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Schladitz

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[54] **DEVICE FOR VAPORIZING FUEL OIL**

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[52] **U.S. Cl.** **431/208;** 431/170

[51] **Int. Cl.²** **F23D 11/44**

[58] **Field of Search** 431/11, 207, 208, 170

[56] **References Cited**

UNITED STATES PATENTS

2,507,464	5/1950	DeAndradeso	431/208
3,241,594	3/1966	Bottrill	431/11
3,326,262	6/1967	Weller et al.	431/11
3,807,939	4/1974	Carlsson et al.	431/208

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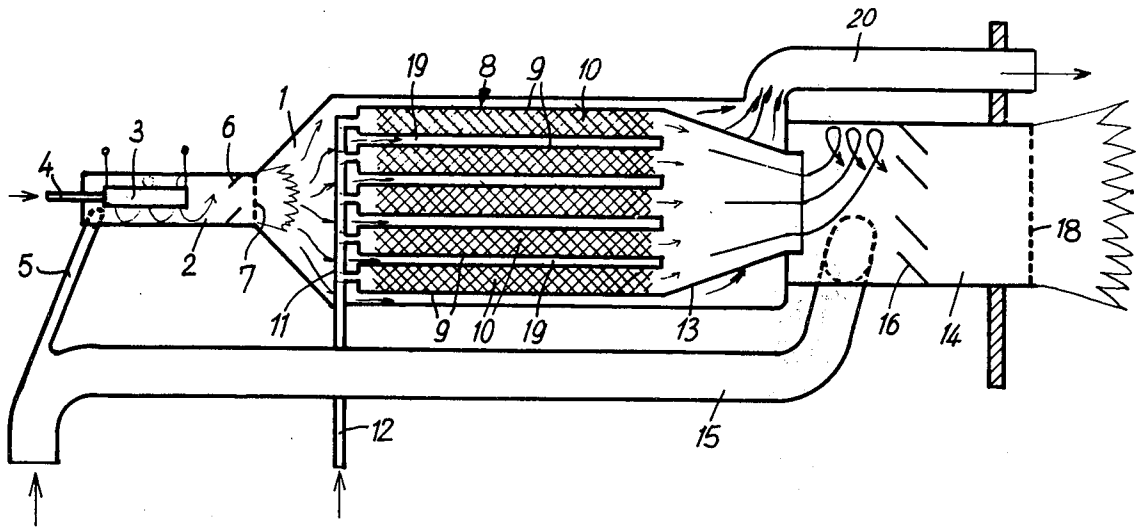
[57] **ABSTRACT**

Liquid fuel is vaporized in two or more stages. In a first stage a small quantity of fuel is passed through a porous body which is electrically heated. The resultant vapor is mixed with air and combusted, and the heat so generated is employed to vaporize a further large quantity of fuel. This is also passed through a porous body which is heated by contact with the combustion gases of the first stage.

