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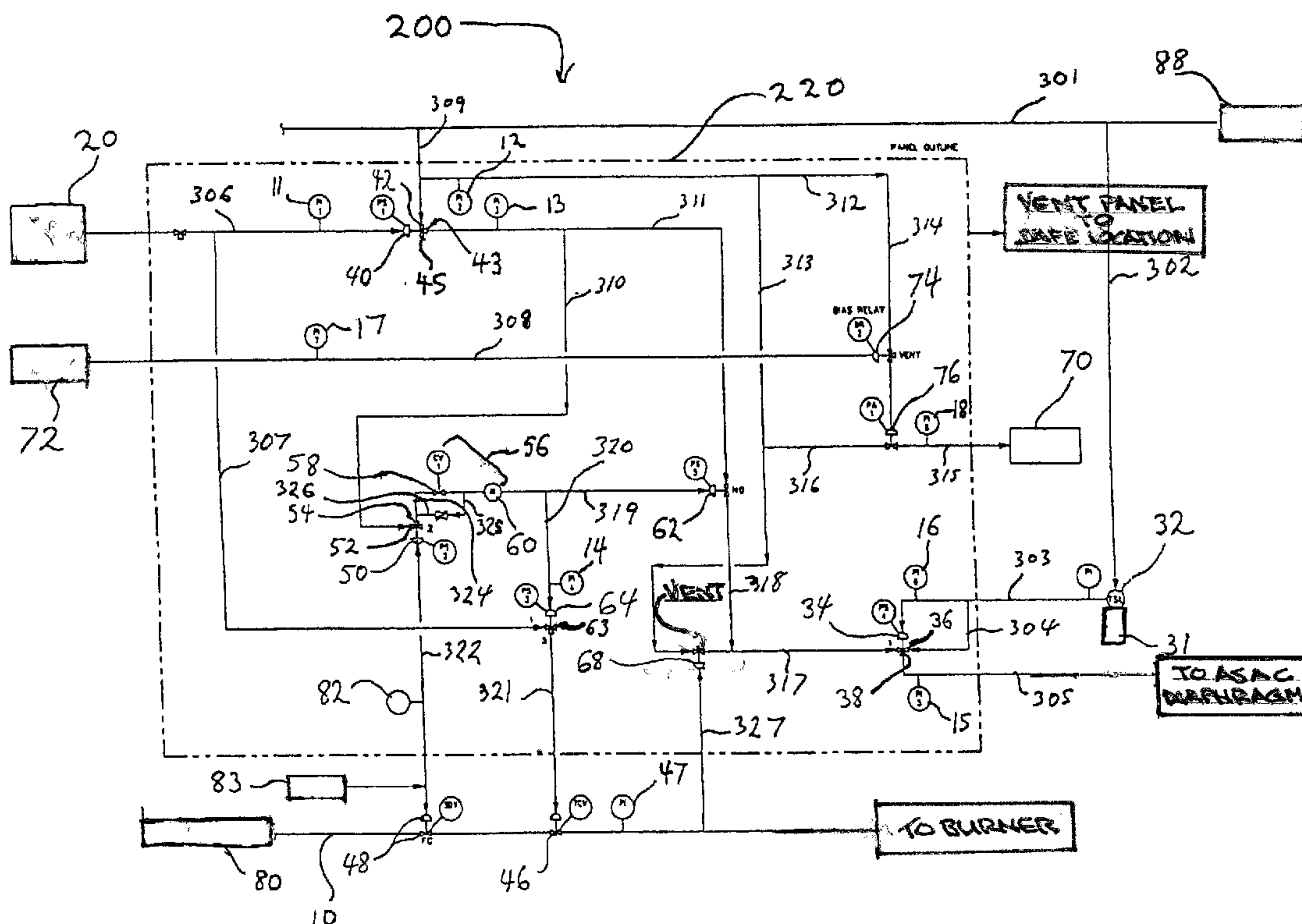
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(54) Titre : COMMANDE D'UN CONTROLEUR D'AIR SECONDAIRE REGLABLE POUR BRULEUR

(54) Title: CONTROL OF AN ADJUSTABLE SECONDARY AIR CONTROLLER FOR A BURNER



(57) Abrégé/Abstract:

The present invention relates to a system and method for controlling a burner's adjustable secondary air controller. Specifically, the system relates to a control logic for the control of an air supply to a burner such as a natural gas burner used in the production and/or processing of liquid and gaseous petroleum products and in natural gas dehydration systems.

**CONTROL OF AN ADJUSTABLE SECONDARY AIR CONTROLLER
FOR A BURNER**

ABSTRACT OF THE DISCLOSURE

- 5 The present invention relates to a system and method for controlling a burner's adjustable secondary air controller. Specifically, the system relates to a control logic for the control of an air supply to a burner such as a natural gas burner used in the production and/or processing of liquid and gaseous petroleum products and in natural gas dehydration systems.

PATENT APPLICATION**CONTROL OF AN ADJUSTABLE SECONDARY AIR CONTROLLER
FOR A BURNER**

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CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to U.S. Patent Application No. 11/064,253, titled "Control of an Adjustable Secondary Air Controller for a Burner", filed February 22, 2005.

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BACKGROUND OF THE INVENTION**Field of the Invention (Technical Field):**

The present invention relates to a system and method for controlling a burner's adjustable secondary air controller. Specifically, the system relates to a control logic for the control of an air supply to a burner such as a natural gas burner used in the production and/or processing of liquid and gaseous petroleum products and in natural gas dehydration systems.

Background Art:

Burners are used for various applications such as, for example, the production and/or processing of liquid and gaseous petroleum products. However, the typical burner with no variable air controller utilizes an excessive amount of air and oxygen, and such use is inefficient and wasteful since that excessive, unnecessary air is heated.

To increase efficiency, the variable air controller described in U.S. Patent No. 4,568,268, was directed to controlling the total air flowing into the burner housing as a function of the pressure of the natural gas supplied to the burner. That air controller regulates the amount of air, and thus the desired 3% to 5% excess oxygen, and achieves a significant savings of fuel gas. In addition to allowing a primary supply of air which is always available, the secondary air controller controls the overall excess oxygen by controlling only a secondary

air flow. Therefore, that air controller allows regulation of the air fuel ratio over the firing range for 3% to 5% of excess air.

However, the air controller of U.S. Patent No. 4,568,268 is prone to several problems.

5 When the burner is at a low firing condition or completely off, many times low stack temperatures, as a result of reducing the air flow in the stack, resulted in stack sweating. Stack sweating was, at times, severe enough to cause water to flow back through the firetube and out of the breech of the flame arrestor. When the burner is off and the secondary air controller is closed, there is insufficient oxygen in the firetube to support firing of the main burners. When
10 the process calls for heat, the main burners will begin firing before the secondary air controller can open creating a lack of oxygen and minor explosions in the firetube. The minor explosions are commonly referred to as "wolfing".

Also, the use of throttling thermostats, which are preferable in many applications, can
15 create firing problems when the heat requirements for the process are low and the gas pressure to the burner is below the pressure required to create the gas velocity needed to properly draw and mix the primary air in the burner venture.

It is also difficult to adjust that air controller. Adjustment of the secondary air controller
20 involves a trial and error changing of the compression springs which oppose the movement of the diaphragm on the secondary air controller. Differences in firetube size, altitude, gas composition, etc. requires adjustment of the secondary air controller. The adjustment entails firing the burner and analyzing the stack gases. If the stack gases do not meet the requirements, the burners are shut down, the compression springs are changed, the burner is
25 relit, and the stack gases are again analyzed. The process of firing analyzing and changing compression springs is continued until the right composition of stack gases is obtained. Getting the correct compressions springs installed has proven to be, at times, a long and difficult task.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a system for controlling a secondary air controller of a heating apparatus comprising a control logic for controlling flow of fuel to the heating apparatus and controlling the opening of a valve of the secondary air controller. An embodiment of the control logic preferably comprises a plurality of lines for communicating signals, a plurality of relays connected to the lines, and at least one controller to send a pressure signal to the relays, and the relays activate the flow of fuel and the opening of a valve of the secondary air controller.

