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(54) **DUAL FUEL BOILER WITH BACKFLOW-PREVENTING VALVE ARRANGEMENT**

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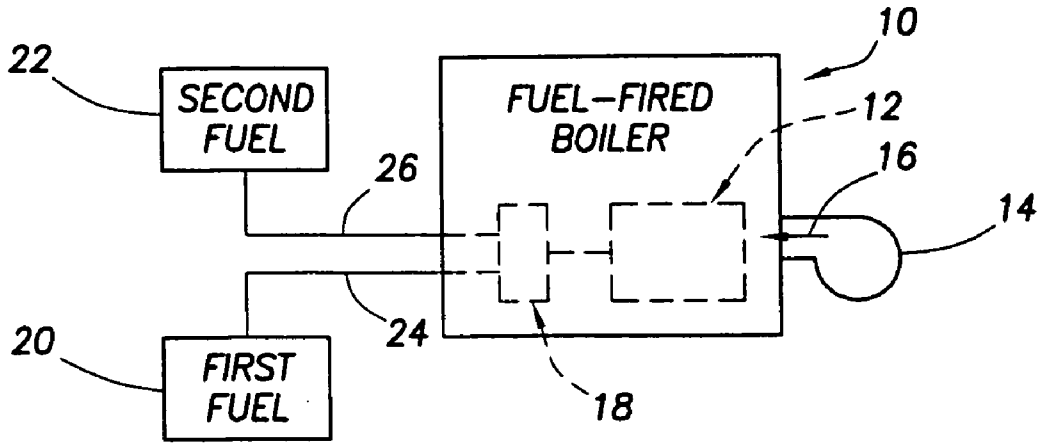
(57) **ABSTRACT**

A dual fuel boiler has fuel delivery apparatus coupled to its burner section through a pressure regulator and operative to deliver to the burner section, from sources thereof, a selectively variable one of (1) a first fuel at a pressure greater than the pressure regulation setting of the pressure regulator, and (2) a second fuel at a pressure less than the pressure regulation setting, the second fuel having a Wobbe index greater that that of the first fuel. The first fuel is flowed to the burner section via a branch supply line in which first and second electromechanical two position, two-way, two position valves are installed in series in opposite normal flow orientations to thereby prevent backflow of the second fuel into the source of the first fuel.