7 Claims, 4 Drawing Figures



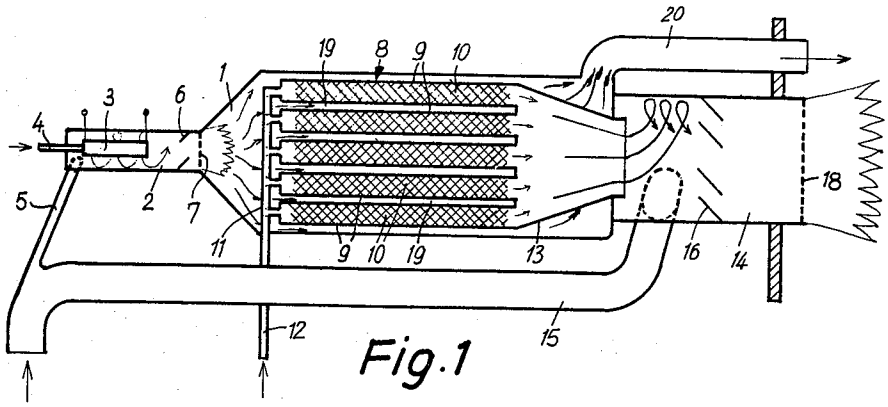


Fig.1

Fig.2

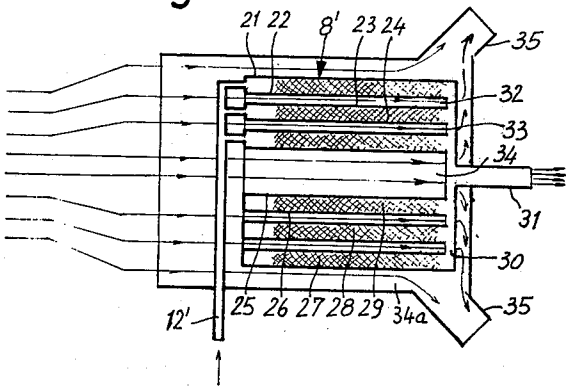


Fig.3

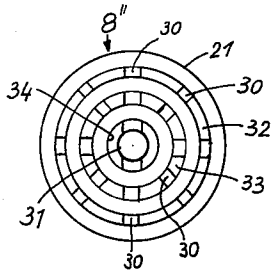
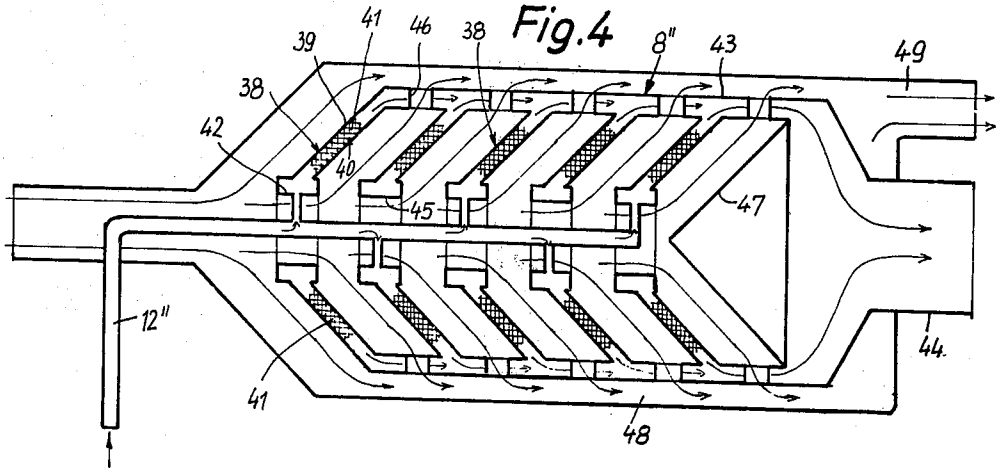


Fig.4



DEVICE FOR VAPORIZING FUEL OIL

BACKGROUND OF THE INVENTION

The invention relates to a method of an apparatus for vaporizing a liquid fuel. It is particularly concerned with vaporizing a predetermined quantity of a liquid fuel by means of a heat exchanger consisting at least partially of polycrystalline whiskers.

Heat exchangers consisting of polycrystalline metal whiskers are described for example in German Pat. No. 1,288,705. Such heat exchangers are electrically heated and are characterized by an extremely large inner surface for their overall volume, so that the medium passing through the heat exchanger can be very rapidly heated to the desired temperature. The use of this known heat exchanger as a heating element for the vaporizing of liquid fuel is particularly effective in obtaining substantially complete combustion of the fuel and thus a reduction of the harmful waste gas constituents (see *Ingenieur Digest*, Vol. 11 (1972), No. 12, pages 43, 44). In order to vaporize large quantities of liquid fuels with such an electric heating element, a correspondingly large amount of electric power is required. This is expensive and in many cases for example in motor vehicles, it is not available in sufficient quantity.

SUMMARY OF THE INVENTION

It is an object of this invention to enable a predetermined quantity of a liquid fuel to be vaporized at low cost in electrical energy.

According to one aspect of the present invention there is provided a method of vaporizing liquid fuel comprising a first stage in which liquid fuel is vaporized or atomized using an electrically heated porous body consisting at least partially of polycrystalline metal whiskers through which the liquid fuel is passed and in which the resultant fuel vapor or mist is ignited, and a second stage in which the heat of the hot combustion gases from the first stage is used in a heat exchanger consisting at least partially of polycrystalline metal whiskers for vaporizing further liquid fuel.

