. The chambers **10** and **11** are interconnected by a throat section **12** of reduced cross section but structurally unobstructed by valves or the like to allow a free gravity flow of the heat transfer pellets **13** from the chamber **10** downwardly through the throat **12** into the treating chamber **11**.

An elevating system is provided for receiving the relatively cooled refractory material from the lowermost chamber **11** and returning it to the upper part of the uppermost chamber **10** and comprising a pellet elevator **14**. The pellet elevator **14** may be of any commercial type providing a convenient means for returning the relatively cool pellets from the bottom of chamber **11** to the top of chamber **10**. Interposed in the conduit **15**, connecting the bottom of chamber **11** with the elevator **14**, I may provided controllable feeder means for variably allowing the pellets to feed from the chamber **11** into the elevator **14**. By such means the rate of gravity flow of the material **13** downwardly through the chambers **10** and **11** may be regulated and thus the time of contact of the pellets with the different fluids may be controlled. Such control forms no part of the present invention.

An annular combustion chamber **16** is supplied with fuel and air for supporting combustion and the rate of such supply may be under control in known manner to provide the desired heating of the material **13** within the chamber **10** from one or more indexes of load upon the unit or of demand for heat. The arrangement and operation may be similar to that disclosed in Reissue Patent 23,087 to Ervin G. Bailey and Paul S. Dickey. The heated products of combustion from the combustion chamber **16** are admitted through a lower portion of the chamber **10** to pass upwardly through the interstices of the gas-pervious fluent mass **13** in intimate counterflow contact with the descending pellets whereby the pellets are heated to a high temperature and the gases leave through a flue gas outlet **17** at a relatively low temperature. Positioned in the outlet pipe **17** is a damper **18** for regulating the rate of discharge of the flue gas therethrough.

The pellets **13** move downwardly in a continuous column through chamber **10** while being heated and through throat **12** into the subjacent chamber **11** and thence after giving up the major portion of their heat, through the conduit **15** to the elevator **14**. The fluid to be heated in the chamber **11**, such as air, steam, naphtha, or the like (in the present embodiment being a gaseous or vaporous hydrocarbon), is introduced through a conduit **19** to a lower portion of the chamber **11** under a predetermined pressure and passes upwardly through the interstices between the descending pellets **13** in the chamber **11** where it is heated in counterflow heat transfer and then passes out at a desired temperature through an outlet conduit **20**.

My invention is concerned particularly with controlling the relative pressures in the chambers **10** and **11** to regulate or prevent fluid flow between the chambers. Joining the throat **12** in any convenient manner, and communicating with the interior thereof, is a sample pipe connection **21** joining a fluid mixing and aspirating section **22** to which a supply stream of water is admitted as at **23**. Connected to the enlarged pipe portion **22** is a pipe **24** which discharges into a separating and cleaning chamber **25**. Desirably I continually withdraw from the throat **12** a small sample stream of fluid for analysis in analyzing and measuring apparatus to be described whereby I ascertain the nature of the fluid in the throat **12** both for visually indicating the same and at the same time using such knowledge in controlling the relative pressures in the chambers.

The function of the aspirating chamber 22 and cleaning chamber 25, both of which are well known in the art, is to provide a continuous sample stream of fluid from the throat 12 under pressure at the discharge of the apparatus 25 and which sample has been cleaned or washed.

In the embodiment being described I preferably continuously analyze the sample stream of fluid from the throat 12 to ascertain its relative content as to percentage free oxygen or combustible. From such knowledge it will be evident as to whether there is a passage of fluid from either chamber 10 or 11 into the throat 12. For example, assuming that the products of combustion within the chamber 10 are representative of complete combustion with some excess air, then the presence of such heating gases within the throat 12 will be evident by a showing of free oxygen upon an analysis of the sample fluid from the throat 12. On the other hand if there is some flow of gaseous or vaporous hydrocarbons from the chamber 11 into the throat 12 the presence of such a combustible hydrocarbon in the sample drawn from the throat 12 will show up in the analyzing apparatus as a preponderance of unburned combustible.

Thus a showing of free oxygen within the throat 12 will indicate a downward passage of combustion gases from the chamber 10 toward the chamber 11; while a showing of free unburned combustibles in the throat 12 will indicate an upward flow of hydrocarbon fluid from the chamber 11 toward the chamber 10. If the analyzing apparatus shows a balanced condition i. e. neither toward free oxygen nor toward combustible, it will indicate a balanced pressure condition without fluid flow in either direction through the throat 12.

Within the apparatus 25 the cleaned flow of sample gas from the throat 12 is divided into two flows which eventually appear under pressure through the pipes 26 and 27.

The sample flow which is directed from the chamber 25 to the pipe 26 will be continually analyzed for the presence of free oxygen through the agency of a bridge network 28 while the sample flow passing through the pipe 27 will be continually analyzed for the presence of unburned combustible through the agency of a bridge network 29.

