Oct. 8, 1940. J. F. SHANNON 2,217,610

METHOD AND MEANS FOR OPERATION OF VAPOR GENERATORS

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Fig. 2

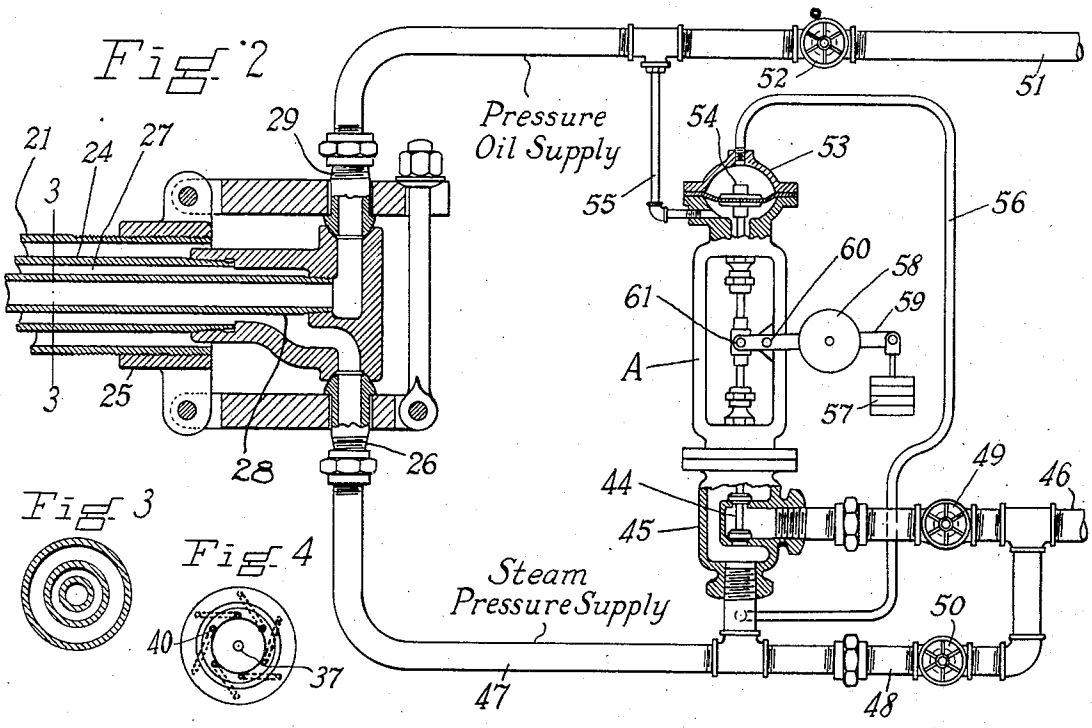


