United States Patent [19]

Almstrom et al.

[11] **3,827,241**

[45] **Aug. 6, 1974**

[54] **GOVERNING POWER OUTPUT OF HOT GAS ENGINES**

[75] Inventors: **Sten Hakan Almstrom**, Lund; **Yngve Roland Gothberg**, Malmo, both of Sweden

[73] Assignee: **Kommanditbolaget United Stirling (Sweden) AB & Co.**, Malmo, Sweden

[22] Filed: **Sept. 4, 1973**

[21] Appl. No.: **394,090**

[30] **Foreign Application Priority Data**

Sept. 5, 1972 Great Britain 41038/72

[52] **U.S. Cl.** **60/521**

[51] **Int. Cl.** **F02g 1/04**

[58] **Field of Search** 60/518, 521, 522

[56] **References Cited**

UNITED STATES PATENTS

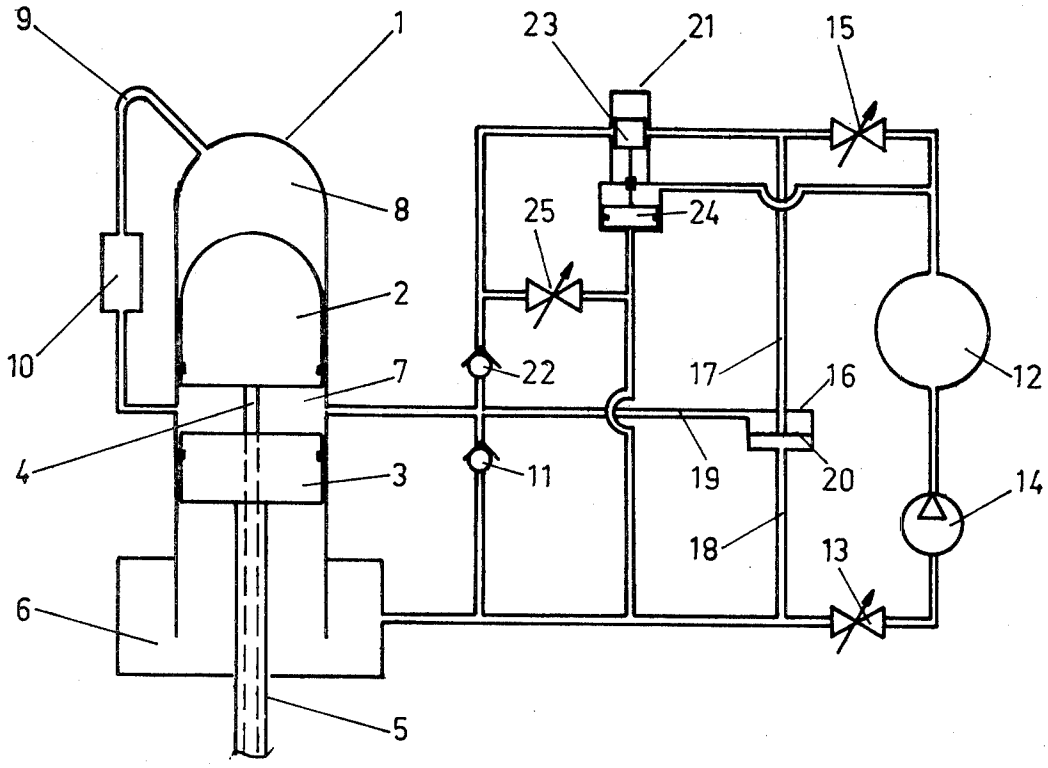
2,746,241	5/1956	Dros et al.	60/521
3,355,881	12/1967	Brandes	60/521
3,397,533	8/1968	Steiner et al.	60/521
3,458,994	8/1969	Heffner	60/521

Primary Examiner—Edgar W. Geoghegan
Assistant Examiner—H. Burks, Sr.
Attorney, Agent, or Firm—Laurence R. Brown

[57] **ABSTRACT**

To reduce the pressure requirements for introducing working gas to increase engine power, the gas is introduced at the high pressure portion of the working cycle but only under the low output load conditions, and if a high engine load is present then the gas is introduced at the lower pressure portion of the working cycle. Pressure sensing valves control the flow of gas under these conditions.