The sample fluid stream is provided with a proportionate supply of a vaporized liquid fuel before it reaches the pipe 26 and passes through a catalytic combustion chamber 30. In passing through the chamber 30 the mixture of sample fluid and vaporized fuel is burned on a heated element forming a leg of the balanceable bridge 28. The resistance of the bridge leg varies as its temperature changes and thus causes an unbalance of the bridge in direction and amount dependent upon the change in oxygen content of the sample supplied through the pipe 26. An amplifier and motor control device 31, which may be like that disclosed in the Ryder Patent 2,275,317, is connected to an adjustable bridge contact 32, the latter arranged to be movable over a resistance portion of the bridge 28 for balancing the bridge following an unbalance thereof. A motor 33 is connected by cable 34 to the amplifier and motor control circuit 31 to be energized by the latter for operation in one direction or the other dependent upon the direction of the bridge unbalance. The motor 33 is adapted to position the balancing arm 32 by way of operative connection 35 to restore the bridge to a balanced condition. The motor 33 is also arranged to mechanically position a valve stem 36 of a pilot valve 37 continually establishing in the pipe 38 a fluid loading pressure representative of percent free oxygen in the fluid sample being drawn from the throat 12. The pilot valve 37 may be like that disclosed in the patent to Johnson No. 2,054,464. It is sufficient to say that an upward movement of the valve stem results in a pressure increase in the pipe 38, while a downward movement of the valve stem produces a drop in the pressure in the pipe 38.

The motor 33 is arranged, through element 39, to position a pointer 40, of an indicator 41, in proper direction and extent to continually indicate the percent free oxygen in the sample gas stream.

The arrangement by which the motor 33 properly positions the contact arm 32, the pilot stem 36, and the pointer 40, are shown quite diagrammatically and need not be shown more in detail for they comprise known mechanical mechanisms such as gear trains, linkage, chain drives or the like to reduce the relatively high speed motion of the motor 33 to proper incremental motions.

In similar fashion the balanceable bridge 29 has a catalytic chamber 42 including a resistance leg of the bridge whose resistance varies with temperature change resulting from catalytic burning of the sample stream admitted through the pipe 27. This portion of the sample stream includes a proportionate addition of free air to combine with any combustibles present in the sample withdrawn from the throat 12. Thus the bridge network 29 serves to analyze the sample for the presence of combustible.

An amplifier and motor control device 43, sensitive to bridge unbalance, controls a motor 44 which positions the balancing contact arm 45, the movable element of a pneumatic pilot valve 46, and assists in the positioning of the pointer 40. The pilot valve 46 is arranged to continuously establish in a pipe 47 an air loading pressure representative of percent combustible in the sample fluid stream.

The indicating device 41 may be provided with two separate pointers operating over a single or separate scale to the end that one pointer will indicate the percent free oxygen while the other pointer will indicate the percent combustible in the sample fluid stream. As shown, the device 41, has a single pointer 40 which may be moved toward one portion of the scale indicating percent free oxygen or toward the other portion of the scale whereon is indicated the percent combustible. Within the device 41 is the necessary linkage or differential mechanism driven by the motors 33, 44 whereby the single pointer 40 is positioned in accordance with the resultant of the motion of the motors. At any time when the percent free oxygen is equal to the percent combustible the pointer 40 will be at rest at the center of the scale indicative of a balanced condition within the throat 12 wherein there is no preponderance of fluid from the chamber 10 over that from the chamber 11 or vice versa. If combustion gases from the chamber 10 tend to move downwardly through the throat 12 the pointer 40 will move toward that portion of the scale indicating free oxygen in the throat 12; conversely, should the combustible hydrocarbon gases from the chamber 11 tend to move upwardly through the throat 12,

the pointer 40 will move toward that portion of the scale indicating a preponderance of combustibles in the throat 12.

The pipes 38 and 47 join a pneumatic relay 48 arranged to establish in the pipe 49 a control pressure for the control device 50 which is adapted to position the damper 18.

The fluid loading pressures of the pipes 38, 47 are subjected upon opposing chambers, separated by a diaphragm or similar agency within the relay 48 to the end that if such pressures are equal and balanced out within the relay, no change is effected upon the control pressure within the pipe 49 and the damper 18 remains in its last position. If however the pressure within pipe 38 is greater than that within the pipe 47 then the relay 48 acts to increase (for example) the control pressure within the pipe 49; while conversely, if the pressure within the pipe 47 predominates over that within the pipe 38, the pressure within the pipe 49 will decrease. The arrangement is such that an increase or a decrease of pressure within the pipe 49 results in a positioning of the damper 18 in proper direction and amount to correct the undesirable condition within the throat 12.

Assuming that the arrangement indicates that free oxygen exists within the throat 12 the assumption is of course that combustion gases are passing from the chamber 10 downwardly into or through the throat 12. Such action indicates a predominant pressure within the chamber 10 over that within the chamber 11 and this may be corrected by slightly opening the damper 18 to relieve the pressure within the chamber 10. On the other hand if the sample from the throat 12 shows the presence of combustible it is indicative of an upward passage of combustible gases or vapors from the chamber 11 into the throat 12 or through the throat into the chamber 10. This obviously would result from a lower pressure in chamber 10 than that within chamber 11 and may be corrected by slightly closing the damper 18.

