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Nederlof

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[54] **HEATER FOR HOT-GAS ENGINE**

[75] Inventor: **Anton Marie Nederlof,** Emmasingel, Eindhoven, Netherlands

[73] Assignee: **U.S. Philips Corporation,** New York, N.Y.

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[51] **Int. Cl.** **F02g 1/06**

[58] **Field of Search** 60/516, 517, 524; 73/349, 73/359

[56] **References Cited**

UNITED STATES PATENTS

1,785,662	12/1930	Waterloo	73/349
3,456,438	7/1969	Meijer et al.	60/24
3,780,584	12/1973	Long et al.	73/349
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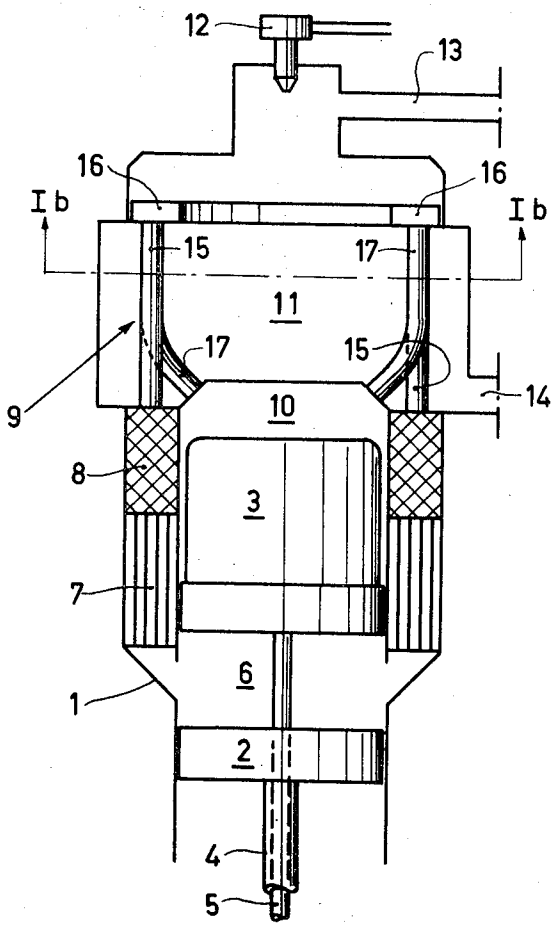
Primary Examiner—Irwin C. Cohen
Assistant Examiner—Allen M. Ostrager
Attorney, Agent, or Firm—Frank R. Trifari

[57] **ABSTRACT**

A hot-gas engine having a heater comprising at least one row of pipes arranged in a circle around a space for combustion gases, at least one pipe being wider than the remaining pipes in a radial direction of the circle.