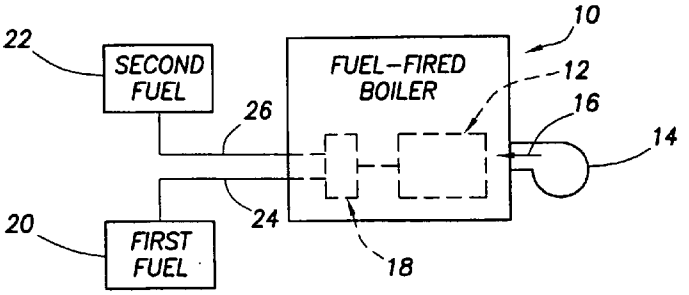


FIG. 1

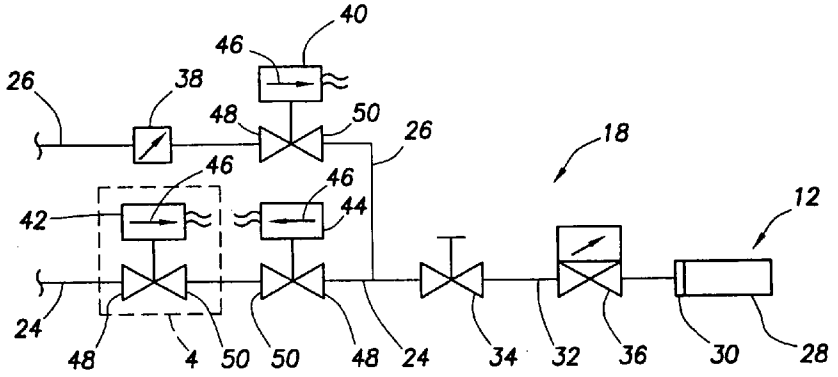


FIG. 2

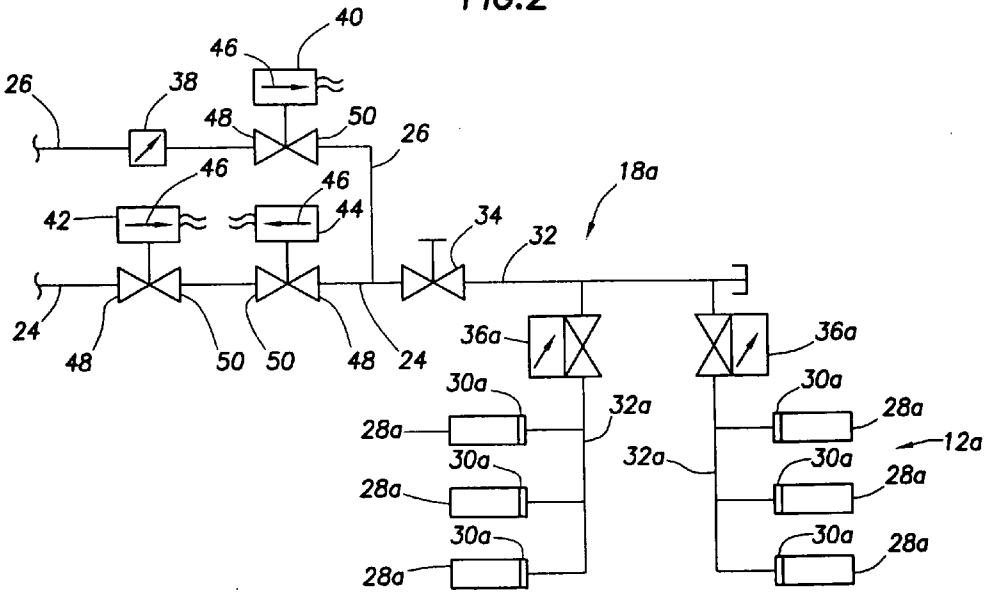


FIG. 3

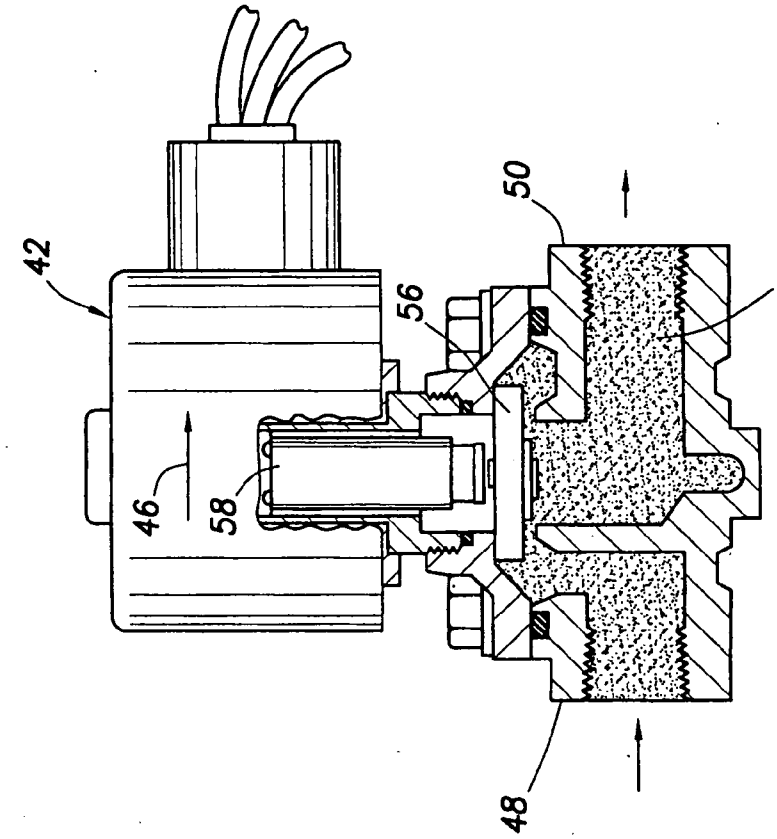


FIG.4B

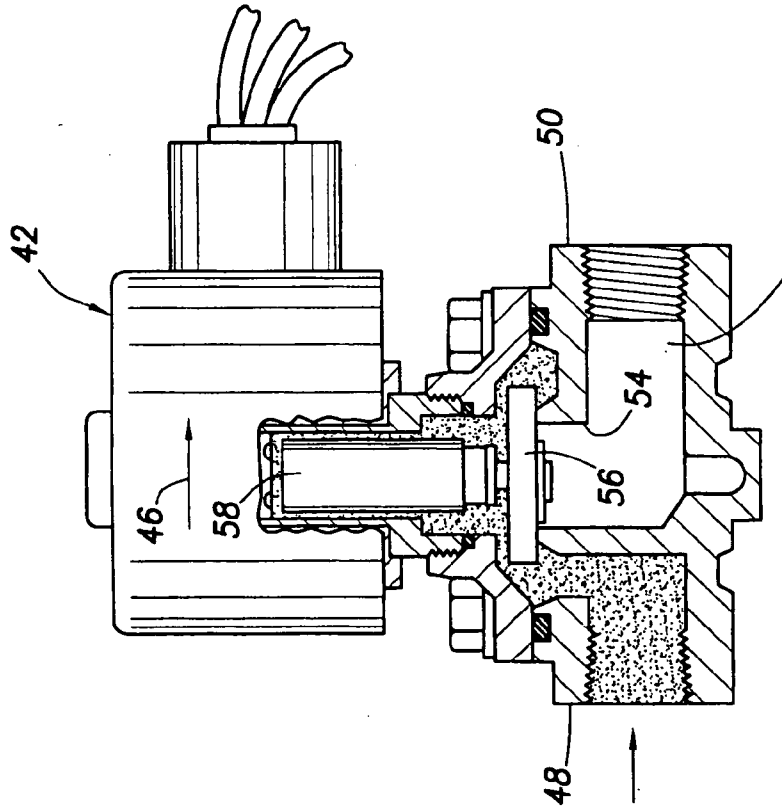


FIG.4A

DUAL FUEL BOILER WITH BACKFLOW-PREVENTING VALVE ARRANGEMENT

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to combustion apparatus and, in a preferred embodiment thereof, more particularly relates to a specially designed dual fuel burner system for a fuel-fired heating appliance such as, for example, a boiler.

[0002] Dual fuel boilers have been supplied, primarily by power burner type boiler manufacturers, for many years. The ability to selectively operate a boiler, or other type of fuel-fired heating appliance, with one or the other of two different fuels (such as, for example, natural gas or propane) is desirable to provide operation if and when the primary fuel source is interrupted. Often the pricing of the primary fuel source can be discounted if the customer agrees to accept interruption of the fuel supply by the supplier when so requested. In this event, the customer simply switches to the secondary or "backup" fuel source until the source of primary fuel is re-established by the supplier.

[0003] Conventional power burner practices are (1) to have two separate burner heads that can be interchanged to accommodate the switch back and forth between the two different types of fuel, or (2) to have back-up fuels with essentially the same Wobbe indexes such as propane-air to back up natural gas. The first listed conventional design, of course, requires a mechanical modification to the overall burner structure each time that a different fuel is to be used to fire the boiler.

[0004] A desirably simplified technique for switching back and forth between two alternative fuel sources (a primary fuel source and an alternate or secondary fuel source) in a dual fuel boiler is illustrated and described in U.S. Pat. No. 6,904,873 to Ashton which is assigned to the same assignee as the assignee of this application, and which is hereby incorporated in its entirety herein by this reference.

[0005] In further developing the dual fuel boiler illustrated and described in U.S. Pat. No. 6,904,873 a goal was established to provide it with a modified primary fuel/secondary fuel switching system having a valving arrangement that even more effectively prevents secondary fuel back pressure from potentially contaminating the primary fuel source with secondary fuel.