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The control logic preferably further comprises a permission start control linking at least one fuel valve and at least one relay. The system preferably comprises a stack temperature control linked to the valve of the secondary air controller. The system preferably comprises a biasing relay providing adjustment to regulate pressure to a diaphragm of the secondary air controller. The system preferably comprises a trimming air control valve to control introduction of air into a fire tube of the heating apparatus. The trimming air control valve is preferably linked to an accumulator and responds to an increase in pressure within the accumulator.

The present invention also provides a system for controlling a secondary air controller of a heating apparatus comprising a control logic for controlling flow of fuel to the heating apparatus and controlling the opening of a valve of the secondary air controller, said control logic comprising a plurality of lines for communicating signals, a plurality of relays connected to the lines to activate the flow of fuel, at least one controller to send a pressure signal to the relays, a temperature control valve in communication with the controller(s) to receive a pressure signal from the controller(s), and a biasing relay in communication with the temperature control valve to vent pressure on the secondary air controller and control the opening of a valve of the secondary air controller.

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The present invention also provides a method for controlling a secondary air controller of a heating apparatus comprising the steps of controlling flow of fuel to the heating apparatus via a control logic and controlling opening of a valve of the secondary air controller via the control logic. The method also comprises the control logic communicating signals via a
5 plurality of lines, connecting a plurality of relays to the lines, controlling the flow of fuel and the opening of a valve of the secondary air controller via the relays and the lines, and sending a pressure signal to the relays via at least one controller.

The method further comprises providing a permission start control and linking at least
10 one fuel valve and at least one relay with the permission to start control. The method also preferably comprises providing a stack temperature control, and linking the stack temperature control to the valve of the secondary air controller. The method preferably comprises adjusting and regulating pressure to a diaphragm of the secondary air controller via a biasing relay.

15 The method preferably comprises providing a trimming air control valve and controlling introduction of air into a fire tube of the heating apparatus. Preferably, the method comprises linking an accumulator to the trimming air control valve and sending a pressure signal from the accumulator to the trimming air control valve.

20 The invention also provides a method for controlling a secondary air controller of a heating apparatus via a control logic to control a flow of fuel to the heating apparatus and to control opening of a valve of the secondary air controller, said method comprising communicating signals via a plurality of lines, connecting a plurality of relays to the lines, controlling the flow of fuel via the relays and the lines, sending a pressure signal to the relays
25 via at least one controller, sending a pressure signal to a temperature control valve via the at least one controller, sending a pressure signal to a biasing relay via the temperature control valve, and venting pressure on the secondary air controller via the biasing relay to control the opening of a valve of the secondary air controller.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

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The accompanying drawings, which are incorporated into and form a part of the specification, illustrate one or more embodiments of the present invention and, together with the description, serve to explain the principles of the invention. The drawings are only for the purpose of illustrating one or more preferred embodiments of the invention and are not to be construed as limiting the invention. In the drawings:

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Fig. 1 is an elevational, schematic view of a typical burner heating system described in U.S. Patent No. 4,568,268;

Fig. 2 is a cross-sectional view taken along the line 2---2 of Fig. 1;

Fig. 3 is an enlarged, cross-sectional view of the variable air controller of U.S. Patent No. 4,568,268;

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Fig. 4 is a schematic of a control logic of an embodiment of the present invention;

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Fig. 5 is an enlarged cross-sectional view of a mechanically adjustable embodiment of a variable air controller of the present invention; and

Fig. 6 is a schematic of a control logic of an embodiment of the present invention wherein an air control valve responds to a biasing relay.

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DETAILED DESCRIPTION OF THE INVENTION

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides a system and method for controlling a burner's adjustable secondary air controller. Specifically, the system comprises a control. The present invention may be used in any burner wherein the control of an air supply to the burner as described herein is desired. Such burners include, but are not limited to, natural gas burners used in the production and/or processing of liquid and gaseous petroleum products.

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As used herein, the terms "a", "an", and "the" mean one or more.

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A non-limiting embodiment of the invention comprises a control logic to: (1) ensure that the burner gas supply closes when the burner gas pressure lowers to a predetermined pressure and does not open again until the burner gas supply pressure rises above the predetermined pressure or higher; (2) ensure that the air controller is open before the main burners begin firing; and (3) prevent stack temperatures from getting low enough to create stack sweating.

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While the present invention may be used in connection with a burner in various types of uses, for purposes of illustration only the following discussion incorporates the burner and air controller described in U.S. Patent No. 4,568,268.

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Referring to Fig. 1, the invention of U.S. Patent No. 4,568,268 is directed to a heating apparatus such as burner **110** comprising a housing **120** with atmospheric air inlet **122**, preferably including a flame arrestor **124**, which is covered by a hood **126** for keeping out

debris and/or snow. Baffle **130** in housing **120** separates housing **120** into primary air inlet chamber **132** and combustion chamber **134**. Main burner **136** and pilot burner **138** extend through baffle **130**. Main burner **136** and pilot burner **138** each includes a metering device such as venturis **140** and **142** for mixing air and fuel and metering devices **140** and **142** are
 5 positioned in primary air inlet chamber **132**. Main burner **136** and pilot burner **138** each includes burner tips **144** and **146** which are positioned in combustion chamber **134**. Therefore, primary air enters combustion chamber **134** and is mixed with the fuel by the metering devices and provides a flame at main burner **136** and pilot burner **138**. In addition, adjustable secondary air controller **170** is provided for controlling secondary air so as to optimize the air
 10 fuel ratio. Secondary air controller **170** comprises valve **172** positioned between ambient air and combustion chamber **134**, and a fuel pressure responsive means such as diaphragm **196** is connected to valve **172** for controlling the amount of secondary air in response to fuel pressure.

15 Fuel gas is supplied to the main burner venturi **140** by line **148** from on-off valve **150** from motor valve **149**. Motor valve **149** automatically regulates the flow of gas to main burner **138** in response to the control of a pneumatic thermostat **152** from a line **154**. Gas supply pressure is supplied to thermostat **152** through line **156** which also supplied to burners **136** and **138**. Gas for pilot burner **138** is supplied by line **158** through manual on-off valve **160** provided
 20 to allow shut-down of pilot **138** when the system is not in operation or to control the gas when pilot **138** is being lighted. Thermostat **152** and motor valve main burner valve **149** may be of either the on-off (snap) type or the throttling type.

Referring to Fig. 2, to regulate the air fuel ratio over the firing range of the burner
 25 between 3% to 5% of excess oxygen, secondary air is supplied to combustion chamber **134** through variable air controller **170**. Variable air controller **170** is positioned between ambient air and combustion chamber **134** of the burner and is preferably positioned between primary inlet air chamber **132** and the combustion chamber **134** although air controller **170** may receive air in other ways. Air controller **170** includes valve element **172** which is connected to any

suitable fuel pressure responsive means **174** for controlling the amount of secondary air supplied to combustion chamber **134** in response to the fuel pressure. Thus, pressure responsive means **174** may be connected to line **176** which in turn is connected to fuel line **148**.

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Air controller **170** of U.S Patent No. 4,568,268 is shown in more detail in Fig. 3. Air controller **170** automatically adjusts and controls the secondary supply of air flow to achieve the desired excess oxygen amount. Air controller **170** includes body **180** comprising variable size opening **182**. Body **180** includes wall **181** which increases in size from a first end **184** to a second end **186** and is preferably tapered. Valve **172**, such as a circular plate, is movable in opening **182** for changing the area of gap **183** between wall **181** and the outer edge of plate **172**. Preferably, there is an air bypass in plate **172**, such as leaving a minimum area open in gap **183**, at all times which provides a minimum amount of air flow through air controller **170**.