Fig. 3

Fig. 4

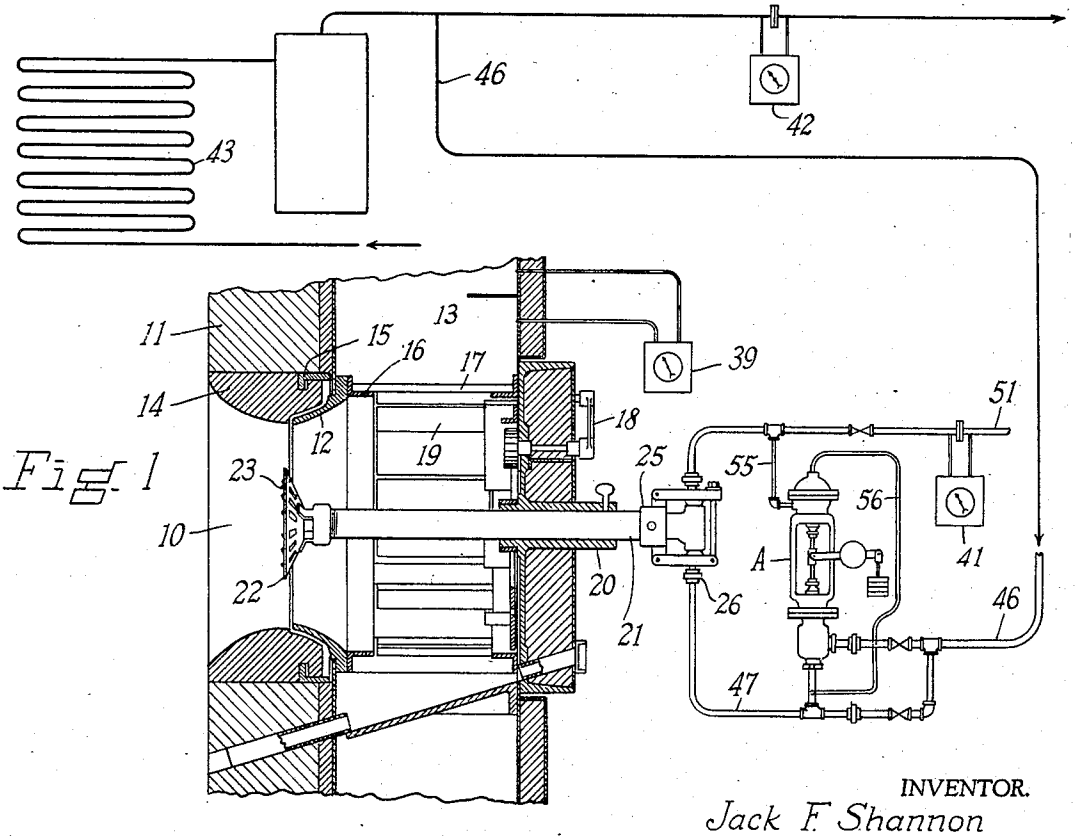


Fig. 1

INVENTOR.
Jack F. Shannon

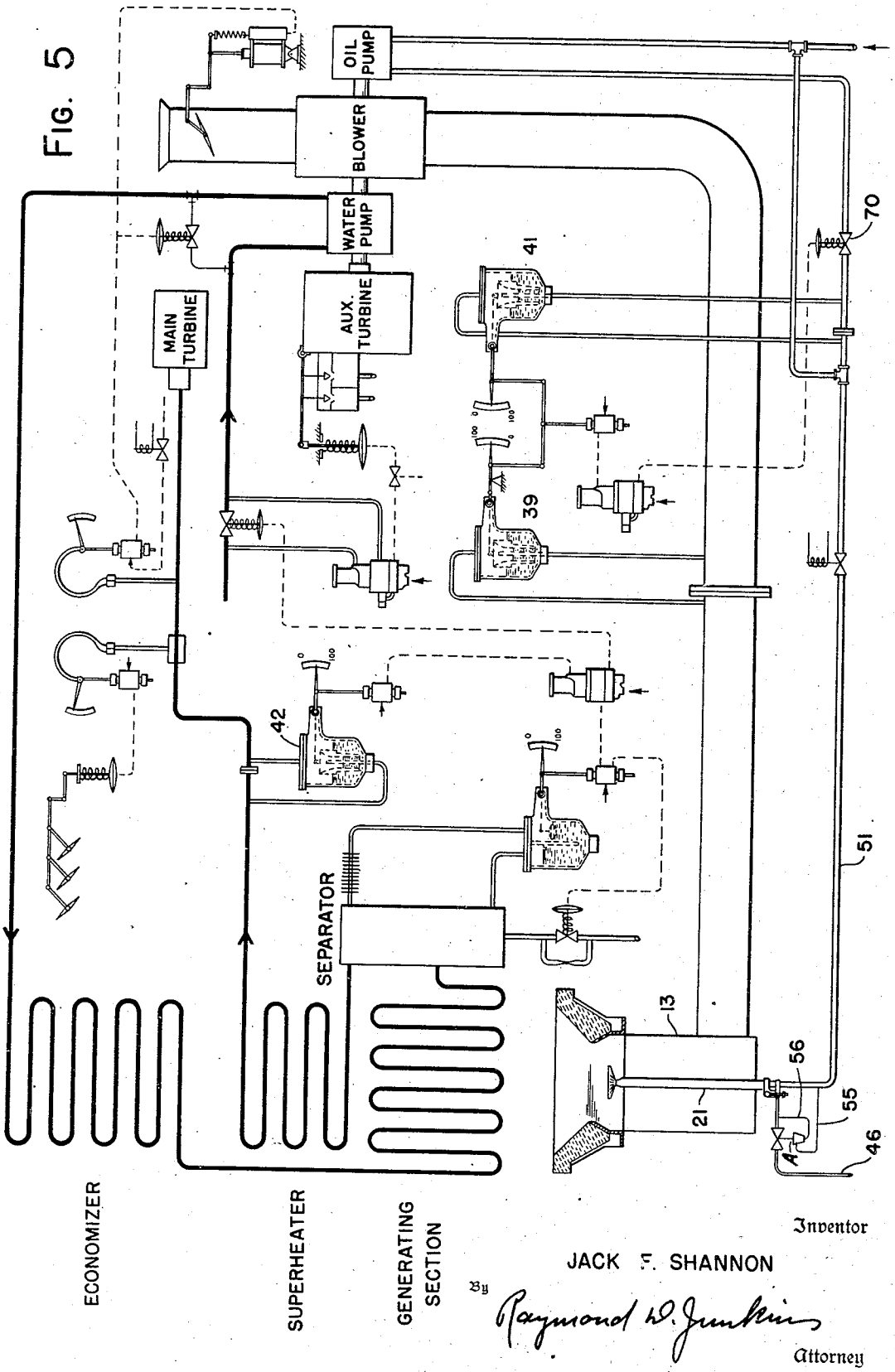
BY
Basil R. Peacock
ATTORNEY.