SUMMARY OF THE INVENTION

[0006] In carrying out principles of the present invention, in accordance with a preferred embodiment thereof, a specially designed dual fuel heating appliance is provided. The heating appliance is representatively a dual fuel boiler and comprises fuel burner apparatus having an inlet portion, and fuel delivery apparatus operative to deliver to the fuel burner apparatus a selectively variable one of a first fuel (representatively natural gas) from a source thereof, and a second fuel (representatively propane) from a source thereof.

[0007] The fuel delivery apparatus includes a main fuel supply line connected to the inlet portion of the fuel burner apparatus, a first fuel supply branch line connected to the main fuel supply line and connectable to the first fuel source, first valve apparatus connected in the first fuel supply branch line and being openable and closable to selectively permit and preclude flow of the first fuel therethrough, a second fuel supply branch line connected to the main fuel supply line and connectable to the second fuel source, and second valve apparatus connected in the second fuel supply branch line and being openable and closable to selectively permit and preclude flow of the second fuel therethrough.

[0008] According to a key aspect of the invention, the first valve apparatus includes first and second electromechanical two position, two-way valves connected in series, and in opposite normal flow orientations, in the first fuel supply branch line. When these two valves are closed, second fuel backpressure on one of the valves is added to the diaphragm closing spring force thereof to more positively preclude the pressurized second fuel from backflowing into and contaminating the first fuel source.

[0009] Preferably, the dual fuel heating appliance, which is illustrated in both single and multiple burner embodiments, additionally incorporates therein the relative first and second fuel pressure control technique disclosed in U.S. Pat. No. 6,904,873 which permits the use of either the first fuel or the second fuel, the first and second fuels having different Wobbe indexes, without modifying the supply orifice structure of the burner apparatus. To accomplish this, the fuel delivery system further includes a first pressure regulator through which both of the first and second fuels must flow to reach the burner apparatus, and a second pressure regulator through which only the higher Wobbe index fuel must flow to reach the burner apparatus, the pressure regulation setting of the first pressure regulator being higher than the pressure regulation setting of the second pressure regulator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a schematic diagram of a representative dual fuel-fired boiler embodying principles of the present invention;

[0011] FIG. **2** is a schematic diagram of a specially designed dual fuel delivery system utilized in the boiler;

[0012] FIG. **3** is a schematic diagram of a multi-burner version of the FIG. **2** fuel delivery system; and

[0013] FIGS. **4**A and **4**B are enlarged scale schematic cross-sectional views of the dashed area "**4**" in FIG. **2** and respectively illustrate one of the electromechanical valves in FIG. **2** in its de-energized, normally closed orientation and its energized, opened position.

DETAILED DESCRIPTION

[0014] Schematically illustrated in FIG. **1** is a fuel-fired heating appliance which embodies principles of the present invention and is representatively a dual fuel boiler **10**. While a fuel-fired boiler is representatively illustrated, the heating appliance could be a variety of other types of dual fuel heating appliances such as, for example, a pool heater or other type of fuel-fired water heater, and principles of the present invention are not limited to boiler applications.

[0015] The dual fuel boiler **10** includes fuel burner apparatus **12** which is representatively of a non-aspirating type, and a combustion air blower **14** used to supply the fuel burner apparatus **12** with combustion air **16**. According to a key aspect of the present invention, the dual fuel boiler **10**

is provided with a specially designed fuel delivery system **18** which is operatively associated with the burner apparatus **12** and may be utilized to selectively supply to the burner apparatus **12** either a primary first fuel **20** (representatively natural gas) or a secondary fuel **22** (representatively propane) having a Wobbe index higher than that of the first fuel **20**. First fuel **20** is supplied to the boiler **10** via a branch fuel supply line **24**, and the second fuel **22** is supplied to the boiler **10** via a branch fuel supply line **26**.