Plate **172** is mounted on a movable rod **188** which is slidable through well **189** of body **180** and secured to wall **190**. Suitable biasing means such as one or more springs **192** and **194** are provided between walls **189** and **190** for yieldably urging plate **172** in a direction for reducing the volume of air flow through opening **182**. Pressure responsive means, such as a diaphragm **196**, is provided in housing **189** and on wall **190** and connected to valve **172** for moving valve **172** in a direction for increasing the volume of air in response to an increase in the pressure of the fuel. Diaphragm **196** is exposed to a port **198** which is connected to line **176**. Therefore, increased pressure fuel acts on diaphragm **196** to move valve **182** towards second end **186** of tapered body **180** for increasing the annular area and increasing the volume of air. The area of valve opening **182** is varied approximately linearly with the pressurized fuel gas.

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Additional secondary air for pilot burner **146** enters combustion chamber **134** through opening **164**. Adjustment plate **162** provides a minimum area of opening consistent with stable

burning of pilot burner **146** and to provide good lighting of the fuel air mixture at main burner tip **144** when main burner **136** is turned on.

When main burner **136** is turned on, additional secondary air is now required for
 5 complete combustion and to achieve the desired 3% to 5% excess oxygen. Therefore, valve element **172** in air controller **170** opens and closes in proportion to the fuel gas pressure supplied to main burner **136** to achieve this desired result.

Referring to Fig. 4, control logic **200** of an embodiment of the present invention
 10 overcomes the problems of sweating, lack of oxygen when the burner comes on, and low firing pressure. Control logic **200** also preferably provides for adjustment of secondary air controller **170**. Control logic **200** preferably comprises control panel **220**. Preferably, lines for communicating pressure signals, such as, but not limited to, lines **301-327**, are provided which form connections between relays and other components of the system. Preferably, pressure
 15 gauges, **11-18**, are also provided and disposed along lines **301-327**. Instrument air or gas source **88** may be utilized to provide air or gas to control logic **200**. If source **88** is utilized, control panel **220** is preferably vented to a safe location (not shown).

In an embodiment, control panel **220** comprises a permission to start control feature **83**.
 20 Control panel **220** preferably comprises at least one alarm **82** that informs an operator of any type of failure in the burner firing system (e.g., that the pilot light is no longer burning). When control panel **220** senses some type of alarm condition in the firing system, control panel **220** preferably shuts the firing system down until the problem or problems causing activation of alarm **82** have been corrected, and a permission to start signal has been sent to burner **110**
 25 and/or control logic **200**. For example, once the pilot light (not shown) is relit, the operator can clear the alarm but the burner system will not restart until a permission to start signal has been sent to burner **110** and/or control logic **200**.

Alarm **82** preferably vents the pressure signal shown as permission to start and causes

valve **48** to close thereby stopping the flow of fuel to the burner and causing three-way pressure relay **50** to shift thereby venting the supply pressure so temperature control valve **46** cannot open. Also, normally opened pressure relay **62** is opened sending a pressure signal to fully open secondary air control valve **172** (shown in Fig. 3). Opening air control valve **172**
 5 purges fire tube **114** (shown in Fig. 1) and establishes conditions where the pilot light (not shown) can be safely relit.

In an embodiment, during cold start, air control valve **172** will preferably be wide open as throttling thermostat stack low temperature control **32** is cold and outputting a maximum
 10 signal of preferably between approximately 20 and 25 psig to relay **34**. Relay **34** preferably communicates from thermostat stack low temperature control **32** to air control valve **172** via ports **36** and **38**.

Process temperature controller **20** may be of any type known in the art and may
 15 include, but is not limited to, a throttling thermostat. When temperature controller **20** requests heat, output from temperature controller **20** at a signal of preferably between approximately 20 and 25 psig preferably goes to the diaphragm (not shown) of relay **40** which is adjusted to communicate ports **42** and **44** when the pressure on burner manifold **80** is greater than the minimum burner firing pressure. The firing pressure is preferably indicated by burner fuel
 20 manifold gauge **47** preferably located downstream of temperature control valve **46**. Relay **40**, and other relays described herein, may be of any type known in the art capable of communicating pressure signals and may include, but are not limited to, snap acting switches.

Assuming that burners **136** and **138** (shown in Fig. 1) have a permission to start, valve
 25 **48** is preferably open and ports **52** and **54** of snap acting, start permission relay **50** are in communication. Output from snap acting relay **40** preferably activates time delay relay **56**, which preferably comprises valve **58** and reservoir **60** through open ports **52** and **54** of start permission relay **50**.

Time delay relay **56** preferably allows purging of combustion chamber **134** prior to introduction of fuel to burners **136** and **138**. The length of the purge time may be altered by adjustment of valve **58**. Valve **58** also preferably comprises an orifice check valve to rapidly vent the lines downstream of valve **58** when start permission relay **50** is vented.

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When time delay relay **56** times out, pressure from start permission relay **50** will preferably close relay **62** and activate relay **64** to allow pressure to the diaphragm (not shown) of temperature control valve **46**. Fuel will then flow to burners **136** and **138**. Because secondary air controller valve **172** is preferably fully open, there is adequate oxygen to support combustion without "wolfing".

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Thermostat stack low temperature control **32** will preferably remain in control of air control valve **172** until thermostat stack low temperature control **32** is satisfied and relay **34** preferably switches ports to allow fuel manifold pressure to control air control valve **172** through bias relay **68**. Bias relay **68** is preferably adjusted to compensate for fuel conditions including, but not limited to, heat content, site altitude, and stack draft. The adjustment will preferably regulate pressure to air control valve diaphragm **196** (shown in Fig. 3) to provide excess oxygen in the stack exhaust of 2 to 5% across the entire firing range.

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Without changing the design of the air control valve **172**, biasing relay **68** can be used to overcome the problem of adjusting air control valve **172** to allow for different operating conditions such as altitude, gas composition, stack height, etc. Biasing relay **68** is an apparatus that either increases or decreases a pressure signal and the magnitude of the increase or decrease in the pressure signal can be adjusted. Once the magnitude of the pressure increase or decrease has been set, the magnitude stays fixed until it is manually changed. For example, a burner unit that is firing without enough excess air indicates that springs **192** and **194**, which resist the opening of air control valve opening **172**, are exerting too great a force against the force created by diaphragm **196** of air control valve **172**. The volume of secondary air flowing to burner **110** can be increased by adjusting biasing relay **68** to

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increase the pressure signal to diaphragm **196** of air control valve **172** thereby increasing the force exerted by diaphragm **196** against the force created by springs **192** and **194** further opening air control valve **172**. The magnitude of the increase in force generated by diaphragm **196** would then remain constant throughout the firing pressure range of burner **110**.

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Referring to Fig. 4, the diaphragm (not shown) of biasing relay **68** is preferably connected to line **10** that supplies fuel to burner **110**. Preferably, at all times biasing relay **68** is sensing the fuel pressure going to burner **110**. If the amount of secondary air going to burner **110** must be increased or decreased, biasing relay **68** can be adjusted to change the magnitude of the pressure signal going to diaphragm **196** of air control valve **172** thereby either increasing or decreasing air control valve opening **182** in response to burner firing pressure.

Preferably, the embodiment provides for a "warm shutdown". Generally, as process temperature is satisfied (i.e., when the heat output of fire tube **114** exceeds the heat required by the process utilizing burner **110**) burners **136** and **138** are turned off at a preset minimum pressure to avoid pressure fluctuations and noise from low fuel pressure to burners **136** and **138**. When process temperature controller **20** is satisfied, output to relay **40** and relay **64** declines. When the declining fuel pressure in manifold **80** reaches 1 to 2 psig (or at whatever point burner firing inconsistency occurs), temperature control valve **46** preferably will close as pressure to the diaphragm (not shown) of relay **64** will vent via port **45** of relay **40** (via relay **50**). In turn, pressure to the diaphragm (not shown) of temperature control valve **46** will preferably vent through port **63** of relay **64**. Relay **62** then preferably returns to its normally open position.

Air control valve **172** then preferably returns to its normally closed position – slightly open at the zero position. For all practical purposes, air flow through idle combustion chamber **134** is now blocked.

Following warm shutdown, startup from idle mode (burners off, process warm) preferably proceeds as follows. As process temperature controller **20** requests heat, output from temperature controller **20** goes to the diaphragm (not shown) of relay **40** which is adjusted to communicate ports **42** and **44** when the pressure on burner manifold **80** is greater than the
5 minimum burner firing pressure. Firing pressure is indicated by burner fuel manifold gauge **47** located downstream of temperature control valve **46**.