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METHOD AND MEANS FOR OPERATION OF VAPOR GENERATORS

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FIG. 5



Inventor

JACK F. SHANNON

By Raymond W. Junkin

Attorney

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2,217,610

METHOD AND MEANS FOR OPERATION OF VAPOR GENERATORS

Jack F. Shannon, Cleveland, Ohio, assignor to Bailey Meter Company, a corporation of Delaware

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6 Claims. (Cl. 158—1)

This invention is concerned with a steam generator and firing means therefor, together with the method of operation of both the generator and firing means in combination as a unit, and of the burner as a separate device firing some other equipment than a steam generator.

The invention has particular application to light weight forced flow vapor generators with minimum liquid and heat storage for a maximum of heat absorbing surface for generating superheated steam at high pressure while practically maintaining uniform temperature and pressure over a wide range of substantially instantaneous load variations, as, for instance, in mobile service of the character adapted to ships, locomotives and the like where it is important that the means firing the elements of combustion shall be adjustable for varying the rates of heat release over a much wider range of operation than is possible with usual equipment, and where efficiency of combustion must be maintained at a high level in spite of variations in steam demand.

With variable capacity vapor generators of the light weight portable type for land and marine use, fuel burners having a wide range are required, which means that, at times, the demand for fuel is at a minimum while at other times the demand is at a maximum. With burners for oil operating on the mechanical atomization principle, and with these also operating on the principle of atomization by the pressure of a mixing fluid, such as steam or air, operation at widely varying rates is unsatisfactory and hence it has heretofore been necessary for installations of oil burners on variable capacity equipment to design and select the oil burning equipment for an expected normal condition representative of the major period of operation of the equipment. While such expected normal condition might represent a small range, operation over a wider range introduced operating difficulties and inefficiencies in the burning of the fuel for which the usual types of combustion control could not compensate.

In such oil burning installations as I have referred to the main control for combustion is air flow through the furnace being fired and control of oil flow primarily to correspond to such air flow, in the case of a steam boiler such control then gives a resulting steam pressure which, of course, is a function of boiler load when controls of the type set forth in the application of E. G. Bailey, Ser. No. 55,020, filed Dec. 18, 1935, (U. S. Patent 2,170,342) and E. G. Bailey et al., Ser. No. 55,021, filed Dec. 18, 1935, (U. S. Patent 2,170,345) are used; this present invention is comprehensive enough to include its combination with control systems of the character set forth in the aforesaid applications and which, since fully illustrated in said copending applications, need not here be reproduced.

