Feb. 3, 1970 R. J. MEIJER 3,492,813

HOT-GAS RECIPROCATING ENGINE WITH COOLED ROLLING DIAPHRAGM SEAL

Filed May 29, 1968 2 Sheets-Sheet 1

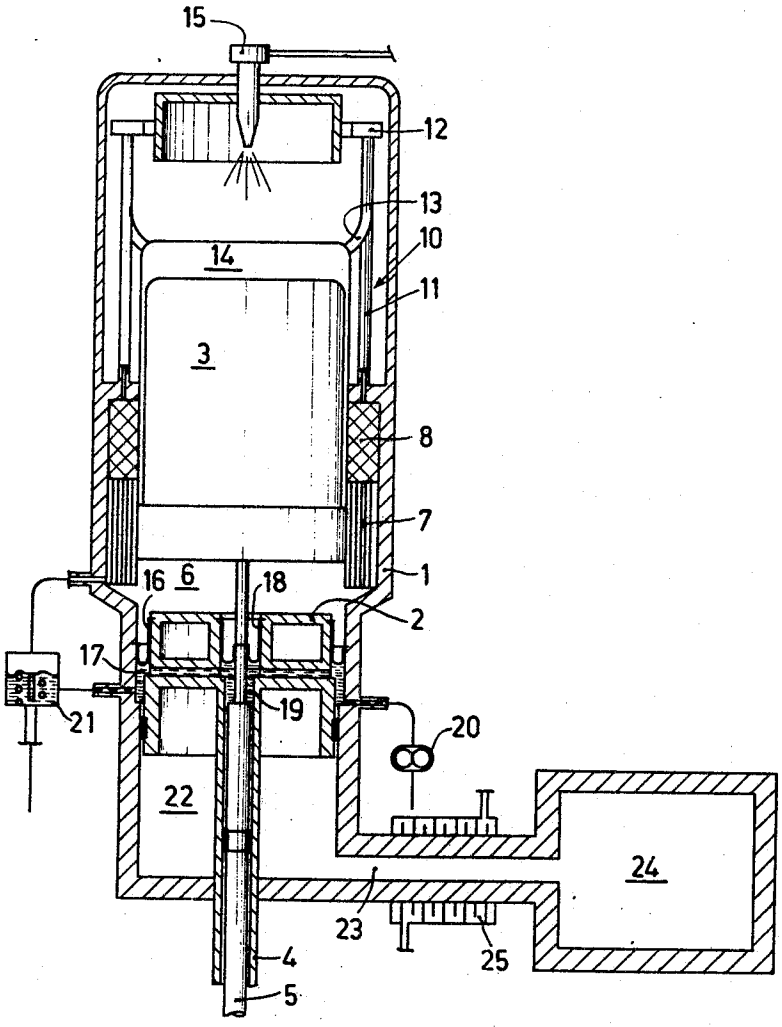

FIG. 1

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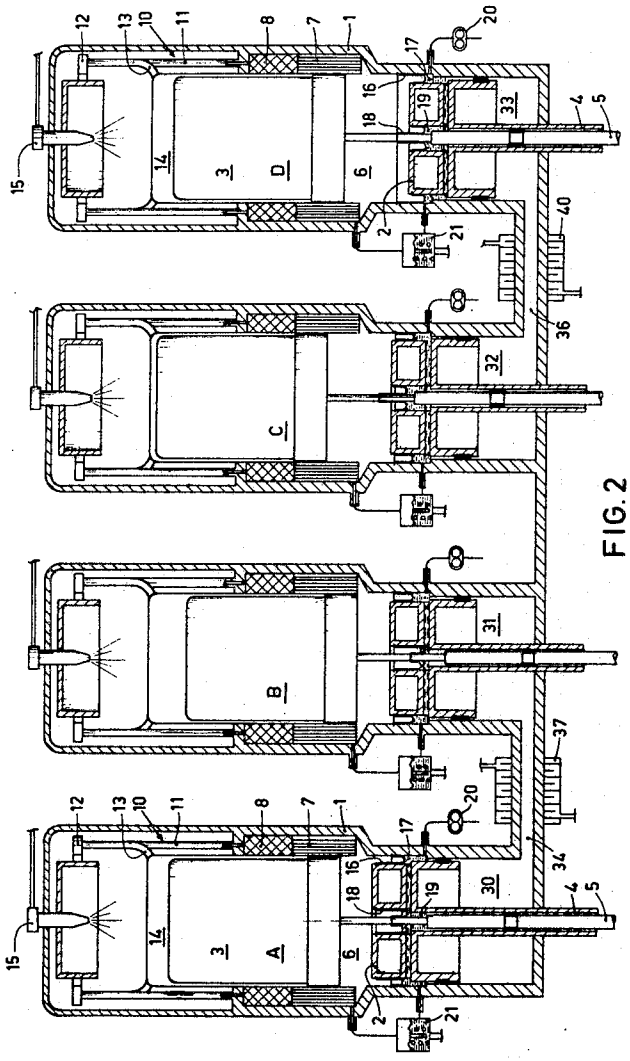