Assuming that the burners have a permission to start, valve **48** is preferably open and ports **52** and **54** of start permission relay **50** are preferably in communication. Output from
10 relay **40** preferably activates time delay relay **56** through open ports **52** and **54** of start permission relay **50**.

Time delay relay **56** preferably allows purging of the combustion chamber prior to introduction of fuel to the burners. The length of the purge time may be altered by adjustment
15 of valve **58**.

When time delay relay **56** times out, pressure from start permission relay **50** will preferably close relay **62** and preferably activate relay **64** to allow pressure to the diaphragm (not shown) of temperature control valve **46**. Fuel will then flow to the burners.

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Air control valve **172** then preferably responds to pressure via relay **62** and relay **66**, to put fully open air control valve **172** into purge mode in anticipation of burner ignition. As time delay relay **56** times out, the process preferably reverts to normal operation through bias relay **68**.

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The preferred embodiment of the present invention also prevents stack **31** from sweating during long idle periods. If the burner system is idle (i.e., no heat is required by the process), and low stack temperature is detected, thermostat stack low temperature control **32** preferably outputs pressure to relay **34** and air control valve **172** will preferably open in

response to thermostat stack low temperature control **32**. Wide open air control valve **172** will allow air flow to warm stack **31** to prevent sweating by removing heat from the process until process temperature controller **20** detects low process temperatures and begins controlling to initiate the cold start sequence described above.

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The preferred embodiment of the present invention also preferably provides for emergency shutdown and restart of burner **110**. If burner shutdown valve **48** activates, fuel to the burners is interrupted and start permission relay **50** will close and vent the signal to time delay relay **56** and the diaphragms (not shown) of relay **64** and relay **62**. Loss of a permission
10 signal will preferably close temperature control valve **46**. Pressure flows to air control valve **172** via relay **62** and relay **66**. This pressure preferably drives air control valve **172** to full open position and initiates purging of combustion chamber **34**. When the problem causing the shutdown is rectified, burner shutdown valve **48** and start permission relay **50** will preferably reopen and startup will commence for cold startup or startup from idle as described above,
15 depending on the temperature of stack **31** at the time of startup.

In some applications involving a natural gas dehydrator, the volume of gas recovered by the dehydration process will be insufficient to provide all the fuel required for a reboiler, but in other cases the volume of gas recovered by the process will exceed 60% or more of the fuel
20 required for the reboiler. Utilizing a secondary air controller **170** on a natural gas dehydrator can increase firing efficiency of the reboiler to such an extent that the volume of gas recovered by the process exceeds the volume of fuel required to fire the reboiler, and the excess volume of recovered gas must then be used for other applications or else vented. Therefore, to control the efficiency in combustion chamber **134** so that excess fuel recovered is completely
25 consumed, trimming air control valve **70** is preferably provided as shown in Fig. 4.

Preferably, trimming air control valve is disposed on the same baffle **130** that holds the other air control valves and trimming air control valve **70** is preferably of the same design as the other air control valves. However, the pressure signal to the diaphragm (not shown) of

trimming air control valve **70** is supplied by biasing relay; **74** rather than by biasing relay **68** which sends the pressure signals to the other air control valves located on the baffle.

Typically, on a natural gas dehydrator, the gas recovery system is designed to operate
5 at between approximately 15 and 28 psig. As long as the volume of gas recovered by natural gas dehydration process does not exceed the volume of gas required to fire burner **110**, the pressure in the recovered gas system will remain at the set pressure (e.g., between approximately 15 and 18 psig) for make-up fuel to begin feeding into the fuel system. If the installation of air controller **172** causes the volume of gas recovered by the natural gas
10 dehydration process to exceed the volume of gas required to fire burner **110**, pressure will begin to rise in the recovered gas system. If the volume of recovered gas is enough to fire burner **110** and still cause the pressure in the recovered gas system to rise to, for example, approximately 28 psig, excess gas will be vented.

15 To prevent the pressure in the recovered gas system from reaching 28 psig, excess fuel is preferably accumulated in accumulator **72** comprising a reservoir such as, for example, a pressure tank. The normal operating pressure of accumulator **72** is preferably approximately 15 psig.

20 Preferably, in operation, there is a signal to the diaphragm (not shown) of biasing relay **74** or other type adjustable, throttling pressure pilot coming from accumulator **72**. At a set point of preferably between approximately 18 and 23 psig, more preferably between approximately 18 and 20 psig pressure in accumulator **72**, biasing relay **74** preferably sends a pressure signal to multiplying relay **76**. Multiplying relay **76** preferably sends a pressure signal to the
25 diaphragm (not shown) of trimming air control valve **70** thereby opening trimming air control valve **70**. Multiplying relay **76** preferably multiplies the signal output of biasing relay **74** by as much as six times or as necessary to provide adequate pressure to open trimming air control valve **70**. As trimming air control valve **70** opens, additional air is admitted into fire tube **114** thereby decreasing firing efficiency and causing burner **110** to begin consuming the

accumulated fuel. Opening trimming air control valve **70** introduces excess secondary air into fire tube **114** thereby decreasing firing efficiency and causing burner **110** to begin consuming more fuel. Preferably, multiplying relay **76** amplifies pressure from accumulator **72** above the set point pressure to obtain a quick response of trimming air control valve **70**. Preferably, the
5 pressure rise in accumulator **72** is limited to from between approximately 1 and 5 psi above the set point.

When the excess fuel in accumulator **72** is consumed and the pressure in accumulator **72** decreases to the set point (e.g., 18 psig) or less, biasing relay **74** and multiplying relay **76**
10 preferably vent the pressure from the diaphragm (not shown) of trimming air control valve **70**, and trimming air control valve **70** closes. When trimming air control valve **70** closes, air controller **170** returns to normal operation.

In another embodiment, shown in Fig. 5, the invention may comprise secondary air
15 controller **90** that may be utilized in lieu of biasing relay **68** for adjustment purposes. Secondary air controller **90** preferably comprises tension springs **91** that oppose the movement of diaphragm **92** on secondary air controller **90**. This provides, without disassembly of the diaphragm case, for adjustment of the spring tension by simply rotating bolt **93** thus changing the force exerted against diaphragm **92**. Bolt **93** is preferably connected to plate **94** which is
20 preferably connected at the top to springs **91**. Springs **91** are preferably connected at the bottom to plate **95**. Plate **95** is preferably connected to resist the downward movement of diaphragm **92**. Without disassembly or shutting off burner **110**, the amount of secondary air induced into fire tube **114** can be adjusted, in a real time mode, by preferably turning bolt **93** either clock wise or counter-clock wise to decrease or increase the tension in springs **91**.

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Another embodiment of the present invention is applicable for use on smaller dehydrators, heaters, and other production equipment where utilization of all features described above may not be economically warranted, but where significant fuel savings may be realized.

The majority of firetube applications in the oil and gas industry are typically small wellhead separators, treaters, dehydrators, and heaters. Most of this equipment requires smaller amounts of heat for the process – generally less than 500,000 BTU per hour and frequently less than 100,000 BTU per hour. For these smaller applications, a full adjustable secondary air controller system, as described above, may be considered to be too complicated and/or too expensive. But because such a system may still provide for more economical processing of gas, the following described embodiment is applicable.

Thus, the following embodiment preferably addresses only the issues of fuel economy, stack sweating during low firing and off periods, and adjustment for fuel content, altitude, and stack draft. In this embodiment, the adjustable secondary air controller housing, burner, pilot and air control valve are constructed in a fashion similar to that shown in Fig. 1. However, the air control valve will respond to the an output from a biasing relay and low temperature thermostat as described below and as shown in Fig. 6.

Referring to Fig. 6, control logic **400** overcomes the problems of sweating and provides for adjustment of secondary air controller **172** (shown in Fig. 3). Preferably, lines for communicating pressure signals, such as, but not limited to, lines **401 - 410**, are provided which form connections between relays and other components of the system. Preferably, pressure gauges, **411- 414**, are also provided and disposed along lines **401- 410**. Instrument air or gas source **419** may be utilized to provide air or gas to control logic **400**.