4 Claims, 2 Drawing Figures



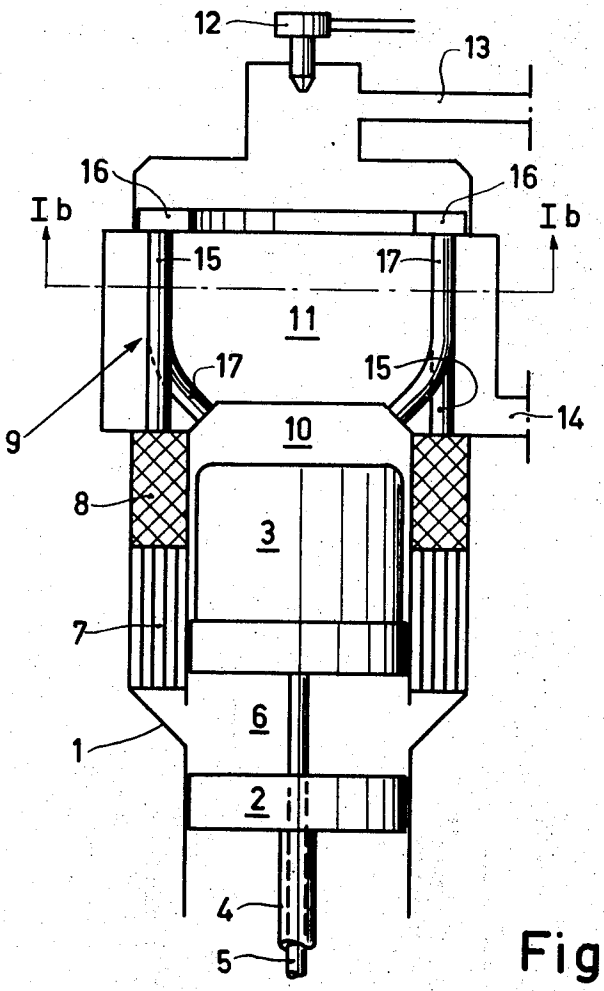


Fig. 1a

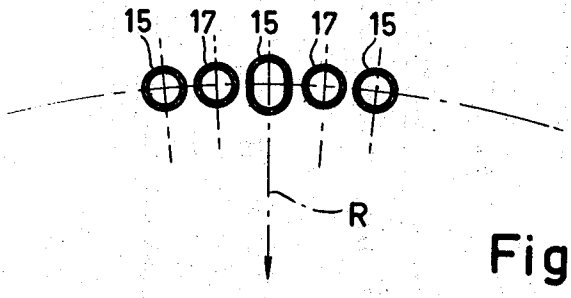


Fig. 1b

HEATER FOR HOT-GAS ENGINE

BACKGROUND OF THE INVENTION

The invention relates to a hot-gas engine comprising a heater having at least one row of pipes of equal wall thicknesses arranged around a space for combustion gases and extending mutually mainly in parallel. The center lines of these pipes are located on a common circle, the pipes having the same widths in the tangential direction of the circle and equal passages for gases of combustion being present between the pipes.

Hot-gas engines of the present type are known, for example, from Dutch Pat. Nos. 82,253 and 99,795 and British Pat. No. 1,053,052. In these known hot-gas engines the heater consists of a number of circular pipes of the same diameter. The combustion gases flow around the heater pipes while giving off thermal energy through the walls of the pipes to the working medium of the engine flowing through said pipes, said medium performing a thermodynamic cycle in a closed working space of the engine. Since the pipes which are arranged in a circle have the same wall thicknesses and diameters and the same passages are present between the pipes, a heater transfer occurs which is uniformly divided between the various pipes and is substantially the same for each pipe. All heater pipes are substantially at the same temperature.

For control purposes (control air/fuel ratio; power control etc.) the temperature of the working medium in the heater pipes often serves as a parameter. For that purpose, temperature-sensitive elements, for example thermocouples, are provided in one or more heater pipes.

This suffers from the drawback that the passage of the relevant heater pipe is reduced and the resistance to flow thereof is increased. Consequently, the working medium-mass flow through such pipe changes and the flow rate increases. The heat transfer for this pipe then deviates from that of the remaining pipes. The result of this is that the value for the working medium temperature provided by the temperature-sensitive element deviates from the temperature prevailing in all the other pipes and relevant for control purposes. So an incorrect temperature signal is supplied to the control system in which the temperature of the working medium in the heater pipes serves as a parameter, as a result of which the control becomes inaccurate and unreliable.

SUMMARY OF THE NEW INVENTION

It is the object of the invention to avoid the above drawback in a simple and inexpensive manner. In order to realize such objective, the hot-gas engine according to the invention is characterized in that at least one pipe is present which, at least over a part of its longitudinal dimension, is wider in a radial direction of the circle than the remaining pipes.

The widening of the pipe in a radial direction results in the following advantages. First of all, the passage (hydraulic diameter) of said pipe is larger than that of the remaining pipes. The enlargement of the passage provides an extra space in which the temperature-sensitive element can be accommodated so that after assembly of said element the remaining passage (hydraulic diameter) corresponds to that of the remaining pipes.

Since the widening is provided in a radial direction, and the pipe width in a tangential direction is therefore

unvaried, the pipe can remain arranged on the common circle while maintaining the passage between said pipe and the adjacent pipes which is equal to the passage between the remaining pipes mutually. The heat transfer for the widened pipe then is substantially identical to that for the remaining pipes.

Since the widened pipe can be maintained on the common circle while maintaining the passages between the pipes which are the same everywhere, the upper end of the widened pipe, in the cases in which all the upper ends of the pipes open into an annular duct (British Pat. No. 1,053,052; Dutch Pat. No. 99,975) remains opening into the same place in said annular duct. The advantage thereof is that the annular duct need not be constructed unnecessarily wide.

If for the widened pipe a circular pipe of a larger diameter than the remaining circular pipes would be used, and if said pipe is arranged on the common circle, on the one hand the symmetry of the pipe arrangement would be disturbed, since the remaining pipes of smaller diameter have to be displaced so as to obtain the same passages between all the pipes, on the other hand, due to the larger pipe width in the tangential direction of the circle, the heat transfer to the pipe having the larger diameter would differ since the combustion gases flow against a larger pipe surface area.