FIG. 2

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HOT-GAS RECIPROCATING ENGINE WITH COOLED ROLLING DIAPHRAGM SEAL

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U.S. Cl. 60—24 5 Claims

ABSTRACT OF THE DISCLOSURE

A hot gas engine having a rolling diaphragm seal between the compression piston and the housing and means for cooling the seal by cooling a medium in the buffer space which contacts the compression piston.

The invention relates to a hot-gas reciprocating engine having first and second spaces of variable volume, one having a higher mean operating temperature than the other. These spaces communicate with each other via a regenerator through which a working medium can flow reciprocally between said spaces. The volume of these spaces is varied by pistons coupled with driving means and there are provided seals between one piston and a co-operating cylinder wall, and between this piston and the piston rod of another piston, each seal being bounded on one side by one of the spaces and on the other side by supporting liquid.

Engines of the kind set forth are known. The material of which the rolling diaphragms are made offers a poor resistance to high temperatures because the creep then rapidly increases and the fatigue strength decreases. This implies that the rolling diaphragms have to be cooled. A direct cooling of the rolling diaphragms, for example, by cooling the supporting liquid or by cooling the part of the cylinder wall over which the rolling diaphragms slide downwards, involves great constructional difficulties. Furthermore, the piston-rod seal, if any, is located at the center of the piston and can be cooled directly only with great difficulty.

The invention has for an object to provide a hot-gas reciprocating engine, in which the rolling diaphragms are cooled in an effective and constructionally simple manner. For this purpose, the hot-gas reciprocating engine according to the invention is characterized in that each of the said buffer spaces communicates via a duct with a further space which contains the same medium as the relevant buffer space, while the communication duct or the further space includes a cooler. In the hot-gas reciprocating engine according to the invention, when the relevant piston is moved, the medium in the buffer space flows alternately into and out of the further space and passes the cooler arranged in the communication duct. Thus, the medium contained in the buffer space is satisfactorily cooled. This medium is in direct contact with the relevant piston so that this piston is also cooled by this medium. This results in an effective cooling of the rolling diaphragms co-operating with the relevant piston-like body. The cooler may be arranged in a simple manner in the communication duct and may have a low flow resistance. Since the pressure of the medium in the buffer space is generally substantially equal to the mean pressure prevaling in the working space, which pressure may be of the order of 100 atmospheres, the medium has a comparatively large heat capacity so that it is capable of transferring a large quantity of heat even at comparatively small temperature differences. Due to the high pressure of the medium, both in the piston and in the cooler, a satisfactory heat transfer between wall and medium is ensured.

The invention further relates to a hot-gas reciprocating engine which comprises several working spaces and in which, each of the buffer spaces below the relevant pistons communicates with at least one buffer space below a piston associated with another working space, while each of the communications includes a cooler.

The invention will be described more fully with reference to the drawing.

FIGURE 1 shows a single-cylinder hot-gas engine in which the buffer space communicates with a further space.

FIGURE 2 shows diagrammatically and not to scale a multi-cylinder hot-gas engine in which the buffer spaces communicate with each other.