The invention is particularly adapted to vapor pressure plants which are oil fired and operating over a wide range of capacity and wherein it is desirable to automatically maintain a constant steam pressure, and wherein the main control is from plant load, or steam pressure as a function of load to adjust the oil flow air flow ratio for the varying loads. In such installations fired for instance by fluid pressure atomizing oil burners such as the steam atomizing type, difficulties are encountered when the normal range is departed from and fuel consumption drops for instance to a rate as low as three pounds per hour.

With the above and other objects in view I will now describe the equipment illustrated in the drawings which show a desirable embodiment of the invention and wherein—

Fig. 1 is a partly sectional and partly diagrammatic illustration of a boiler burner combination;

Fig. 2 is an enlarged view partly in section and partly in side elevation of the assembled equipment;

Fig. 3 is a sectional view on the line 3—3 of Fig. 2, and

Fig. 4 is a front elevation of the burner discharge head.

Fig. 5 is a diagrammatic representation of a control system embodying my invention.

The liquid fuel burner of the combination and which forms a part of this present invention is disclosed in U. S. Patent 2,103,958 to which reference is made for details of the same, only so much thereof being herein disclosed as is essential to understand the functioning of this invention.

The liquid fuel burner is arranged to discharge through a circular fuel burner opening 10 in a furnace wall 11. A metallic cone member 12 opens into the windbox 13 with its smaller or front end nearer to the inner side of the furnace wall 11. The burner opening is flared from the front end of the cone member 12 by means of the molded tile 14 held in position by a grid 15. On the outer or rear end of the cone member 12 and abutting the same and the outer wall

of the windbox 13 is an air register 16 of cylindrical form having a series of circularly arranged openings 17, the amount of opening of which is controlled by a lever 18 moving air doors 19 which control the openings 17.

The hub 20 positioned centrally of the air register mounts an axially adjustable distance piece 21. On the furnace or front end of the distance piece 21 is a conical impeller plate 22, having a circular series of adjacent ports 23 in said impeller plate 22 and angularly directed to effect rotation of the air entering through register 16 from the windbox 13.

Within the distance piece 21 is a burner barrel 24 on the furnace end of which is mounted the discharge head of the burner as described in the aforesaid patent and a front view of which head is shown in Figure 4. The fuel orifice 37 which receives liquid fuel under pressure from a whirl chamber is arranged to discharge the fuel in the form of a flaring hollow cone of minute particles of fuel which are contacted by a stream of air passing through the opening 16 and converging toward the fuel stream. The air stream continuously scrubs the surface of the fuel cone and combustion progresses, once ignited, according to the effectiveness of the mixing of the fuel and air. The relatively smooth conical form of the fuel stream and the annular form of the surrounding air stream are not conducive to extremely rapid combustion of the fuel and a relatively long flame is the result.

However, the rate of fuel combustion can be substantially accelerated with a correspondingly shorter flame by causing jets of gaseous fluid at a relatively high velocity to sweep across the boundary surface of the fuel cone at spaced locations and in different directions at the same angle to the cone axis. For this purpose the burner orifice 37 is surrounded with a series of fluid passages 40 extending through the burner head in circular formation concentric to the orifice 37 and directed at an oblique angle to the axis of the burner and its cone of fuel spray. The passages are symmetrically arranged relative to the axis of the burner and directed so as to discharge a circular series of non-intersecting fluid jets collectively in a direction opposite to the direction of rotation of the air stream. As the fuel cone leaves the orifice 37 it is swept by the series of gaseous fluid jets. A turbulent condition is thereby effected at intervals in the zone of contact of the air and fuel streams causing air to be swept into the fuel stream and fuel particles to be thrown into the air stream. A rapid intermixing of the air and fuel is the result and the flame is considerably shortened, thus the burner is adapted for operation over a wide range of fuel capacities with a consistently high degree of fuel burning efficiency. With high rates of fuel consumption, and corespondingly high fuel pressure, the fluid supply may be cut off and the burner operated as a straight mechanical atomizing burner. However, when the fuel rate and/or pressure of the fuel drop below the point at which the desired combustion conditions can be maintained by mechanical atomization the gaseous fluid supply is opened; the greater the degree of mechanical atomization of the fuel effected when the burner is operated as last mentioned the less is the amount of gaseous fluid required to secure the desired combustion conditions. To secure uniform results at all rates of fuel supply under conditions demanding the gaseous fluid there must be maintained a predetermined pressure differential between steam and oil pressures, with the steam pressure always at least as high as that of the oil.