In operation then, the system continually samples the fluid within the throat 12, analyzes the sample for the presence of free oxygen and/or combustibles, and so controls the pressure within the chamber 10 that a balanced condition exists between the chambers 10 and 11 and thus within the throat 12, thereby preventing the passage of fluid from one chamber to the other with consequent dilution of a fluid, waste of a fluid, or spoilage of products, etc.

While I have described my invention as applied to an arrangement of apparatus directed particularly to the heating of a gaseous or vaporous hydrocarbon in the chamber 11, it is to be understood that other fluids may be substituted for the hydrocarbon so long as a sample of the fluid within the throat 12 may be obtained and analyzed to ascertain whether it is composed principally of fluid from the chamber 10 or from the chamber 11. By way of example assume that atmospheric air is being passed through the chamber 11 to be highly heated therein for process use. Under this condition a sample of the fluid which might pass into the throat 12 from the chamber 10 may be expected to have a free oxygen content of 6 to 8% whereas a sample of the fluid which might be expected to pass upwardly from the chamber 11 into the throat 12 would have a free oxygen content in the nature of 20%. My invention may readily be so adjusted that the bridge 28, for example, would analyze for free oxygen over an entirely different range than would the bridge 29. Thus the instrument 41 could readily be arranged to indicate the relative fluids and the control be so arranged as to position the damper 18 in proper direction and amount to hold balanced conditions across the throat 12 and prevent intermingling of the fluids between the chambers 10 and 11.

While I have chosen to illustrate and describe a preferred embodiment of my invention it is to be understood that this is by way of example only and is not to be considered as limiting.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The method of operating a fluid heater of the type having an upper and a lower chamber connected by a structurally unobstructed throat of reduced cross-section with fluent gas-pervious heat transfer material in the chambers and throat and having means for controlling the draft through said chambers and throat and provision for substantially continually moving such material by gravity downwardly progressively through the chambers and throat and exteriorly from the lower chamber back to the upper chamber including, supplying hot products of combustion to the upper chamber to heat the material as it passes therethrough, passing a combustible fluid to be heated through the lower chamber in direct contact with the material passing therethrough, continually withdrawing a sample stream of fluid from the throat, continually and separately analyzing the sample fluid to determine the percent free oxygen and the percent combustibles therein, operating the draft controlling means to increase the draft upon a preponderance of oxygen in the throat, and operating the draft controlling means to decrease the draft upon a preponderance of combustibles in the throat.

2. The combination with a fluid heater system having an upper chamber and a lower chamber, a passage forming a throat between said chambers, a fluent gas-pervious mass of solid heat transfer material enclosed by and substantially filling said chambers and throat, means external of said chambers and throat to return the material from an exit in the lower chamber to an inlet to the upper chamber, means supplying hot products of combustion to the upper chamber to heat the material as it passes therethrough, means supplying a combustible fluid to the lower chamber in direct contact with the heated material passing therethrough, means for withdrawing hot products of combustion from the upper chamber, means continually withdrawing a sample stream of fluid from the throat, analyzing apparatus continually and separately analyzing the sample fluid to determine the percent free oxygen and the percent combustible therein, means continually responsive to the determinations of said analyzing apparatus, and damper means regulating the removal of hot products of combustion through said withdrawing means and continually controlled by said responsive means in a direction to prevent transfer of either hot products of combustion or combustible fluid through the throat.

3. The method of operating a fluid heater system of the type having an upper and a lower chamber connected by a structurally unobstructed throat of reduced cross-section with fluent gas-pervious heat transfer material in the

chambers and throat and having means for controlling the draft through said chambers and throat and provision for substantially continually moving such material by gravity downwardly progressively through the chambers and throat and exteriorly from the lower chamber back to the upper chamber including, supplying a fluid heating medium to one of said chambers to heat the material as it passes therethrough, passing a fluid to be heated and of different composition than said heating medium through the other of said chambers in direct contact with the material passing therethrough, continually withdrawing a sample stream of fluid from the throat, continually analyzing the sample stream with respect to the fluid heating medium, continually analyzing the sample stream with respect to the fluid to be heated, operating the draft controlling means to increase the draft upon a preponderance of fluid heating medium in the throat, and operating the draft controlling means to decrease the draft upon a preponderance of the fluid to be heated in the throat.

4. The combination with a fluid heater having an upper chamber and a lower chamber, a passage forming a throat between said chambers, a fluent gas-pervious mass of solid heat transfer material enclosed by and substantially filling said chambers and throat, means external of said chambers and throat to return the material from an exit in the lower chamber to an inlet to the upper chamber, of a fluid heating medium supply for the material in one of said chambers, a supply

of fluid of different composition to be heated and passed through the other of said chambers in direct contact with the heated material therein, means continually withdrawing a sample stream of fluid from the throat, means continually analyzing the sample stream with respect to the fluid heating medium, means continually analyzing the sample stream with respect to the fluid of different composition to be heated, and means continually responsive to the analyses of both said analyzing means, draft regulating means controlling pressures within the chambers and throat and continually controlled by said responsive means in a direction to prevent transfer of either fluid through the throat.

ISAAC HARTER.

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