Thus, the heat required to vaporize the main quantity of fuel is obtained by combustion of a relatively small quantity of liquid fuel, and electrical energy is employed only to vaporize this small quantity. The cost of vaporizing the main quantity of fuel can therefore be substantially reduced. For example, with heat obtainable from 1 kg of fuel oil, approximately 26 kg of fuel oil can be vaporized, while for the vaporizing of 1 kg of fuel oil solely by electrical energy some 540 watts would be needed.

Preferably, the same fuel is used for the first and second stages, although in principle it is possible to use different fuels for the two stages, for example a fuel having a higher calorific value and/or lower boiling point for the first stage in order that the porous body may be kept as small as possible.

The method may be used to vaporize fuel oil for oil-fired heating installations or to vaporize diesel oil or petrol to operate an internal combustion engine. In both cases the vaporous condition of the fuel permits intense blending with air so that a more complete combustion and thus a better utilization of energy can be achieved, together with a diminution of harmful emissions. Preferably turbulence in the mixing chambers will be generated further to improve this blending.

The fuel vapour produced in the second stage need not be fed directly to the final consumer unit but may be ignited and used to vaporize a further correspondingly larger quantity of fuel. This three-stage method can be ideal for industrial heating installations which require a very large amount of heat. If necessary, more than three stages can be connected in series.

According to another aspect of the present invention there is provided apparatus for vaporizing liquid fuel comprising an electrically heatable porous body consisting at least partially of polycrystalline metal whiskers, means for supplying liquid fuel to the porous body, a first mixing chamber into which said body delivers, an air source connected to said first mixing chamber, a first combustion chamber into which said first mixing chamber discharges a heat exchanger consisting at least partially of polycrystalline metal whiskers and adjacent the first combustion chamber, the heat exchanger being arranged to be heated by hot combustion gases from the fuel burned in the first combustion chamber and providing heat exchange paths for a liquid fuel which is to be vaporized thereby, a second mixing chamber adjacent the heat exchanger and into which said paths deliver, an air source connected to said second mixing chamber, and a second combustion chamber into which said second mixing chamber discharges.

In one preferred form the heat exchanger includes tubes which are externally exposed to the hot combustion gases and are arranged to be internally traversed by the liquid fuel, each tube being at least partially filled with said whiskers, which are in heat-conductive contact with the walls of the tubes.

In another preferred form the heat exchanger includes at least on pair of co-axial tubes, the inside of the inner tube and the outside of the outer tube being exposed to the hot combustion gases, and the annular intermediate space between the two tubes being at least partially filled with said whiskers in heat conductive contact with the tube walls and arranged to be traversed by the liquid fuel.

The heat exchanger may alternatively include at least one pair of co-axial funnel-shaped members defining a funnel-shaped space between them, the sides of said members facing away from said space being exposed to the hot combustion gases, and said space being at least partially filled with said whiskers in heat conductive contact with said members and arranged to be traversed from inside outwardly by the liquid fuel. This embodiment has the advantage that the fuel, which increases its volume during vaporizing as it flows through the funnel-shaped annular gap from the inside outwardly, finds an ever-increasing pore volume, so substantially obviating the risk of clogging by deposits of the vaporized or still-to-be vaporized fuel oil. Such funnel-shaped heat exchangers can be disposed serially in any desired number, and arranged so that the liquid fuel is fed to all of them for each to vaporize a proportion of the fuel. The heat exchangers are conveniently enclosed by a casing which holds the evaporated fuel and conveys it to the consumer unit.

The mixing chambers of both stages can be supplied with air for combustion by a common suction or pressure blower. The supply of air to the mixing chambers is effected preferably in a tangential direction in order to achieve an eddy formation and thus a satisfactory blending of the air with the fuel vapor.

The first mixing chamber can also be constructed as a tube in which the porous body is coaxially disposed, and means can be provided in the tube to create turbulence in the air thereby to assist mixture with the vaporized or atomized fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention some constructional forms will now be described by way of example, with reference to the accompanying drawing, in which:

FIG. 1 is a diagrammatic longitudinal section of fuel vaporizing apparatus according to the invention, including a heat exchanger;

FIG. 2 is a longitudinal section of another heat exchanger which can be used in the apparatus of FIG. 1;

FIG. 3 is an end view of the heat exchanger of FIG. 2, viewed from the right of that figure; and

FIG. 4 is a longitudinal section through a third heat exchanger which can be used in the apparatus of FIG. 1.

