United States Patent

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[33] France
[31] 172477

[54] **IMPROVEMENTS IN LIQUID FUEL VAPORIZING COMBUSTION SYSTEMS**
5 Claims, 6 Drawing Figs.

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[51] Int. Cl. F02c 3/22
[50] Field of Search 60/39.71, 39.74; 431/248, 247

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ABSTRACT: A T-shaped liquid fuel prevaporizing device for a combustion chamber, said device comprising a tubular shank projecting into the combustion chamber and two arms projecting from the downstream section of said shank to open into the combustion chamber, wherein overheating of the device is minimized by compartmenting the downstream section of the tubular shank by longitudinal partitions to form separate but intercommunicating passages which are selectively fed with combustion air alone and with fuel/air mixture.

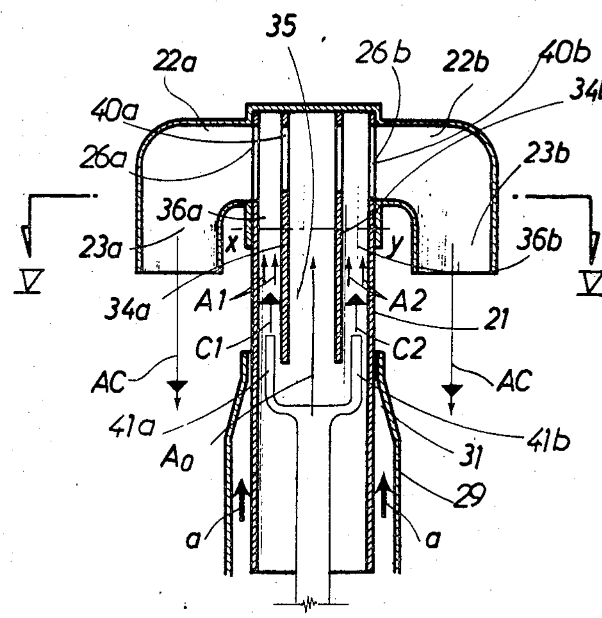


FIG.: 1
PRIOR ART

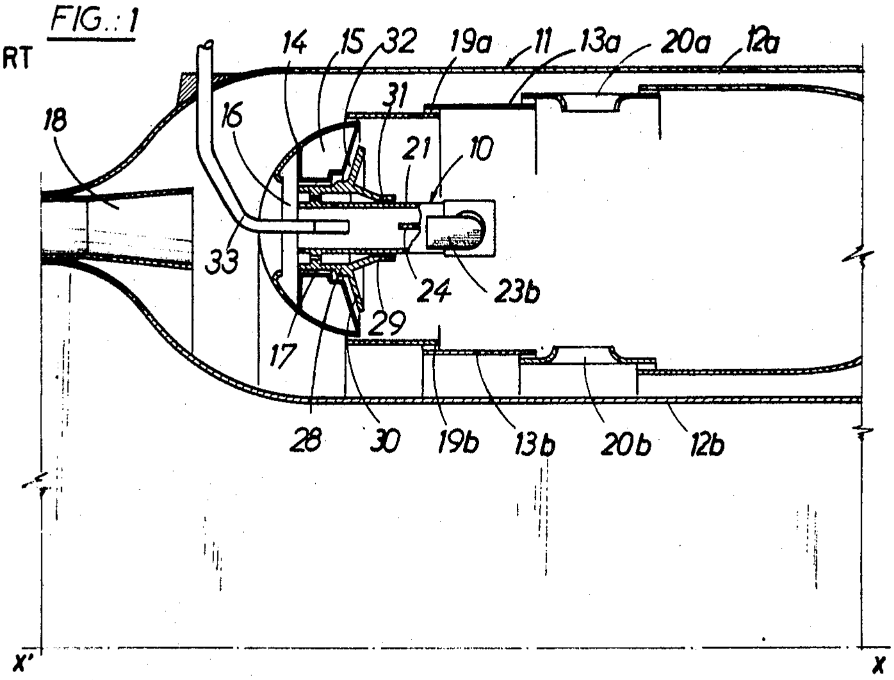


FIG.: 2
PRIOR ART

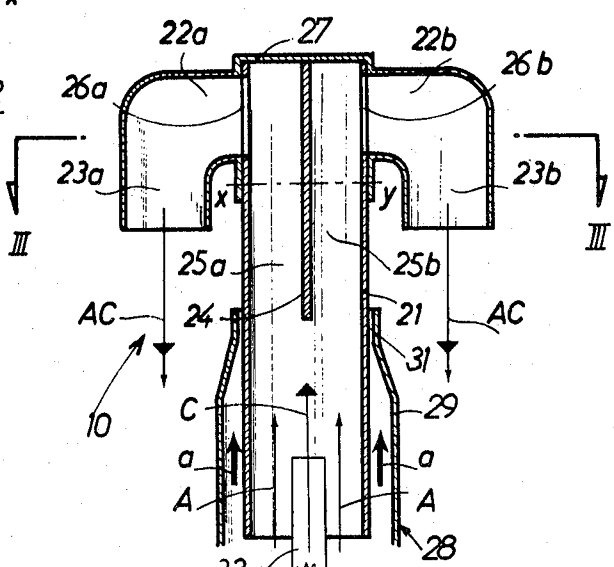


FIG.: 3
PRIOR ART

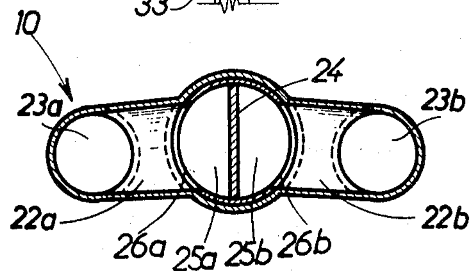


FIG.: 4

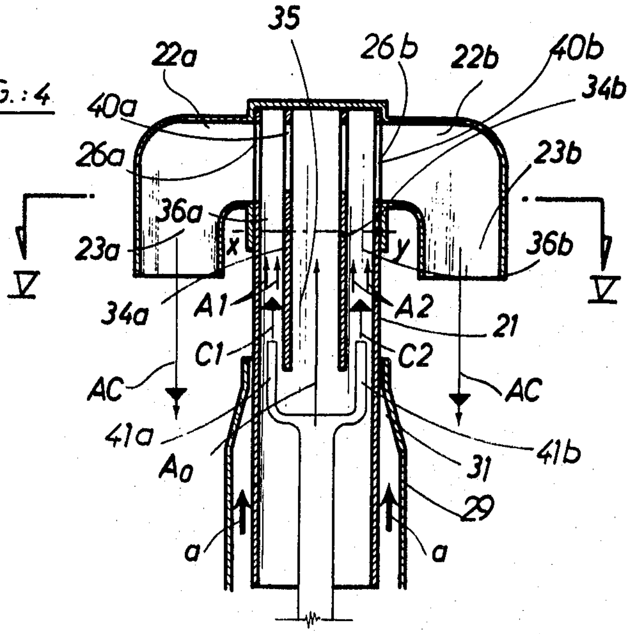


FIG. : 5

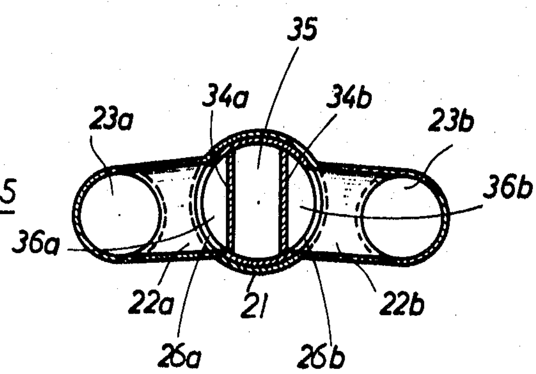
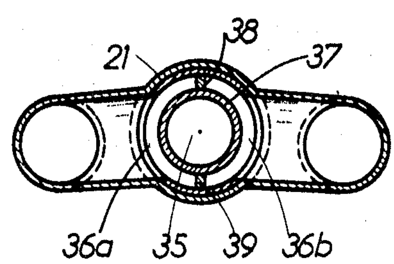


FIG.:5a



IMPROVEMENTS IN LIQUID FUEL VAPORIZING COMBUSTION SYSTEMS

This invention relates generally to combustion systems, more especially in gas-turbine motive-power installations, having, in combination, a combustion chamber including an annular end wall, a source of liquid fuel and a source of combustion air, and a plurality of tubular liquid fuel vaporizers mounted to project into the combustion chamber from said annular end wall thereof.