Control logic **400** may comprise at least one alarm **420** that senses a problem with the burner or the process (for example, that the pilot light is no longer burning), and interrupts the control signal to temperature control valve **415** which shuts the firing system down until the problem or problems causing activation of the alarm(s) have been corrected. For example, once the pilot light (not shown) is relit, the operator can clear the alarm and the adjustable secondary air controller / burner system will restart.

Alarm **420** preferably vents the pressure signal through line **401** and causes valve **415** to close thereby stopping the flow of fuel to the burner and returning air control valve **172** (shown in Fig. 3) to its idle position. At idle position, air control valve **172** is slightly open to
5 allow enough air flow to permit the pilot light (not shown) to be safely relit.

Preferably, during cold start, air control valve **172** will be wide open as throttling thermostat stack low temperature control **417** is cold and outputting a maximum signal of preferably between approximately 20 and 25 psig to relay **418**. Relay **418** communicates from
10 thermostat stack low temperature control **417** to air control valve **172** via ports **422** and **423**. Relay **418**, and other relays described herein, may be of any type known in the art capable of communicating pressure signals and may include, but are not limited to, snap acting switches.

Process temperature controller **20** (previously described) may be of any type known in
15 the art and may include, but is not limited to, a throttling thermostat. Assuming the pilot is established and alarm(s) **420** is in a permissive position, when temperature controller **20** requests heat, output from temperature controller **20** at a signal of preferably between approximately 20 and 25 psig goes to the diaphragm (not shown) of valve **415** via line **401** to permit pressure on burner manifold **404**. The firing pressure is indicated by burner fuel
20 manifold gauge **411** preferably located downstream of temperature control valve **415**.

Assuming that burner **136** (shown in Fig. 1) has a permission to start via alarm(s) **420**, valve **415** is open and fuel will flow to burner **136**. Because secondary air controller valve **172** is fully open, there is adequate oxygen to support combustion without "wolfing".
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Preferably, thermostat stack low temperature control **417** will remain in control of air control valve **172** until thermostat stack low temperature control **417** reaches its low set point (usually in the range of approximately 300 to 400 degrees F) and relay **418** switches ports to allow fuel manifold pressure to control air control valve **172** through bias relay **416**. Preferably,

bias relay **416** is adjusted to compensate for fuel conditions including, but not limited to, heat content, site altitude, and stack draft. The adjustment regulates pressure to air control valve diaphragm **196** (shown in Fig. 3) to provide excess oxygen in the stack exhaust of approximately 2 to 5% across the entire firing range.

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Without changing the design of air control valve **172**, biasing relay **416** can be used to overcome the problem of adjusting air control valve **172** to allow for different operating conditions such as altitude, gas composition, stack height, etc. Preferably biasing relay **416** is an apparatus that either increases or decreases a pressure signal, and the magnitude of the increase or decrease in the pressure signal can be adjusted. Once the magnitude of the pressure increase or decrease has been set, the magnitude stays fixed until it is manually changed. For example, a burner unit that is firing without enough excess air indicates that springs **192** and **194** (shown in Fig. 3), which resist the opening of air control valve opening **172**, are exerting too great a force against the force created by diaphragm **196** of air control valve **172**. The volume of secondary air flowing to burner **110** can be increased by adjusting biasing relay **416** to increase the pressure signal to diaphragm **196** of air control valve **172** thereby increasing the force exerted by diaphragm **196** against the force created by springs **192** and **194** further opening air control valve **172**. The magnitude of the increase in force generated by diaphragm **196** would then remain constant throughout the firing pressure range of burner **110**.

Referring to Fig. 6, the diaphragm (not shown) of biasing relay **416** is preferably connected to line **404** that supplies fuel to burner **110**. Preferably, at all times, biasing relay **416** senses the fuel pressure going to burner **110**. If the amount of secondary air going to burner **110** must be increased or decreased, biasing relay **416** can be adjusted to change the magnitude of the pressure signal going to diaphragm **196** of air control valve **172** thereby either increasing or decreasing air control valve opening **182** in response to burner firing pressure.

This embodiment provides for a "warm shutdown". Generally, as process temperature

is satisfied (i.e., when the heat output of fire tube **114** exceeds the heat required by the process utilizing burner **110**) burner **136** is turned off. When process temperature controller **20** is satisfied, output to alarm(s) **420** and temperature control valve **415** declines. As the output pressure from the process temperature controller **20** declines, temperature control valve **415** will close, and biasing relay **416** will revert to its normal position and vent the pressure on the air control valve diaphragm **92** (shown in Fig. 5) via vent ports **424** and **425**.

Air control valve **172** then returns to its normally closed position – slightly open at the zero position. For all practical purposes, air flow through idle combustion chamber **134** is now blocked.

Following warm shutdown, startup from idle mode (burners off, process warm) preferably proceeds as follows. As process temperature controller **20** requests heat, output from temperature controller **20** goes to alarm(s) **420** and to the temperature control valve **415**.

Assuming that the burner has a permission to start, alarm(s) **420** is in a permissive mode, and the control signal from process temperature controller **20** is communicated to the diaphragm of temperature control valve **415**. Fuel will then flow to the burner.

This embodiment also prevents stack **31** from sweating during long idle periods. Preferably, if the burner system is idle (i.e., no heat is required by the process), and low stack temperature is detected, thermostat stack low temperature control **417** outputs pressure to relay **418**, and air control valve **172** will open in response to thermostat stack low temperature control **417**. Opening air control valve **172** allows air flow to warm stack **31** to prevent sweating by removing heat from the process until process temperature controller **20** detects low process temperatures and begins controlling to initiate the cold start sequence described above.

Preferably, this embodiment also provides for emergency shutdown and restart of burner **110**. If alarm(s) **420** activates, temperature control valve **415** will close and fuel to the

burner is interrupted, biasing relay **416** vents pressure from the air control valve diaphragm **92** (shown in Fig.5), and air control valve **172** returns to its idle position. When the problem causing the shutdown is rectified, alarm(s) **420** allows pressure to the diaphragm of temperature control valve **415** and startup will commence for cold startup or startup from idle
5 as described above, depending on the temperature of stack **31** at the time of startup.

This embodiment is useable in concert with the trimming control valve as shown in Fig. 4 and whose function and design are described above.

10 The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

Although the invention has been described in detail with particular reference to the
15 preferred embodiments in the attachment, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover all such modifications and equivalents.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

- 5 1. A method for controlling a secondary air controller of a heating apparatus comprising: providing a pneumatic control circuit, the control circuit pneumatically adjusting the secondary air controller into an open position for a delayed period of time prior to a fuel being provided to a burner of the heating apparatus; permitting ignition of the heating apparatus only when a pneumatic start permission relay signal is received; and pneumatically adjusting a position of the secondary air controller based on a
 - 10 pressure of the fuel supplied to a burner of the heating apparatus and based on an output of a pneumatically adjustable biasing relay pneumatically connected to the secondary air controller, the biasing relay increasing or decreasing a signal pressure to a diaphragm of the secondary air controller.
- 15 2. The method of claim 1 wherein providing the pneumatic control circuit further comprises connecting and operating the pneumatic control circuit with a fuel gas source.
3. The method of claim 1 further comprising: providing a stack temperature control; pneumatically linking the stack temperature control to the pneumatic control circuit; and maintaining a temperature
 - 20 of stack gases to prevent sweating.
4. The method of claim 1 wherein the secondary air controller comprises an adjustable spring-loaded biasing component.
- 25 5. The method of claim 1 further comprising providing a trimming air control valve and controlling introduction of only secondary combustion air into a fire tube of the heating apparatus.
6. A system for controlling secondary air to a heating apparatus comprising: a secondary air controller, said secondary air controller comprising: a valve; a diaphragm in communication with
 - 30 said valve; a thermostat; and pneumatic control logic, said logic comprising a pneumatic start permission relay and a pneumatic adjustable biasing relay pneumatically connected to said diaphragm of said secondary air controller said biasing relay increasing or decreasing a signal pressure to said diaphragm.
- 35 7. The system of claim 6 wherein said pneumatic control logic further comprises at least one relay which activates a flow of pressurized fuel to the heating apparatus.