DETAILED DESCRIPTION

Reference will first be made to FIG. 1, which shows apparatus for vaporizing predetermined quantities of fuel oil to operate a heating boiler.

The apparatus illustrated has a first combustion chamber 1 into which a first mixing chamber 2 discharges. Coaxially disposed in the tubular mixing chamber 2 is a cylindrical porous body 3 which consists at least partially of polycrystalline metal whiskers and into which leads a line 4 which supplies the fuel oil which is to be vaporized. The porous body 3 is constructed as an electric heating element and is so heated by electric current that the through-flowing fuel oil emerges in vapor or atomized form from the downstream end (the right hand end as viewed in the Figure) of the porous body 3 into the mixing chamber 2. Porous bodies of this type which can be used as electric heating elements are described inter alia in German Pat. No. 1,288,705 and U.S. Pat. application Ser. Nos. 358,344, filed May 8, 1973 and 453,497 filed Mar. 21, 1974.

An air supply line 5 discharges tangentially into the mixing chamber 2 and so produces an air eddy, indicated by the helical arrow in the mixing chamber 2. This causes intensive blending of the air with the fuel oil vapor or mist emerging from the porous body 3. For additional turbulence there is also provided a baffle 6 in the mixing chamber 2. The combustion chamber end of the mixing chamber 2 is defined by a filter 7. The mixing chamber 2 also contains a device (not shown) for igniting the fuel-oil mixture, which burns with a blue non-sooting flame in the combustion chamber 1.

Following the combustion chamber 1 in the downstream direction is a heat exchanger generally designated by reference numeral 8 and which in the embodiment of FIG. 1 consists of a plurality of parallel tubes 9, wholly or partly filled with polycrystalline metal whiskers in heat-conductive communication with the inner walls of the tubes. The left hand ends of the tubes 9 communicate with an oil feed line 12 through a distributor manifold 11. The fuel source may be common to lines 4 and 12. The right hand ends of the tubes 9 open into a funnel 13 which discharges into a second mixing chamber 14. This also has an air supply line 15 delivering air tangentially into its upstream end, the air being supplied from the same compressed air source as the line 5. Baffle plates 16 are disposed in the mixing chamber 14 to add to the turbulence. The mixing chamber 14 discharges into a combustion chamber 17 of a heating boiler and its downstream end is defined by a screen or filter 18.

The hot combustion gases from the combustion chamber 1 flow along the intermediate spaces 19 between the tubes 9 of the heat exchanger 8 and around the latter. The tubes 9 and the whiskers 10 contained in them are so intensely heated by these gases that the oil fed through the line 12 emerges into the funnel 13 in vapor form. The oil vapor passes into the mixing chamber 14 where it is blended with air from the line 15. This mixture is encouraged by the tangential supply of air creating turbulence as well as by the baffle plates 16. The fuel-air mixture is ignited by an ignition device (not shown) and burns with a blue flame in the combustion chamber 17. The combustion gases from the chamber 1 which flow around the heat exchanger 8 pass through a waste-gas tube 20 and likewise into the combustion chamber 17.

With this apparatus as much fuel oil is vaporized by means of the electric heating element 3, and then ignited as is sufficient to vaporize in the heat exchange 8 the quantity of fuel oil required to operate the heating boiler. The electrical energy to be expended is therefore minimal. This is aided by the fuel oil being supplied through the line 4 under pressure, so that a mechanical diminution of the oil droplets occurs as the fuel oil flows through the porous heating element 3.

The heat exchanger 8 may be constructed in accordance with the previously mentioned German Patent and U.S. Pat. applications.

The heat exchanger 8′ shown in FIGS. 2 and 3 can be used instead of the heat exchanger 8 of FIG. 1. The exchanger 8′ consists of six coaxial tubes 21, 22, 23, 24, 25 and 26, paired off to provide three radially separated annular spaces 27, 28 and 29, each of which contains a porous whisker skeleton. Their left hand ends as seen in FIG. 2, are connected to an oil feed tube 12′. The right hand ends of these annular spaces 27, 28 and 29 communicate through radial tubes 30 with a central tube 31 from which the oil vapor can emerge into the mixing chamber. The remaining intermediate annular spaces 32 and 33 formed by the co-axial tubes, the central duct 34 and the outer annular space 34a are traversed by hot combustion gases from the combustion chamber 1, these finally being passed through an outlet nozzle 35 into the combustion chamber 17 of the heating boiler.