[**0016**] In FIG. **2** there is schematically shown a representative single burner version of the burner apparatus **12** and the fuel delivery system **18**. The burner apparatus **12** is a single, non-aspirating type fuel burner **28** having incorporated therein, in an inlet head portion thereof, a fuel discharge orifice **30**. According to a key aspect of the present invention, the fuel delivery system **18**, compared to the fuel delivery system incorporated in the dual fuel boiler systems illustrated and described in U.S. Pat. No. 6,904,873, has an improved valving arrangement, later described herein, that more effectively prevents secondary fuel back pressure from potentially contaminating the primary fuel source with secondary fuel.

[**0017**] In addition to the branch fuel supply lines **24** and **26**, the fuel delivery system **18** includes a main fuel supply line **32** coupled as shown to the branch fuel supply lines **24**,**26** and extending from its juncture therewith to the burner inlet fuel orifice **30**. A manual shutoff valve **34** and a pressure regulator apparatus **36** are connected as shown in the main fuel supply line **32** between the branch supply lines **24**,**26** and the fuel discharge orifice **30**.

[**0018**] As schematically and representatively illustrated, the pressure regulator apparatus **36** is a combination pressure regulator and safety or operating valve. Alternatively, the pressure regulator apparatus **36** may comprise separate pressure regulator and valve structures operatively connected in the main fuel supply line **32** upstream from the manual shutoff valve **34** without departing from principles of the present invention. A pressure regulator **38** is installed as shown in the second branch fuel supply line **26**. Preferably, the pressure regulator **38** is a "lock-up" type regulator, of a conventional construction, which incorporates therein a check valve structure that prevents leftward fluid backflow through the regulator **38**.

[**0019**] The improved valving arrangement of the fuel delivery system **18** also includes three electromechanical normally closed, two position, two-way, gas valves **40**,**42**,**44** of the solenoid/diaphragm type utilizing a linear motor output motion as later described herein. Valve **40** is connected in the branch fuel supply line **26** downstream of the pressure regulator **38**, and valves **42**,**44** are connected in series in the branch fuel supply line **24**, with valve **42** being upstream of the valve **44**.

[**0020**] Manual shutoff valves (not shown) are connected in the branch fuel supply lines **24** and **26**, respectively upstream of the pressure regulator **38** and the electromechanical valve **42**. The manual shutoff valve **34** may be optionally installed, where shown, in addition to these non-illustrated manual shutoff valves.

[**0021**] Each of the valves **40**,**42**,**44** has a normal or intended internal flow direction as indicated by the arrow **46** thereon. When it is desired to supply natural gas to the boiler **10**, the electromechanical valve **40** is left closed, and the electromechanical valves **42** and **44** are electrically opened to permit natural gas to flow to the burner **12** via the lines **24** and **32**. When it is desired to supply propane to the boiler **10**, the electromechanical valves **42** and **44** are closed and the electromechanical valve **40** is electrically opened to permit propane to flow to the burner **12** via the lines **26** and **32**.

[**0022**] FIG. **4**A cross-sectionally depicts the electromechanical valve **42** (which is configured similarly to the valves **40** and **44**) in its de-energized normally closed orientation, and FIG. **4**B cross-sectionally depicts the valve **42** in its energized or opened configuration. Like valves **40** and **44**, valve **42** has an inlet end **48**, an outlet end **50**, and an internal flow passage **52** extending therethrough between the ends **48** and **50**. Internal flow passage **52** extends through an orifice **54**. When the valve **42** is in its normally closed FIG. **4**A orientation, the orifice **54** is blocked by a closure diaphragm **56** which is coupled to the vertically movable core **58** of the solenoid portion of the valve and spring-driven downwardly against the top side of the orifice **54** to close it against gas flow therethrough. When the valve **42** is electrically energized to open it (see FIG. **4**B), the solenoid core **58** is electrically driven upwardly to thereby open the orifice **54** and permit gas flow in either direction through the internal passage **52** between the valve's inlet and outlet ends **48**,**50**.