8. The system of claim 7 wherein said pneumatic control logic links at least one fuel valve and at
5 least one pneumatic relay.

9. The system of claim 6 further comprising a stack temperature control linked to said valve of said
secondary air controller maintaining a temperature of stack gases for the prevention of sweating.

10 10. The system of claim 6 wherein said pneumatic control logic is operated by a fuel gas.

11. The system of claim 6 further comprising a trimming air control valve to control introduction of
secondary combustion air into a fire tube of the heating apparatus.

15 12. The system of claim 11 wherein said trimming air control valve is in pneumatic communication
with a pressure going to a burner of the heating apparatus.

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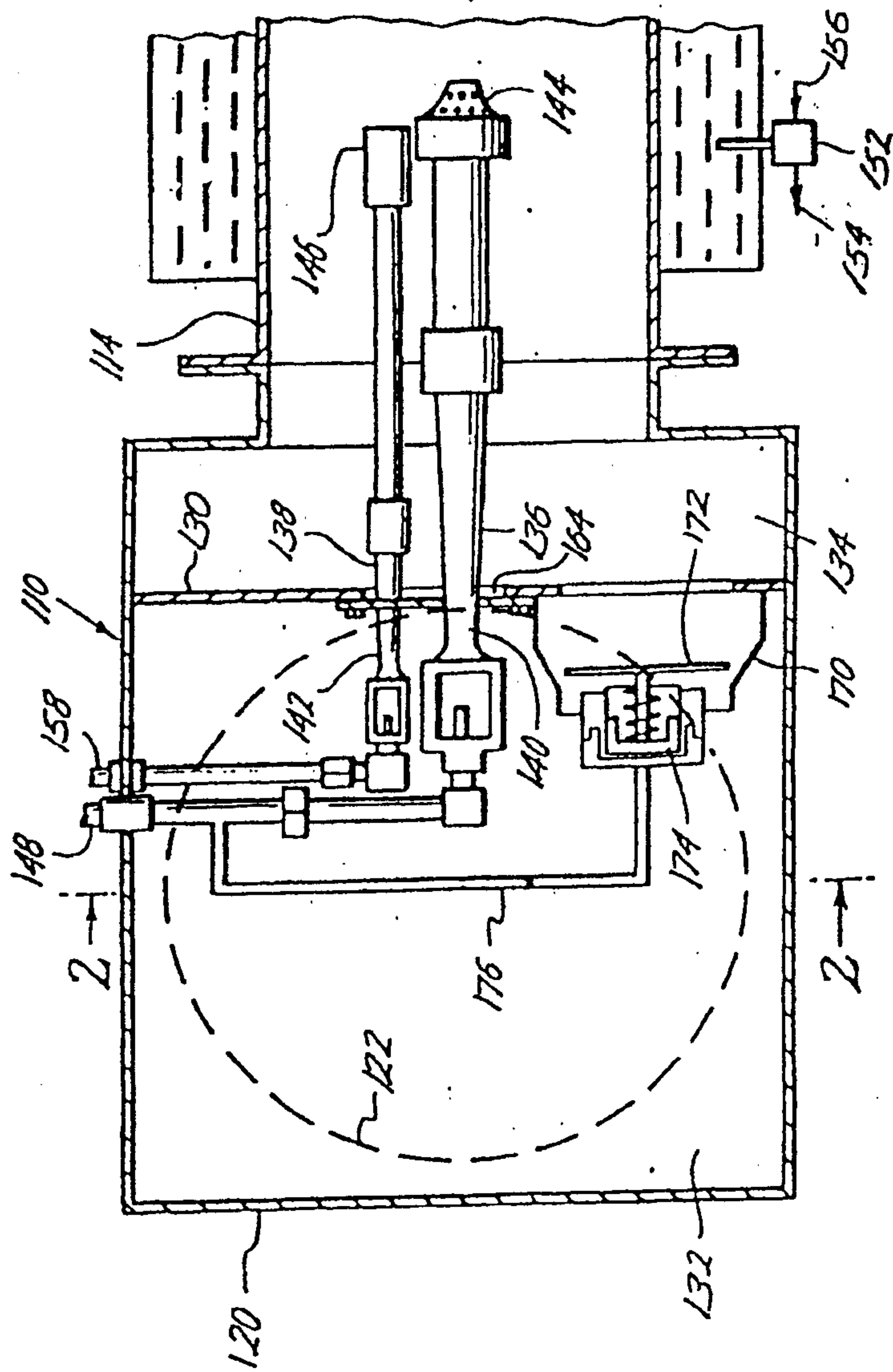
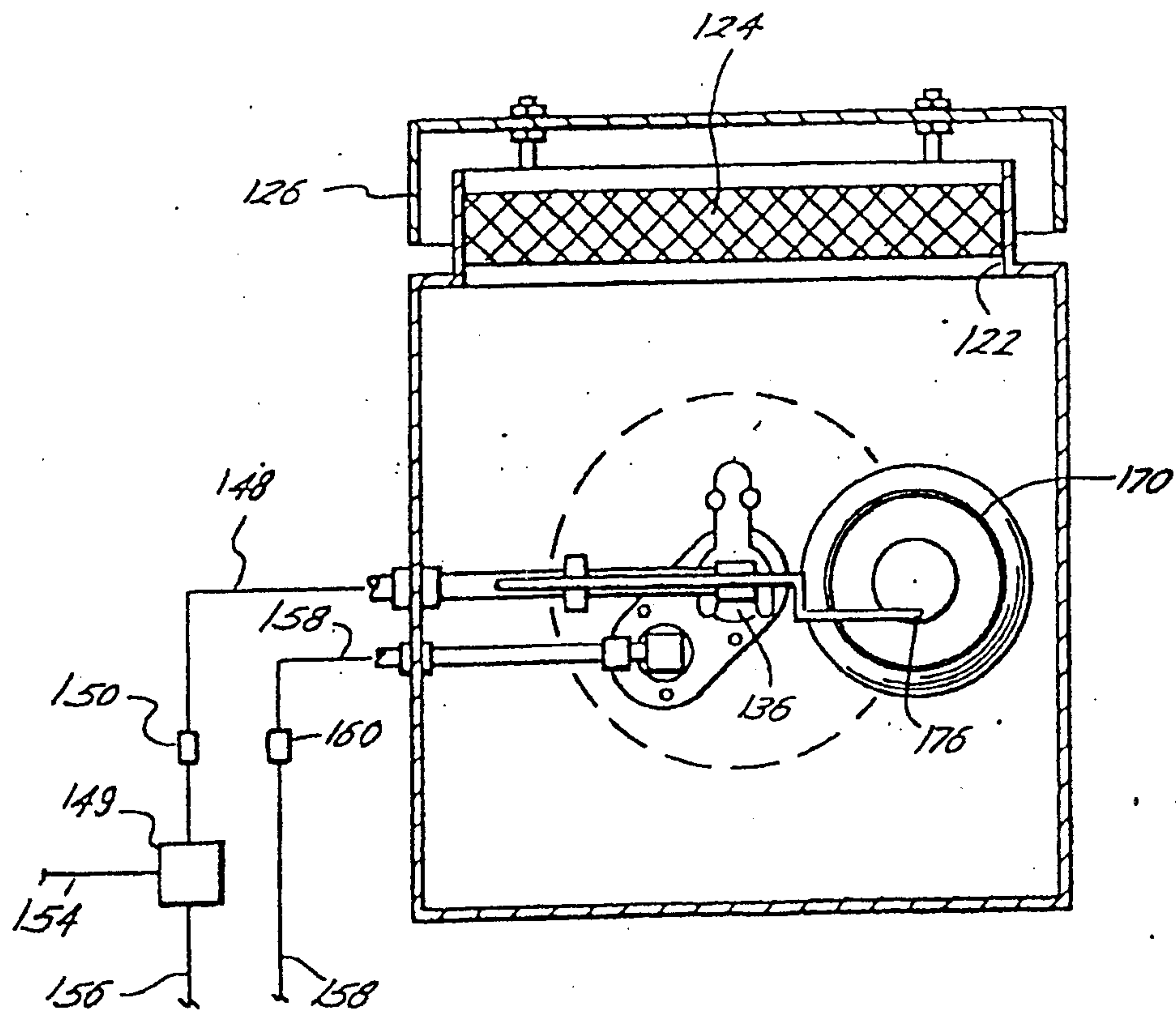