The heat exchanger 8″ of FIG. 4 which can likewise be used instead of the heat exchanger 8 of FIG. 1, consists of a plurality of co-axial serially-disposed funnel-shaped member 38 nested together in spaced relationship. Each member 38 forms a heat exchanger element having two parallel frusto-conical walls 39 and 40 between which there is a whisker skeleton 41. The funnel-shaped members 38 are connected for in-parallel flow of fuel oil, the supply being through line 12″ to the inner periphery 42 of each funnel-shaped member 38 and the oil vapor being carried away at the outer periphery through a double shell 43, into which the spaces between the walls 39, 40 of each funnel-shaped member 38 discharge. The double shell 43 continues in a tube nozzle 44 through which the oil vapor is fed to the mixing chamber and then to the combustion chamber of the heating boiler. The heating gases from the

combustion chamber 1 flow externally along the double shell 43 and internally through the central duct formed by the inner peripheral faces 45 of the funnel-shaped members 38, the latter heating gases branching off to flow radially outwardly between adjacent funnel-shaped members 38 and through the double shell 43 by means of ports 46 into outer annular space 48. At the right hand or downstream end of the heat exchanger 8'' there is a conical closure plate 47 which deflects the remaining heating gases which have flowed centrally through the heat exchanger radially outwardly. The heating gases are conveyed into the combustion chamber of the heating boiler through the nozzle 49.

This construction has the advantage that the pore volume of the whisker skeleton 41 in each funnel-shaped member 38 is greater at the radially outer edge portion than it is on the inner one. Thus the fuel oil which is heated as it passes through the whisker skeleton from the inside outwardly and so increases its volume, finds a correspondingly larger pore volume. Therefore the risk of clogging by deposits is substantially reduced.

Thus the several aforenoted objects and advantages are most effectively attained. Although several somewhat preferred embodiments have been disclosed and described in detail herein, it should be understood that this invention is in no sense limited thereby and its scope is to be determined by that of the appended claims.

I claim:

1. Apparatus for vaporizing liquid fuel comprising an electrically heatable porous body composed at least partially of polycrystalline metal whiskers, means for supplying liquid fuel to the porous body, a first mixing chamber into which said body delivers, an air source connected to said first mixing chamber, a first combustion chamber into which said first mixing chamber discharges, a heat exchanger composed at least partially of polycrystalline metal whiskers and adjacent the first combustion chamber, the heat exchanger being arranged to be heated by hot combustion gases from the fuel burned in the first combustion chamber and providing heat exchange paths for a liquid fuel which is to be vaporized thereby, a second mixing chamber adjacent the heat exchanger and into which said paths deliver, an air source connected to said second mixing chamber, and a second combustion chamber into which said second mixing chamber discharges.

2. Apparatus according to claim 1, wherein the heat exchanger includes tubes which are externally exposed to the hot combustion gases and are arranged to be internally traversed by the liquid fuel, each tube being at least partially filled with said whiskers, which are in heat-conductive contact with the walls of the tubes.

3. Apparatus according to claim 1, wherein the heat exchanger includes at least one pair of co-axial tubes, the inside of the inner tube and the outside of the outer tube being exposed to the hot combustion gases, and the annular intermediate space between the two tubes being at least partially filled with said whiskers in heat conductive contact with the tube walls and arranged to be traversed by the liquid fuel.

4. Apparatus according to claim 1, wherein the heat exchanger includes at least one pair of co-axial funnel-shaped members defining a funnel-shaped space between them, the sides of said members facing away from said space being exposed to the hot combustion gases, and said space being at least partially filled with said whiskers in heat conductive contact with said members and arranged to be traversed from inside outwardly by the liquid fuel.

5. Apparatus according to claim 1, wherein the two mixing chambers are connected to a common source of compressed air.

6. Apparatus according to claim 1, wherein the first mixing chamber is constructed as a tube in which the porous body is coaxially disposed, and means are provided in the tube to create turbulence in the air thereby to assist mixture with the vaporized or atomized fuel.

7. Apparatus according to claim 1, wherein the connection of at least one air source to the associated mixing chamber is substantially tangential thereto.

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