5 Claims, 2 Drawing Figures



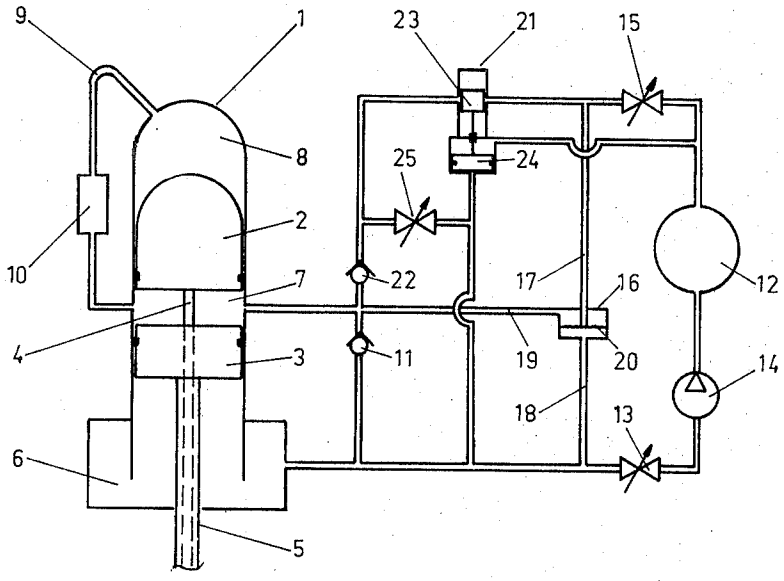


Fig. 1

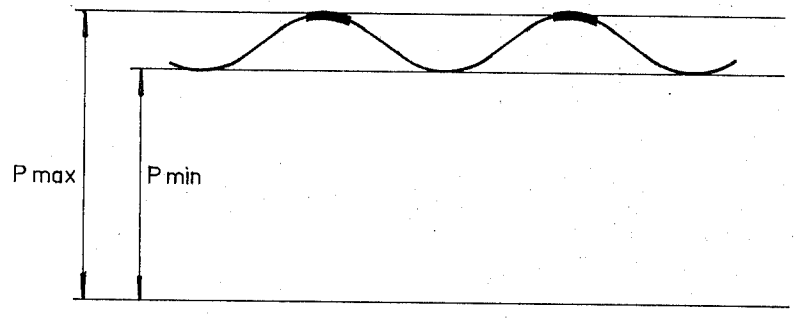


Fig. 2

GOVERNING POWER OUTPUT OF HOT GAS ENGINES

This invention relates to a method of and means for governing the power output of a hot gas engine, the method being of the kind (herein called "the kind defined") in which there is regulation of the amount of "active working gas", that is to say the amount of working gas participating in the working cycles of the engine, any addition to the active working gas being supplied only during periods when high pressure is prevailing in the working cycle of the working gas which is being augmented and the engine is operating at low output load.

It is well known that increase of power of a hot gas engine may be obtained by increasing the amount of active working gas in the engine. It is also known that working gas may be most easily supplied at the lower pressures during the working cycles. However, supply of gas during periods of lowest pressure has an initial effect of braking the engine - at a time when the opposite effect is desired.

Therefore, it has previously been proposed to design valves operated mechanically by the engine and ensuring that supply of working gas will only take place during periods of the highest pressure in the working cycles. These arrangements have the drawback that they are rather complicated and require a very high pressure in the reservoir for supply of working gas.

An object of the present invention is to provide an improved method of the kind defined which may be carried into effect by simple means and without the necessity of a very high pressure in the reservoir for working gas.

A method of the kind defined and according to the invention is characterized in that, although the supply of working gas during periods of high pressure in the working cycle is effected only whilst the engine is operating at low output load, the supply of working gas is effected mainly during periods of lower pressure in the working cycle when higher engine loads prevail.

According to another aspect of the invention for carrying the method into effect there are provided means characterized by a first valve which is coupled in series with a supply valve between a working chamber of the engine and a reservoir for working gas, the said first valve being influenced by maximum cycle pressure in the closing direction and by the actual working cycle pressure in the opening direction, the said first valve also being influenced in the opening direction by the supplied gas, said means also comprising a second valve influenced by the pressure in the reservoir and by the maximum pressure in the working cycle and adapted to open a supply conduit when the maximum pressure in the working cycle exceeds the pressure in the reservoir.

How the invention may be put into practice is described in more detail with reference to the accompanying drawing, in which

FIG. 1 shows a diagram of means according to the invention, and

FIG. 2 shows a diagram of the pressure variations in the working gas during a short period.

The engine shown in FIG. 1 is a one-cylinder single acting hot gas engine having a cylinder 1 with a displacer piston 2 and a working piston 3 provided with piston rods 4 and 5 respectively, connected to a drive mechanism not shown. The lower part of the cylinder — below the working piston 3 — is connected to a buffer space 6. The space between the two pistons is the "cold" working space 7 and the space above the displacer piston 2 is the "hot" working space 8. The two working spaces are interconnected by a pipe system comprising a heater 9 and a regenerator-cooler unit 10.

The buffer space 6 is connected to the working space 7 by a connection including a non-return valve 11 allowing flow of gas only in the direction towards the buffer space 6. Thus the pressure in the buffer space 6 will normally correspond to the maximum cyclic pressure in the working spaces 7 and 8.