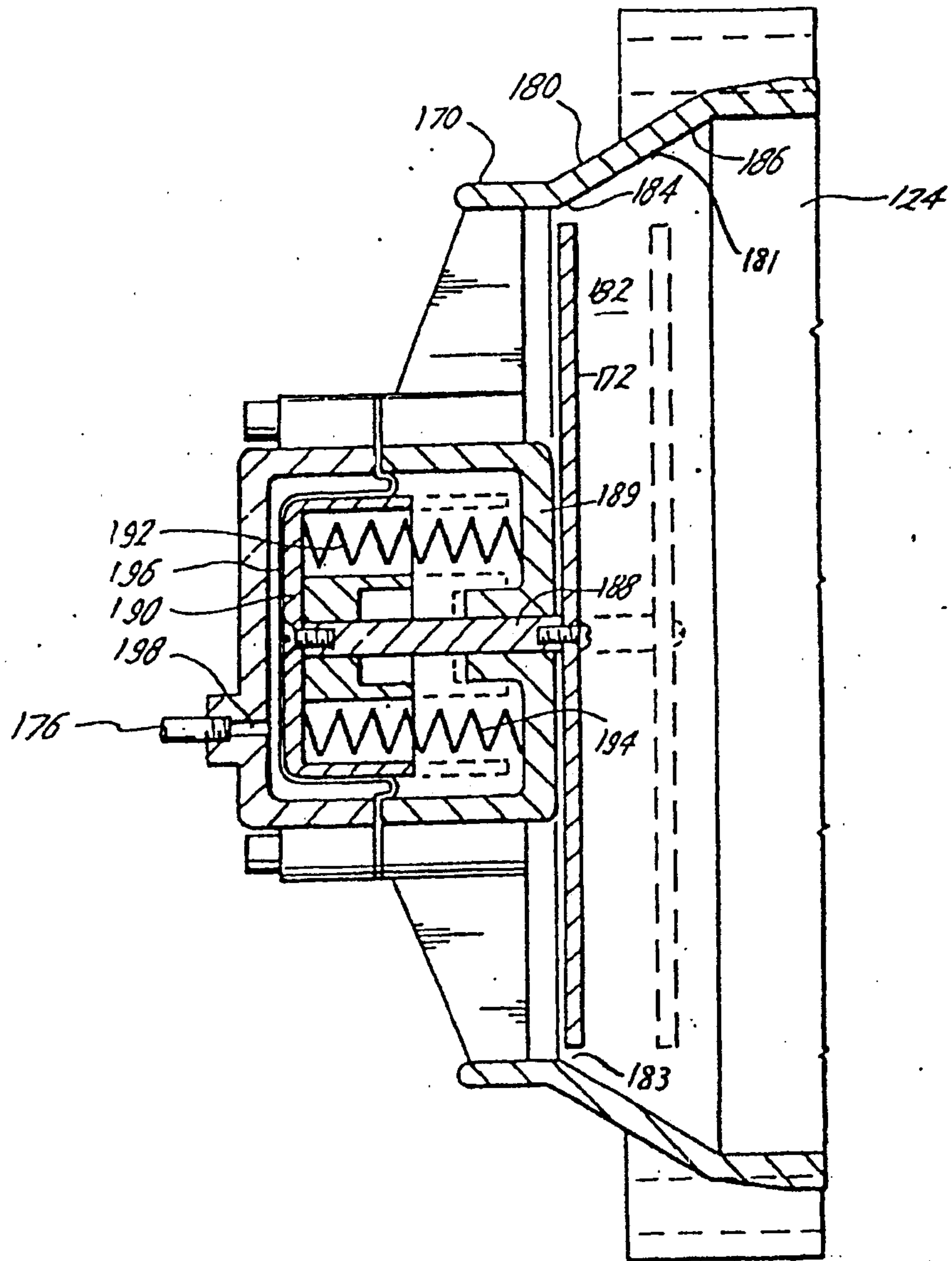
FIG. 1

Fig. 1



PRIOR ART

Fig. 2



PRIOR ART

Fig. 3

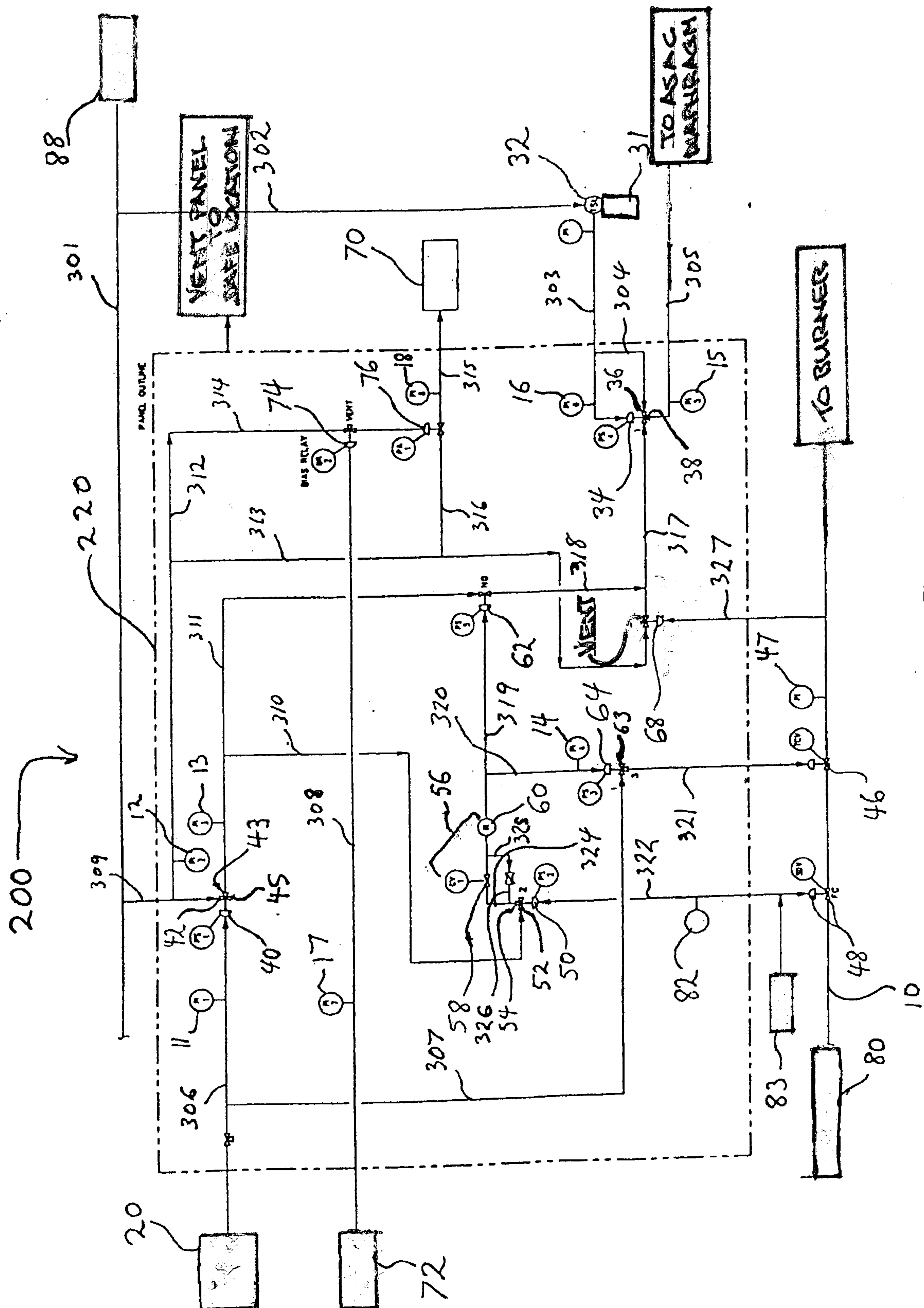