Referring now to FIGURE 1, reference numeral **1** denotes a cylinder of a hot-gas engine. This cylinder accommodates a piston **2** and a displacer **3**. The piston **2** and the displacer **3** are coupled by means of a piston rod **4** and a displacer rod **5**, respectively, with a driving gear (not shown) which is adapted to move this piston and this displacer with a relative phase difference. Between the piston **2** and the displacer **3** is located a compression space **6** which communicates through a cooler **7**, a regenerator **8** and a heater **10** with an expansion space **14**. The heater **10** consists of a crown of pipes **11** joining on the one hand the regenerator **8** and on the other hand the annular duct **12** and of a crown of tubes **13** joining on the one hand the duct **12** and merging on the other hand into an expansion space **14** located above the displacer **3**. The engine further has a burner **15** by means of which heat can be supplied to the heater **10**. The seal between the piston **2** and the cylinder wall **1** is constituted by a rolling diaphragm **16** supported by a liquid **17**, while the seal between the piston **2** and the displacer rod **5** is constituted by a rolling diaphragm **18** supported by a liquid **19**. The liquid-containing spaces **17** and **19** communicate with each other and are continously supplied with liquid by means of a pumping device **20**, provision being further made of a regulating device **21** for maintaining a constant pressure difference over the rolling diaphragms **16** and **18**. Below the piston **2** is located a buffer space **22** which communicates through a duct **23** with a further space **24**. The medium in the buffer space and in the further space is subjected to approximately the same mean pressure as the medium in the working space. The communication duct includes a cooler **25**. When the piston **2** is moved, medium from the space **22** flows reciprocally through the communication duct **23** and is then satisfactorily cooled by the cooler **25**. This implies that the medium in the space **22**, which contacts a large wall surface of the piston **2** has a low temperature and thus satisfactorily cools the piston **2**. Due to the high pressure, the medium has a large heat capacity so that a comparatively large quantity of heat can be transferred even at low temperature differences, while moreover a satisfactory heat transfer between medium and wall is obtained. The rolling diaphragms **16** and **18** contact the wall of the piston **2** along a large part of their length so that the rolling diaphragms can also supply heat to the piston **2**, as a result of which the temperature of the rolling diaphragms will remain low. Thus, a long life of the rolling diaphragms is ensured. The location of the cooler **25** in the communication duct **23** provides a large constructional freedom so that the cooler arranged in this duct may have a low resistance.

FIGURE 2 shows a four-cylinder hot-gas engine having four cylinders, A, B, C and D, the construction of which is fully equal to that of the hot-gas engine of FIGURE **1**. The buffer spaces **30**, **31** of the cylinders A and B communicate with the buffer spaces **32**, **33** of the cylinders C and D through ducts **34** and **36** which include coolers **37** and **40**. The pistons **2** of the cylinders A and B and

of the cylinders C and D are out of phase with respect to each other by 180° so that the overall volume of the buffer spaces **30**, **31** and of the buffer spaces **32**, **33** remains constant, however, the medium constantly flows from one buffer space into the other and passes the cooler arranged in the ducts **34** and **36** and is strongly cooled. The pistons **2** will be kept at a low temperature by this strongly cooled medium so that the rolling diaphragms cooperating with these pistons will also have a low temperature. Under certain conditions, a communication duct including a cooler may be arranged also between the buffer spaces **31** and **32**.

It will appear from the foregoing that the invention provides a particularly simple and effective solution for cooling the rolling diaphragms in hot-gas reciprocating engines.

What is claimed is:

1. A hot gas reciprocating engine including a housing defining a cylinder, at least one set of expansion, compression, and buffer spaces, a pair of compression and displacer pistons movable to vary the volume of said spaces, and a rolling diaphragm seal secured between the compression piston and the housing, the seal being bounded on one side by said compression space and on the other side by supporting liquid, with fluid medium in the buffer space contacting said compression piston, the improvement in combination therewith comprising a remote chamber defining a further space, duct means which connect the buffer and further spaces and through which said fluid medium is reciprocally flowable; means

for cooling said duct and the medium flowing therethrough, whereby the cooled medium contacts and cools the compression piston which in turn cools the seal secured thereto.

2. A hot gas engine as defined in claim **1**, the cooperating cylinder, pistons, and spaces thereof being a first assembly, further comprising a second similar assembly wherein the further space of one assembly is the buffer space of the other assembly.

3. A hot gas engine as defined in claim **1**, wherein the fluid medium is a gas maintained at a pressure of at least 90 atmospheres.

4. A hot gas engine as defined in claim **1** wherein the walls of the compression piston are contacted by the seals along a substantially large part of its length.

5. A hot gas engine as defined in claim **1**, wherein the displacer piston has a rod traversing the compression piston, comprising a further rolling diaphragm seal between the rod and the compression piston.

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