[**0023**] According to a key aspect of the present invention, the electromechanical valves **42**,**44** connected in series in the natural gas branch supply line **24** are "oppositely" connected therein such that their normal flow arrows **46** are oppositely directed. Because of this unique opposite normal flow orientations of the electromechanical valves **42**,**44** in the branch line **24**, when propane is being delivered to the boiler **10** via the branch supply line **26**, propane back pressure on the natural gas valve **44** adds to the spring pressure on its diaphragm **56** so that such propane back pressure cannot lift the diaphragm off the orifice of valve **44** and permit propane backflow through the valve **44**. With the valves **42**,**44** in such opposite normal flow orientations in the line **24**, natural gas flowing rightwardly through the (opened) valves **42**,**44** sequentially passes through the normal inlet **48** of the valve **42**, the normal outlet **50** of the valve **42**, the normal outlet **50** of valve **44**, and the normal inlet **48** of valve **44**. Note that if valve **44** were omitted, the propane back pressure exerted on the diaphragm **56** of valve **42** would be exerted thereon in a direction opposite to that of its diaphragm closure spring, thereby potentially lifting the diaphragm and permitting undesirable propane backflow through the single electromechanical valve **42**.

[**0024**] Natural gas pressure on valve **42** in its normally closed position (for example, when propane is being supplied to the boiler **10**), adds to the closure force on the diaphragm of valve **42** to thereby more positively preclude natural gas flow rightwardly through the branch line **24**. Natural gas backflow through the propane branch supply line **26** when the valve **40** is in its normally closed position, is prevented by the check valve structure in the pressure regulator **38**, and by the diaphragm spring closure force within the valve **40**.

[**0025**] By appropriately opening or closing the electromechanical valve **40**, or the electromechanical valves **42** and **44**, either the first fuel **20** or the second fuel **22** may be

supplied to the burner **28** during firing thereof. AS in the case of the dual fuel boiler apparatus illustrated and described in U.S. Pat. No. 6,904,873, when the first fuel **20** is being supplied to the burner **28** the first fuel **20** is delivered to the pressure regulator apparatus **36** at a pressure higher than its pressure regulation setting, and when the second fuel **22** is being supplied to the burner **28** the second fuel **22** is delivered to the pressure regulator apparatus **36** at a pressure lower than its pressure regulation setting. Further, the pressures of the first and second fuels **20**,**22** as they reach the burner **28** are related to one another in a manner such that the firing rate of the burner **28** is essentially the same regardless of which of the fuels **20**,**22** is being delivered thereto. This advantageously eliminates the necessity of changing out the burner orifice **30** each time a switch is made from either of the fuels **20**,**22** to the other fuel.

[**0026**] Representatively, but not by way of limitation, the setting of the pressure regulator apparatus **36** is nominally 3.5" W.C., the first fuel (by virtue of a non-illustrated upstream pressure regulator) is delivered to the oppositely connected electromechanical valves **42**,**44** at a pressure within the range of from about 7" to about 14" W.C., and the pressure regulator **38** is set to reduce the pressure of the second fuel **22** delivered to the electromechanical valve **40** to about 2.0" W.C. Accordingly, for the fuel delivery system **18** illustratively depicted in FIG. **2**, when the first fuel **20** is being supplied to the burner **28** the pressure regulator apparatus **36** reduces the pressure of the first fuel **20** that it receives to nominally 3.5" W.C. for supply to the burner **28**.

[**0027**] However, when the second fuel **22** is being supplied to the burner **28**, the pressure regulator apparatus **36** does not regulate the pressure of the second fuel downwardly (since the second fuel is delivered to the pressure regulator apparatus **36** at a pressure lower than its setting), and the second fuel **22** is supplied to the burner **28** at a pressure of about 1.3" W.C. due to the inherent valve and supply line pressure drops. Thus, the pressure of the first fuel **20** being supplied to the burner orifice **30** will be a function of the setting of the pressure regulator apparatus **36**, while the pressure of the second fuel **22** being supplied to the burner orifice **30** will be a function of the pressure of the second fuel **22** upstream of the pressure regulator apparatus **36** and the inherent valve and supply line pressure drops.