Liquid fuel vaporizers are already known which consist of a T-shaped hollow structure having a shank projecting longitudinally within the combustion chamber and which, at one of its ends, communicates with the sources of liquid fuel and of combustion air, and, in the vicinity of its other end, opens into the combustion chamber through two lateral arms branching off from the said shank in a substantially symmetrical manner.

While the said vaporizers may have shown themselves to operate sufficiently as regards to the vaporization of the fuel, on the other hand they have presented a problem as regards to the thermal protection of the walls which bound them, in particular in the zone comprising the lateral arms mentioned above, which are subject to the extremely high temperatures prevailing in the upstream portion of the combustion chamber.

It has been established, more particularly, that, when the temperature of the air penetrating into the vaporizer is high, complete vaporization of the fuel takes place well before the fuel enters the lateral arms of the vaporizer, with the consequence that the lateral arms are subject to inadmissable overheating due to the absence of any cooling effect contributed by the vaporization of the fuel.

This is more particularly the care in modern installations in which the air is subject to a high compression ratio, or, alternatively, where this air is preheated by heat-exchange with hot combustion gases.

The present invention has for its object an improvement in combustion systems devices of the type mentioned above, and aims to combat the drawbacks just referred to by transferring the vaporization of the fuel into the most exposed zone of the vaporizer.

According to the present invention, the shank of the T-shaped hollow structure is compartmented by means of a system of longitudinal partitions, in such a way as to define a central passage to be supplied solely with combustion air, and two lateral passages to be supplied simultaneously with combustion air and with liquid fuel, the said passages being intercommunicating and also communicating with the arms of the T-shaped hollow structure.

According to one embodiment, the compartmentation of the shank is effected by means of two flat longitudinal partitions running substantially parallel and bounding a central passage which is included between two lateral passages, the said partitions being perforated by communicating orifices in the region where the lateral ducts branch off.

According to another embodiment, the compartmentation of the shank is effected by means of an inner partition which is substantially coaxial with the axis of the shank and which defines the central passage, and by means of two transverse partitions which divide the peripheral space included between the shank and the inner partition into the lateral passages.

According to one arrangement of the invention, the cross-sectional area of the central passage is greater than the sum of the cross-sectional areas of the lateral passages.

According to a further embodiment, each of the lateral arms of the vaporizer are bent round so that its outlet end faces the annular end wall of the combustion chamber.

In operation the flow-rate of air in the lateral passages is insufficient to supply the amount of heat necessary for the fuel to vaporize, with the consequence that the major part of this fuel remains in the liquid state and is thus able to penetrate in the form of droplets into the most exposed zone of the vaporizer.

The fuel is then able to vaporize in this zone, this ensuring effective protection against occurrences of overheating.

The following description referring to the accompanying drawings is given by way of nonlimitative example to indicate how the invention may be carried into practice.

In the drawings:

FIG. 1 is a view, in fractional section taken along an axial plane, of a combustion system of known type, equipped with a liquid fuel vaporizer likewise of known type;

FIG. 2 is a view on a larger scale, and in longitudinal section, of the known type of prevaporizer shown in FIG. 1;

FIG. 3 is a view, in section taken along the line III—III of the known type of prevaporizer illustrated in FIG. 2;

FIG. 4 is a view similar to FIG. 2, showing a liquid fuel vaporizer in accordance with the present invention;

FIG. 5 is a view, in section taken along the line V—V of the liquid fuel vaporizer illustrated in FIG. 4;

FIG. 5*a* shows a view similar to FIG. 5, but according to a modified version of the present invention.

Referring first to FIGS. 1 to 3, the general reference numeral **10** has been used to denote an already known T-shaped liquid fuel vaporizer fitted into a combustion system **11**, likewise of known type.

The combustion system comprises an annular combustion chamber having an outer casing **12*a*** and an inner casing **12*b*** which are substantially coaxial and which jointly define an annular space inside which two substantially coaxial walls **13*a*–13** bound an annular flame tube in which combustion occurs. The latter flame tube is closed off in its upstream portion by an annular end wall or "done" **14** which cooperates with an annular supporting structure **15**. The annular end wall or dome **14** and the annular structure **15** are pierced by aligned orifices **16**, **17** which are distributed uniformly about the axis x–x 'of the combustion chamber.