The buffer space 6 is connected to a reservoir 12 through a conduit containing a dump valve 13 and a compressor 14. The reservoir 12 is connected to the working space 7 through a system of conduits including a supply valve 15 and a regulating valve 16 coupled in series. The regulating valve 16 is connected to three pipes 17, 18 and 19. The pipe 17 provides a connection to the supply valve 15 and is shown to be closed by a flexible membrane 20 dividing the interior of the valve into two chambers, the lower one of these chambers being connected to the buffer space through the pipe 18 while the upper one is connected to the working space 7 through the pipe 19. As the pressure in the buffer space 6 corresponds to the maximum cyclic pressure in the working chamber 7 the membrane 20 will be kept in contact with the end of the pipe 17 protruding into the interior of the valve 16.

A servo-actuated stop valve 21 is inserted in a pipe connection between the supply valve 15 and the working chamber 7, the said connection including a non-return valve 22 allowing flow of gas only in the direction into the working chamber 7, thus providing minimum cyclic pressure in the pipe connection. The valve 21 contains a piston valve member 23 connected to a piston 24 which is influenced in the direction downwardly by the pressure of the gas in the reservoir 12 and in the direction upwardly by the pressure in the buffer space 6. As long as the pressure in the reservoir 12 is higher than in the buffer space 6 the piston valve member 23 will occupy its lower end position in which it will block the connection between the supply valve 15 and the non-return valve 22. However, if the pressure in the buffer space 6 is increased to a value above the pressure in the reservoir 12 the piston valve member 23 will be moved upwards, allowing flow of gas from the supply valve 15 into the working chamber 7 through the non-return valve 22. A valve 25 is arranged for allowing flow direct from the buffer space 6 to the working space 7.

The illustrated arrangement will operate as follows, reference now also being made to the diagram of FIG. 2.

During normal operation of the engine the gas-pressure in the working chambers 7 and 8 will vary between minimum and maximum values. At low engine loads the said pressures are substantially lower than the gas pressure in the reservoir 12.

Therefore the pistons 23 and 24 in the valve 21 will remain in their bottom positions shown in FIG. 1.

The flexible membrane 20 of the valve 16 will remain in contact with the lower end of the pipe 17, but as the force of the membrane is a function of the difference between the maximum cycle pressure and the actual

prevailing cycle pressure said force is very small during periods when the actual cycle pressure almost equals the maximum cycle pressure. Thus supply of gas from the reservoir **12** to the working space **7** — controlled by the supply valve **15** — will be effected during periods when maximum cycle pressure prevails. The said periods are shown as heavier parts of the wavy line of FIG. **2**, which is a graph in which actual working pressure is plotted vertically against time lapse plotted horizontally.

Especially at low load outputs of the engine it is important to supply working gas during periods of high cyclic pressure. At higher load outputs an increase of the output by supplying gas during periods of low cyclic pressure will not have significant drawbacks. On the contrary it is an advantage to supply gas during periods of low cyclic pressure (when the actual engine load outputs are near the maximum value) as this will make possible a supply of gas even if the gas pressure in the reservoir is lower than the maximum cycle pressure.

In the event of the pressure in the reservoir being lower than the pressure built up in the buffer space **6**, the valve **21** will open a direct supply connection through the non-return valve **22**, allowing supply of gas until the pressure of the gas in the reservoir **12** corresponds to the minimum cyclic pressure.

The valve **25** will — if opened — cause a short-circuit connection between the buffer space **6** and the working space **7** and cause an immediate stop of output power from the engine. Normally decrease in power output is caused by opening the valve **13** and passing gas from the buffer space **6** to the reservoir **12** by means of the compressor **14**.

What we claim is:

1. The method of governing the power output of a hot gas engine which has working cycles of higher and lower pressure in a working gas space, comprising the steps of, introducing additional gas into the working space from a gas reservoir to increase power, and controlling the introduction of said gas as a function of pressure in the engine to introduce the gas at the higher pressure while the engine is operating at a low output load and at a lower pressure when operating at a higher engine load output.

2. Apparatus for governing the power output of a hot gas engine which has working cycles of higher and lower pressure in a working gas space comprising in combination, a reservoir holding working gas under pressure, conduit means including a supply valve for introducing gas from said reservoir to said working space, and control valve means in said conduit means responsive to working pressures in said engine to open said conduit upon a predetermined relationship between the working pressure and the reservoir pressure.

3. Apparatus as defined in claim **2** wherein the control valve means comprises means opening said conduit when the pressure in said reservoir exceeds the maximum working pressure in said space only during the maximum pressure portion of said working cycle.

4. Apparatus as defined in claim **2** wherein the control valve means comprises means opening said conduit when the pressure in said reservoir is lower than the maximum pressure in said working space at a cyclic position when the cyclic pressure is lower than the reservoir pressure.

5. Apparatus as defined in claim **2** wherein the engine has a buffer space in which the pressure is a function of the working cycle pressure, and the control valve means comprises a first control valve in said conduit means responsive to the pressure differential between the working space and the buffer space to pass gas from said reservoir to said working space when the working space pressure exceeds the buffer space pressure and a second control valve responsive to the pressure differential between said reservoir and said working space to pass gas from said reservoir to said working space when the reservoir pressure exceeds the working space pressure.

* * * * *