By arranging a pipe having a larger diameter outside the common circle it can be achieved that the passage between said pipe and the adjacent pipes is equal to that between the remaining pipes. However, the two drawbacks remain that the gases of combustion flow against a larger pipe surface area and that the upper end of the pipe having the larger diameter opens into a place outside the annular duct. In order to avoid the latter, special structural measures would again be required, for example, widening of the annular duct or the provision of a curved member to communicate the upper end of the pipe of larger diameter with the annular duct. All this makes the heater construction complicated and expensive and is therefore undesirable.

The construction according to the invention on the contrary can be made in a simple and inexpensive manner, for example, by starting from a circular pipe of a larger diameter which is flattened in one direction in such manner that a pipe width is obtained which is equal to the diameter of the remaining pipes. Widening of the pipe in the direction at right angles to the direction of flattening then automatically occurs.

The invention will now be described in greater detail with reference to the drawing which shows diagrammatically and not to scale an embodiment of a hot-gas engine having a heater constructed from pipes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1*a* is a sectional elevation view of the new invention, and

FIG. 1*b* is a partial sectional view taken along lines 1*b*—1*b* of FIG. 1*a*.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference numeral 1 in FIG. 1*a* denotes a cylinder in which a piston 2 and a displacer 3 can reciprocate with a mutual phase difference. The piston 2 and the displacer 3 are connected to a driving mechanism not shown by means of a piston rod 4 and a displacer rod 5, respectively. Between the piston 2 and the displacer

3 is present a compression space **6** which communicates with an expansion space **10** above the displacer via a cooler **7**, a regenerator **8** and a heater **9**. The heater **9** is formed by a row of pipes arranged in a circle around a space **11** for combustion gases. Furthermore are present a burner **12** and an inlet **13** for air of combustion, as well as an outlet **14** for combustion gases.

The heater **9** consists of a number of first pipes **15** which communicate at one end with the regenerator **8** and at the other end open into an annular duct **16** and a number of second pipes **17** alternating with the first pipes **15** and communicating the annular duct **16** with the expansion space **10.** In order to avoid complexity of the drawing, only two sets of first and second pipes are shown.

During operation of the hot-gas engine, the hot combustion gases originating from burner **12** and inlet **13** flow past the first pipes **15** and second pipes **17**, while giving off thermal energy to said pipes, and leave the engine via outlet **14.**

As may be seen from FIG. **1***b*, which is a cross-sectional view taken on the line *1b—1b* of FIG. **1***a* of a few of the pipes arranged on a common circle of radius R, the pipes have equal wall thicknesses and equal widths in tangential direction of the circle while furthermore they are arranged so that the same passages are present between the pipes mutually.

Of the pipes shown, the central pipe **15** is widened in the radial direction of the circle relative to the other pipes. Consequently, said pipe has a larger hydraulic diameter. The extra space resulting from the widening is now available for accommodating one or more temperature-sensitive elements, for example thermocouples. After mounting these, a passage remains in the widened pipe which is equal to the passage of the remaining pipes. Since the central pipe **15** has a width in the tangential direction of the circle equal to the diameter of the remaining pipes, the combustion gases from the space **11** flow against substantially the same pipe surface area so that the heat transfer for said central pipe **15** is substantially the same as that in the remaining pipes. A symmetric arrangement of the pipes with equal passages between the pipes is also maintained.

Since the central pipe **15** is arranged on the common circle, it opens in the annular duct **16** on the upper side so that this requires no special structural measures to communicate said pipe with the said duct.

It is achieved with the described simple and inexpensive construction, that the temperature signal supplied by a temperature-sensitive element inside the central pipe **15** actually represents a temperature which also prevails in the remaining heater pipes.

What is claimed is:

1. In a hot-gas engine including an expansion space, and a burner with a corresponding combustion space for combustion gases, the improvement in combination therewith of a heater comprising at least one row of pipes which communicate with the expansion space, said pipes positioned generally parallel and spaced apart with the center lines of the pipes located on a common circle, the pipes having substantially equal diameters in the tangential direction of the circle with equal spaces in said tangential direction between said pipes, said pipes having substantially equal wall thickness, and at least one of said pipes having width in the radial direction greater than the other pipes.

2. Apparatus according to claim **1** wherein said similar pipes are circular in cross-section, and said pipe with greater radial width is generally oblong in cross-section.

3. Apparatus according to claim **1** further comprising temperature-sensing means in the bore of said pipe with greater radial width, wherein said bore with said temperature-sensing means therein has an effective hydraulic radius for gas flow therethrough substantially the same as the hydraulic radii of the bores of the remaining pipes.

4. Apparatus according to claim **3** wherein said temperature-sensing means is a thermocouple.

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