The reference numeral **18** has been used to denote a source of combustion supporter, for example compressed air. The air travels in the annular space included between the casings **12*a*–12** and the flame tube, and penetrates into the combustion space in the form of primary air through orifices **16**, and in the form of secondary air, cooling air and dilution air through orifices such as those at **19*a***, **19*b***, **20*a***, **20*b***. In its downstream section, the combustion system **11** may be followed by an expansion turbine (not shown).

The liquid fuel vaporizer **10** in the example shown here forms part of a series of similar vaporizers, each of which is inserted through a respective orifice **17**.

As is shown in greater detail in FIGS. 2 and 3, each fuel vaporizer **10** comprises a tubular shank **21** of which the upstream portion occupies the orifice **17** and the downstream portion branches off into two lateral arms **22*a***and **22*b***curving back upstream at **23*a***, **23*b***. A longitudinal partition **24** divides the shank **21** into two passages or compartments **25*a***, **25*b***, which communicate with the lateral arms **22*a***, **22*b*** respectively by way of orifices **26*a***, **26*b*** formed in the wall of the shank **21**. In its downstream portion, the shank **21** is closed off by an end plate **27**.

The orifice **17** is so dimensioned as to render it possible to place a member **28** around the shank **21**, which member may sometimes be integral with the shank. This member possesses two extensions, **29** and **30**, which define two passages **31** and **32** (see FIG. 1) permitting direct entry into the combustion space of a small fraction of the flow rate of primary air. The reference numeral **33** denotes a source of liquid fuel.

In operation, the major portion of the flow of primary air, indicated by the arrows A, effects penetration simultaneously with the liquid fuel, indicated by the arrow C, into the upstream end of the shank **21**. The said air is at a relatively high temperature due to the compression it has previously undergone, and in certain instances due to the recuperation in a suitable heat exchanger (not shown) of a proportion of the heat from the exhaust gases from the turbine. The amount of heat contained by it is sufficient, also taking into account the addition of extra heat originating in the combustion space and transmitted through the walls bounding the fuel vaporization **19**, to bring about the complete vaporization of the liquid fuel. At its exit from the arms **22*a* –22*b*** the vaporized fuel/air mixture, indicated by the arrows AC, is directed towards the upstream zone of the combustion space in such a way as to promote in an already known manner the recirculation upstream of a portion of the flow then undergoing combustion.

As has been explained hereinbefore, a problem arises when the temperature of the combustion gases reaches very high values in the upstream zone of the combustion space, that is, the problem of ensuring thermal protection for the walls bounding the fuel vaporizers. This protection is to a certain degree ensured, for the upstream section of the shank 21, by virtue of the presence of an insulating cushion formed by the vaporized fuel/air mixture, too rich to burn, escaping from the arms 22*a*–2222*b*and likewise by virtue of the presence of the weak flow rate of air, indicated by the arrows *a*, which passes along the passages 31 and forms an insulating layer around the shank 21. Nevertheless, the most effective protection, especially for the walls of the bent lateral arms 22*a*,22*b*,which project furthest into the heart of the combustion space, is that which comes about from the cooling of the said walls as a consequence of the vaporization of the fuel.

Experience has shown, however, that when the temperature of the primary air is relatively high, more especially in installations with a high compression ratio and/or provided with a device to recover heat from the exhaust gases, complete vaporization of the fuel takes place well before the fuel enters the lateral arms 22*a* –22*b*, for example at the level shown in FIG. 2 by the broken line *x–y*, so that the bent lateral arms 22*a*, 22*b*, which are most exposed to the heat from the combustion gases, are subject to inadmissible instances of overheating in the absence of any cooling through the vaporization of fuel.

FIGS. 4 and 5 show an embodiment of a liquid fuel vaporizer in accordance with the present invention.

As in the case of FIGS. 1 to 3, the vaporizer comprises a hollow T-shaped structure having a shank 21 and two lateral arms 22*a*, 22*b*, shank being surrounded by a passage 31 wherethrough a weak flow rate of air flows, as indicated by the arrows *a*, so as to form an insulating layer around the shank 21.

According to the invention, shank 21 is compartmented, at least along the downstream portion of its length, by a system of longitudinal partitions in such a way as to define a central passage 35 and two flanking side passages 36*a*, 36*b*.