On the outer end of the distance piece 21 is adjustably mounted a detachable coupling member 25 which holds a supply connection 26 for a high pressure gaseous fluid such as steam at a relatively high pressure in position to communicate with an annular channel 27 formed between a central liquid fuel pipe 28 and the barrel 24; a liquid fuel supply connection 29 communicates with the outer end of the pipe 28 of the burner.

In one installation of liquid fuel burners of the hereinbefore described type the burners carried 70 per cent of the rating with fuel oil alone at 160 lbs. pressure at the burners; when the load dropped to about 20 per cent of rating the burners were operated with steam jets as described with the oil pressure at 15 to 20 lbs. per square inch and steam at a pressure of 50 to 60 lbs. per square inch; under such conditions the flame was observed to be short and bright without the presence of sparklers. However, with oil pressure as low as 10 lbs. per square inch continuous combustion without the use of steam jets was found to be impossible; with steam jets served by steam at predetermined excess above oil pressure throughout the range requiring such jets, operation is more uniform over a wider range than is possible where oil and steam have no predetermined condition.

In the present invention principal regulation of combustion is by maintaining a predetermined oil flow-air flow ratio either by automatic means as set forth in the patent to E. G. Bailey et al., No. 2,170,345, or from manual regulation from indications on suitable measuring instruments as indicated for air at 38 and oil at 41 adjusted in acordance, for instance, with steam demand as indicated by a steam flow measuring device 42 on the outlet of the steam generator 43 fired with products of combustion from the burner shown in Fig. 1. In this arrangement a regulating valve A is provided with the valve element 44 of the equalized type reciprocating in the valve body 45, one side of which is connected to the pressure steam supply 46 from the steam generator 43 and the discharge side to the connection 26 of the oil burner by the pipe 47, a by-pass 48 being provided to permit operation without reference to the regulating valve under emergency conditions such as when, for instance, the regulating valve may require servicing; shut off valves 49 and 50 are provided in the steam supply and by-pass respectively.

The oil supply is indicated at 51 and is coupled to the burner connection 29, a shut-off valve 52 being provided in advance of the regulating valve A.

The regulating valve A, at its upper end, has a diaphragm chamber 53 divided by a diaphragm element 54 connected to reciprocate the valve element 44 to open or closed condition. Assisting to open the valve is the oil pressure in the fuel supply line 51 acting through the pipe 55 connected to the chamber 53 below diaphragm element 54 and which acts against steam pressure from the supply 47 connected to the top side of the diaphragm element 54 through the pipe 56 when stop valve 50 is closed and valve 49 is open. The steam pressure normally being greater than the oil pressure the valve would remain closed except that added to the oil pressure are the weights 57 and 58, both adjustable in effect carried upon the outer end of lever 59 fulcrumed

at 60 and connected at pivot 61 with the stem of balanced valve element 44 which, as stated, is operated by diaphragm element 54. With this arrangement a predetermined differential between oil and steam pressure may be maintained at the burner with the steam pressure always greater than the oil pressure, so long as valve 49 is open and valve 50 closed. When it is desirable at high capacities to operate with mechanical atomization only, the regulating feature may be discontinued by closing valve 49.

In Fig. 5 I illustrate in general the vapor generator and control system disclosed in the referred to Bailey et al. Patent 2,170,345 and Dickey Patent 2,170,346 and including my present invention. The air blower and fuel oil pump are basically controlled as to speed and output from the steam flow meter 42 representative of load. A predetermined volumetric ratio of the liquid fuel-air supplies is obtained through the agency of liquid fuel flow meter 41, air flow meter 39, and liquid fuel regulating valve 70 controlled thereby.