Fig. 4

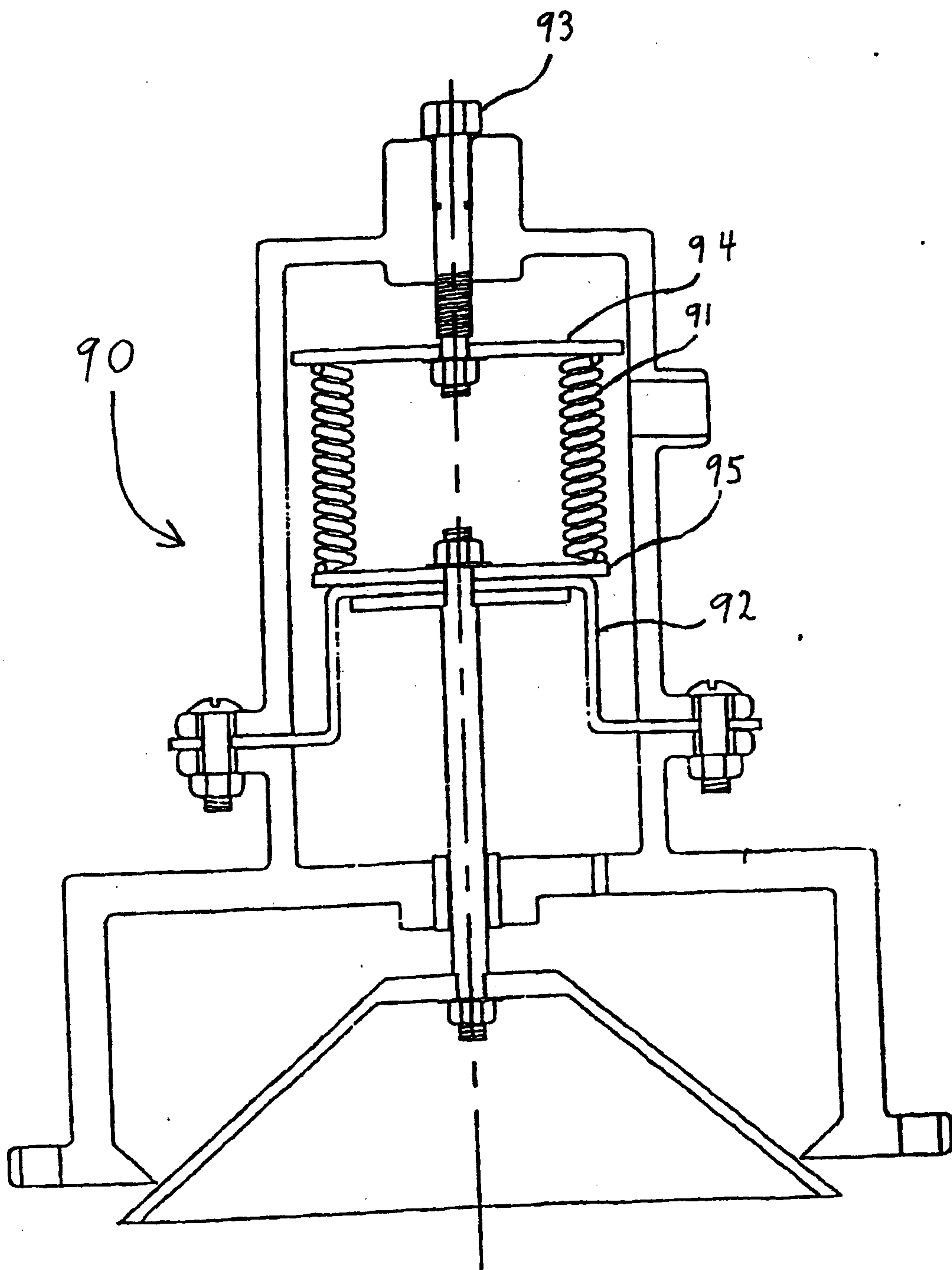


Fig. 5

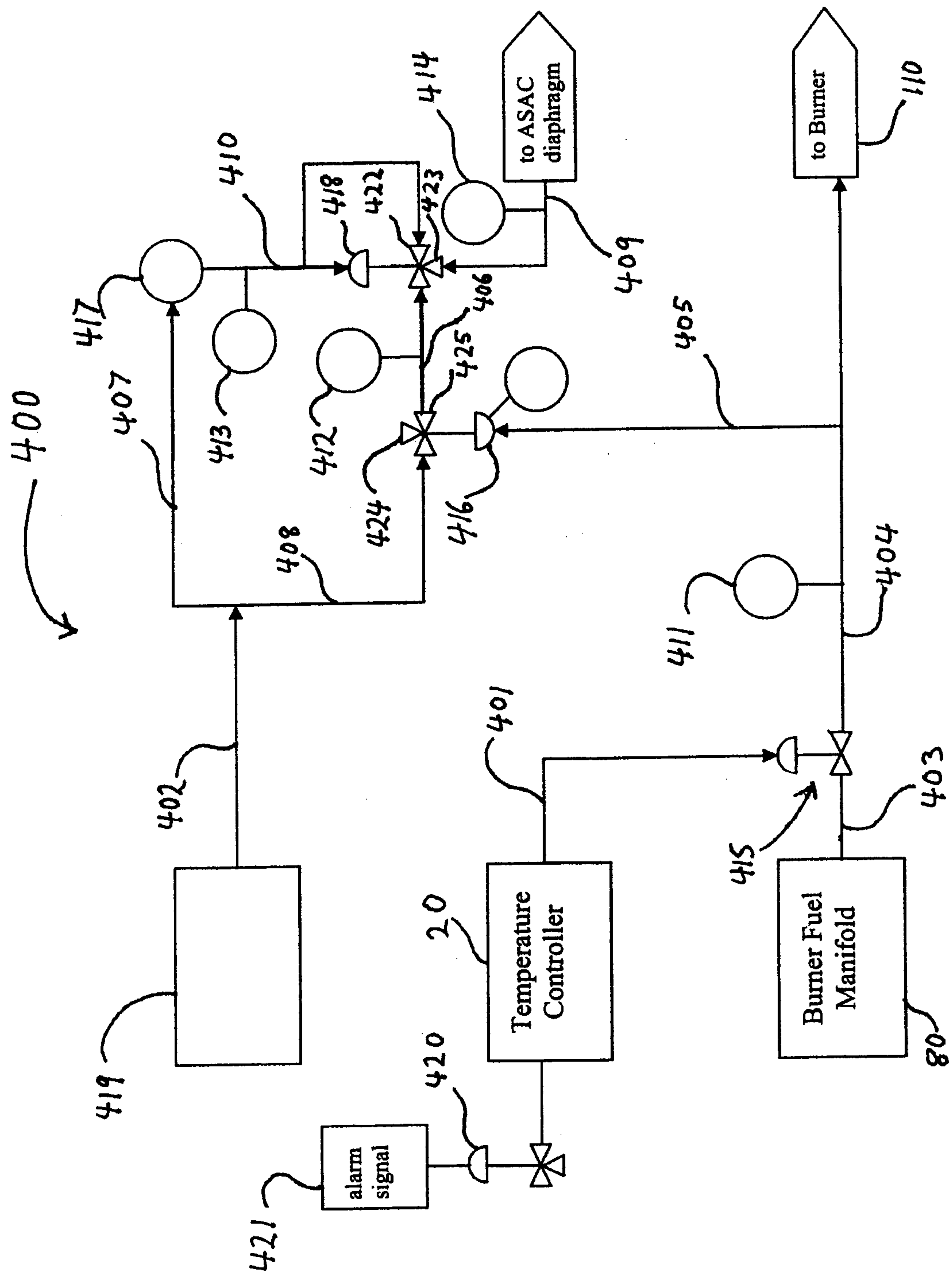


Fig. 6