The said partitions may be flat and substantially parallel, as are, for example, the partitions 34*a*, 34*b*, shown in FIG. 5. But this arrangement is in no way mandatory, as is shown, in particular, by FIG. 5*a*, which relates to a modified version according to which the central passage 35 is bounded by a partition 37 which is substantially coaxial with the axis of the shank 21, while the flanking side passages 36*a*, 36*b*, result from the division into two passages for the peripheral space included between the shank 21 and the partition 37 by means of two transverse partitions 38, 39, which are substantially oppositely situated with respect to the axis.

Opposite the orifices 26*a*, 26*b*, the partitions 34*a*, 34*b*, (or the partition 37) are pierced by orifices 40*a*, 40*b*, which place the lateral arms 22*a*, 22*b*, the flanking side passages 36*a*, 36*b* and the central passage 35 all in communication with one another. At the entrance to each of the flanking side passages 36*a*, 36*b* a liquid-fuel injector 41*a*, 41*b*is provided.

The central passage preferably has a cross-section area of exceeding that of the sum of the cross-sectional areas of the two flanking side lateral passages, so that only a small fraction of the flow rate of primary air, as indicated by the arrows A_1, A_2, is directed along the lateral passages 36*a*, 36*b*into which the injection of liquid fuel is carried out, while the greater portion of the said primary air, indicated by the arrow A_0, passes along the central passage 35, which lacks a fuel injector. The small fraction from the flow rate of primary air that is mixed with fuel in the flanking side passages is so set as to be just sufficient to prevent the occurrence of any possible phenomena of cracking or coking of the fuel.

In operation, the flow rate of air available along the flanking side lateral passages is insufficient to supply the amount of heat necessary for the complete vaporization of the fuel, so that the greater portion of the latter remains in the liquid state, even beyond the level *x–y* . It is consequently in the form of droplets that the fuel, after having reached the downstream zone of the shank 21, is drawn towards the lateral arms 22*a*22*b*, by the remainder, that is, by the greater portion of the flow rate of air, which is fed through the central duct and passes through the orifices 26*a*, 40*a*, 26*b*, 40*b*.

The vaporization of the fuel is thus retarded and is transferred to the lateral arms 22*a*, 22*b*, where it ensures an intense lowering of the temperature, and consequently effective protection against any overheating of the walls of the prevaporizer.

It will be apparent that the embodiments described are examples only and that it would be possible to modify them in various ways within the scope of the invention, as defined by the appended claims.

We claim:

1. A combustion system having, in combustion,
   - a combustion chamber including an annular end wall;
   - a source of liquid fuel and a source of combustion air; and
   - a plurality of tubular liquid fuel vaporizers mounted to project into the combustion chamber from said annular end wall thereof, each of said fuel vaporizers comprising:
   - a tubular shank projecting longitudinally within the combustion chamber and having an open end adjacent said annular end wall and a closed end remote therefrom;
     - two tubular arms each of which branches off laterally from said shank remote from said annular wall and has a free end which opens into the combustion chamber, said shank and said arms forming together an interconnected T-shaped hollow structure with an inlet opening at the open end of the shank and an outlet opening at the free end of each of said two arms;
     - partitions disposed longitudinally within the shank of subdivide said shank into a central passage and two flanking side passages, said partitions being interrupted generally in the region of said laterally branching tubular areas to place said central passage in communication in said region with said flanking side passages and with said tubular arms;
     - means for supplying through the inlet opening of the T-shaped hollow structure all of said three passages with combustion air and only the flanking side passages with the liquid fuel to be vaporized, whereby said fuel is contacted with limited amounts of combustion air before being combined with the remainder of the combustion air for egress through said lateral arms.

2. A system according to claim 1, wherein the longitudinal partitions consist of two substantially planar and substantially parallel partitions perforated to provide orifices for intercommunication.

3. A system according to claim 1, wherein the longitudinal partitions consist of an inner tubular portion substantially coaxial with the axis of the tubular shank and two transverse partitions subdividing the peripheral space included between said portion and said shank.

4. A system according to claim 1, wherein the cross-sectional area of the central passage is greater than the sum of the cross-sectional areas of the two flanking side passages.

5. A system according to claim 1, wherein each of the two arms of the T-shaped hollow structure is bent round to have its free end facing said annular end wall of the combustion chamber.

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