With my invention as described in the foregoing it is possible, for instance, in operating a steam generator of variable capacity where there are fluctuations in steam line pressure, to utilize a method whereby the products of combustion are regulated from load or steam demand to maintain an economical rate of fuel consumption with a predetermined oil flow air flow ratio while covering a wide range of burner operation due to a maintained predetermined pressure differential between steam and oil at the burner with the steam pressure always in excess of oil pressure.

While, in the foregoing, I have described the application of this invention to a steam generator it is nevertheless to be understood that it is also generally applicable to all burners of the type wherein gaseous fluid such as steam and air under pressure may be used and where it is desirable to maintain a predetermined excess of gaseous fluid pressure as compared to fuel pressure.

I claim:

1. In combination, a fluid atomizing liquid fuel burner, conduit means for separately supplying liquid fuel and a gaseous atomizing fluid under positive pressures to said fuel burner, and control means responsive to the pressures in said liquid fuel and atomizing fluid supply conduits for automatically maintaining the atomizing fluid supplied to said fuel burner at a predetermined excess pressure over the liquid fuel pressure over a range of variations of liquid fuel pressure.

2. In combination, a fluid atomizing liquid fuel burner, conduit means for separately supplying liquid fuel and a gaseous atomizing fluid under positive pressures to said fuel burner, and a differential pressure regulating valve responsive to the pressures in said liquid fuel and atomizing fluid supply conduits for automatically maintaining the atomizing fluid supplied to said fuel burner at a predetermined excess pressure over the liquid fuel pressure over a wide range of fuel burner operation.

3. In combination, a vapor generator, a fuel burner port therein, a fluid atomizing liquid fuel burner arranged to discharge through said burner port, an air supply conduit opening to said burner port, conduit means for separately supplying liquid fuel and a gaseous atomizing fluid under positive pressures to said fuel burner, means for maintaining a predetermined volumetric ratio of the liquid fuel-air supplies in accordance with variations in load on said vapor generator, and control means for automatically maintaining the atomizing fluid supplied to said fuel burner at a predetermined excess pressure over the liquid fuel pressure over a wide range of fuel burner operation.

4. In combination, a vapor generator, a fuel burner port therein, a fluid atomizing liquid fuel burner arranged to discharge through said burner port, an air supply conduit opening to said burner port, conduit means for separately supplying liquid fuel and a gaseous atomizing fluid under positive pressures to said fuel burner, means for maintaining a predetermined volumetric ratio of the liquid fuel-air supplies in accordance with variations in load on said vapor generator, and a differential pressure regulating valve responsive to the pressures in said liquid fuel and atomizing fluid supply conduits for automatically maintaining the atomizing fluid supplied to said fuel burner at a predetermined excess pressure over the liquid fuel pressure over a wide range of fuel burner operation.

5. In combination, a vapor generator, a fuel burner port therein, a fluid atomizing liquid fuel burner arranged to discharge through said burner port, an air supply conduit opening to said burner port, conduit means for separately supplying liquid fuel and a gaseous atomizing fluid under positive pressures to said fuel burner, means for maintaining a predetermined volumetric ratio of the liquid fuel-air supplies in accordance with variations in load on said vapor generator, a differential pressure regulating valve responsive to the pressures in said liquid fuel and atomizing fluid supply conduits for automatically maintaining the atomizing fluid supplied to said fuel burner at a predetermined excess pressure over the liquid fuel pressure over a wide range of fuel burner operation, and by-pass conduit means operable to render said control means ineffective.

6. The method of operating a vapor generator fired by a fluid atomizing liquid fuel burner, which comprises maintaining a predetermined volumetric ratio of the liquid fuel and combustion air supplies to said vapor generator in accordance with variations in load on said vapor generator, and automatically maintaining the atomizing fluid supplied to said fuel burner at a predetermined excess pressure over the pressure of the liquid fuel supplied thereto over a wide range of fuel burner operation.

JACK F. SHANNON.