[**0028**] AS can be seen, by simply adjusting the settings of the pressure regulating devices **36** and **38** the fuel delivery system **18** can be correspondingly adjusted to maintain the firing rate of the burner **28** at a substantially constant level when other combinations of fuels are coupled to the fuel delivery system for use with the burner **28**.

[**0029**] FIG. **3** schematically illustrates modified burner apparatus **12***a* and an associated modified fuel delivery system **18***a* which may be alternatively incorporated in the dual fuel boiler **10** or other fuel-fired heating appliance. Instead of the single burner **28** defining the burner apparatus **12** shown in FIG. **2**, the modified burner apparatus **12***a* depicted in FIG. **3** comprises two pluralities of burners **28***a* (representatively two groups of three burners **28***a*). The modified fuel delivery system **18***a* includes two branch fuel supply lines **32***a*, each of which couples the main fuel supply line **32** to one of the two burner groups as shown. The modified fuel delivery system **18***a* also includes two pressure regulating apparatuses **36***a*, each of which is installed in one of the branch lines **32***a*. Representatively, each of the two pressure regulator apparatuses **36***a* has a setting equal to that of the single pressure regulator apparatus **36** shown in FIG. **2**. In all other regards, the modified fuel delivery system **18***a* is identical in construction and operation to the previously described fuel delivery system **18** shown in FIG. **2**. AS in the case of the fuel delivery system **18**, the pressure regulators **36***a* are representatively set at nominally 3.5" W.C., and the second fuel pressure regulator **38** is set to about 2.0" W.C. Thus, by simply opening the valve **40**, or the valves **42**,**44**, the multiple burners **28***a* may be operated at substantially equal firing rates using either of the two fuels **20** and **22** without the necessity of changing out any of the burner orifices **30***a*.

[**0030**] The foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the present invention being limited solely by the appended claims.

What is claimed is:

1. A fuel-fired heating appliance comprising:

fuel burner apparatus having an inlet portion;

pressure regulator apparatus having an outlet portion coupled to said inlet portion of said fuel burner apparatus, and a predetermined pressure regulation setting; and

fuel delivery apparatus coupled to said pressure regulator apparatus inlet portion and operative to deliver thereto a selectively variable one of (1) a first fuel, from a source thereof, at a pressure greater than said predetermined pressure regulation setting, and (2) a second fuel at a pressure lower than said predetermined pressure regulation setting,

said fuel delivery apparatus including a fuel supply line communicated with said inlet portion of said fuel burner apparatus and through which one of said first and second fuels may be flowed, and first and second electromechanical two position, two-way valves connected in series in said fuel supply line in opposite normal flow orientations,

said pressure regulator apparatus regulating the pressure of fuel discharged from its outlet portion only with respect to said first fuel, and

said pressure regulator apparatus and said fuel delivery apparatus being coupled in a manner precluding said pressure regulation setting from being affected by which of said first and second fuels is being delivered to said pressure regulator apparatus.

2. The fuel-fired heating appliance of claim 1 wherein:

said fuel burner apparatus is of a non-aspirating type, and

said fuel-fired heating appliance further comprises a blower operative to supply combustion air to said fuel burner apparatus.

3. The fuel-fired heating appliance of claim 1 wherein:

said fuel-fired heating appliance is a boiler.

4. The fuel-fired heating appliance of claim 1 wherein:

said first fuel is natural gas, and

said second fuel is propane.

5. The fuel-fired heating appliance of claim 1 wherein:

said fuel delivery apparatus further includes a pressure regulator operative to reduce the pressure of the second fuel when it is being flowed to said fuel delivery apparatus.

6. The fuel-fired heating appliance of claim 1 wherein:

said fuel burner apparatus comprises a plurality of fuel burners, and

said pressure regulator apparatus comprises a plurality of pressure regulators operatively coupled to said plurality of fuel burners.

7. A fuel-fired heating appliance comprising:

a fuel burner having an inlet orifice;

a fuel delivery system for alternately supplying first and second fuels having different wobbe indexes to said inlet orifice at different pressures related to said different Wobbe indexes in a predetermined manner such that the firing rate of said fuel burner remains substantially the same, without changing said inlet orifice, regardless of which one of said first and second fuels is being supplied to said fuel burner, said fuel delivery system including:

a fuel supply line communicated with said inlet orifice and through which one of said first and second fuels may be flowed,

first and second electromechanical two position, two-way valves connected in series in said fuel supply line in opposite normal flow orientations,

a first pressure regulator through which both of said first and second fuels must flow to reach said fuel burner, and

a second pressure regulator through which only the higher Wobbe index fuel must flow to reach said fuel burner.

8. The fuel-fired heating appliance of claim 7 wherein:

said fuel-fired heating appliance is a fuel-fired boiler.

9. The fuel-fired heating appliance of claim 7 wherein:

said fuel burner is a non-aspirating type burner, and

said fuel-fired heating appliance further comprises a blower operative to supply combustion air to said fuel burner.

10. The fuel-fired heating appliance of claim 7 wherein:

the pressure regulation setting of said first pressure regulator is higher than the pressure regulation setting of said second pressure regulator.

11. A fuel-fired heating appliance comprising:

non-aspirating type fuel burner apparatus having an orificed fuel inlet portion;

blower apparatus for supplying combustion air to said fuel burner apparatus;

a main fuel supply line structure coupled to said orificed fuel inlet portion;

first pressure regulator apparatus connected in said main fuel line structure and having an inlet portion and a first pressure regulation setting;

a first branch fuel supply line structure, coupled to said inlet portion of said first pressure regulator apparatus for receiving a pressurized first fuel;

a second branch fuel supply line structure, coupled to said inlet portion of said first pressure regulator apparatus, for receiving a pressurized second fuel having a wobbe index higher than that of said first fuel;

valve apparatus operable to permit flow of only a selectively variable one of said first and second fuels to said inlet portion of said first pressure regulator apparatus and thus to said orificed fuel inlet portion of said fuel burner apparatus, said valve apparatus including first and second electromechanical valves connected in series in said first branch fuel supply line structure in opposite normal flow orientations; and

second pressure regulator apparatus connected in said second branch fuel supply line structure and having a second pressure regulation setting,

said first and second pressure regulation settings being related to one another in a predetermined manner such that, without altering said orificed fuel inlet portion of said burner apparatus, the firing rate of said burner apparatus will remain essentially constant regardless of which of said first and second fuels is being supplied thereto.

12. The fuel-fired heating appliance of claim 11 wherein:

said fuel-fired heating appliance is a dual fuel boiler.

13. The fuel-fired heating apparatus of claim 11 wherein:

said burner apparatus comprises a plurality of non-aspirating type fuel burners each having an orificed inlet.

14. The fuel-fired heating appliance of claim 11 wherein:

said first pressure regulation apparatus comprises a plurality of pressure regulator devices.

15. The fuel-fired heating appliance of claim 11 wherein:

said first pressure regulation setting is greater than said second pressure regulation setting.

16. A fuel-fired heating appliance comprising:

fuel burner apparatus having an inlet portion; and

fuel delivery apparatus operative to deliver to said fuel burner apparatus a selectively variable one of a first fuel from a source thereof, and a second fuel from a source thereof,

said fuel delivery apparatus including a main fuel supply line connected to said inlet portion of said fuel burner apparatus, a first fuel supply branch line connected to said main fuel supply line and connectable to said first source, first valve apparatus connected in said first fuel supply branch line and being openable and closable to selectively permit and preclude flow of said first fuel therethrough, said first valve apparatus including first and second electromechanical two position, two-way valves connected in series, and in opposite normal flow orientations, in said first fuel supply branch line, a second fuel supply branch line connected to said main fuel supply line and connectable to said second source, and second valve apparatus connected in said second fuel supply branch line and being openable and

closable to selectively permit and preclude flow of said second fuel therethrough.

17. The fuel-fired heating appliance of claim 16 wherein:

said fuel-fired heating appliance is a dual fuel boiler.

18. The fuel-fired heating appliance of claim 16 wherein:

said first fuel is natural gas, and said second fuel is propane.

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