HOT-GAS RECIPROCATING ENGINE

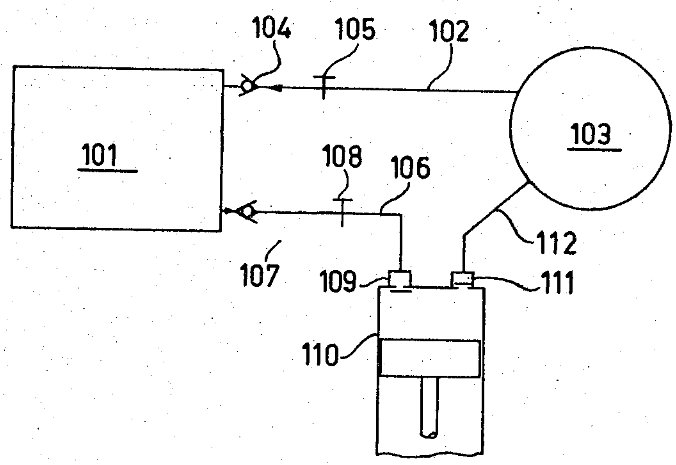

FIG.1

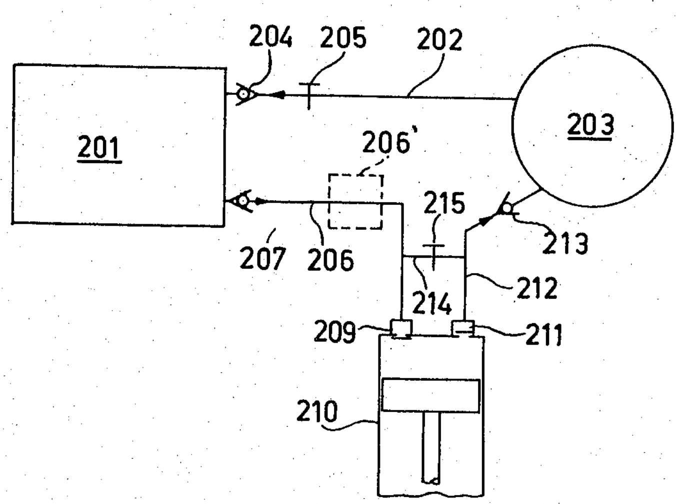

FIG.2

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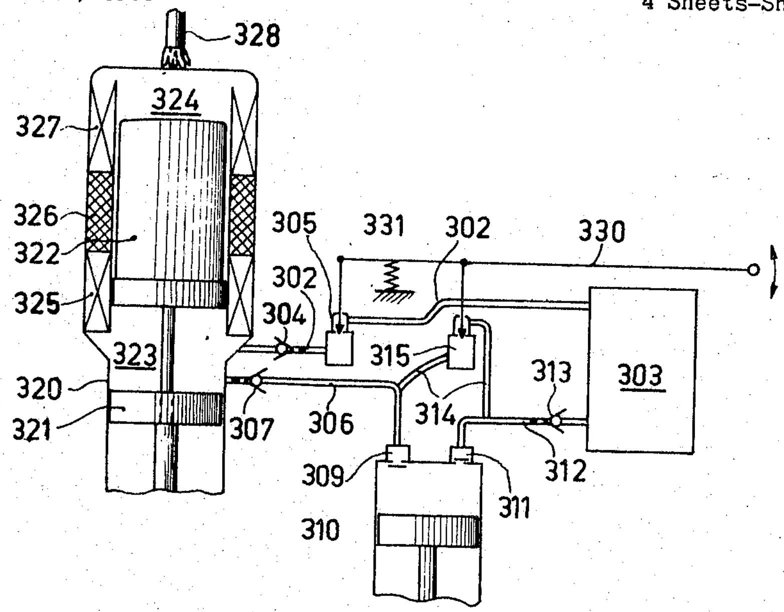

FIG. 3

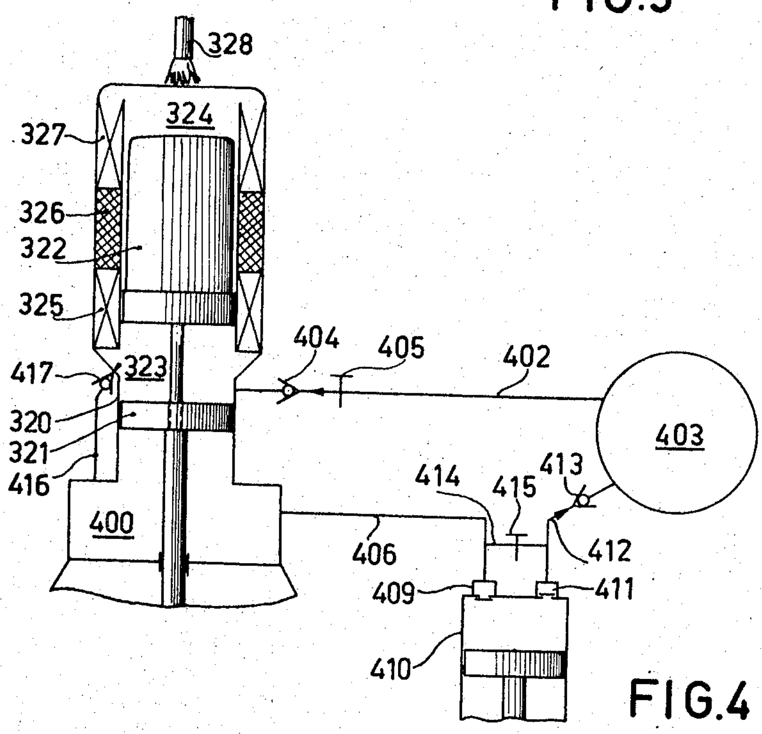

FIG. 4

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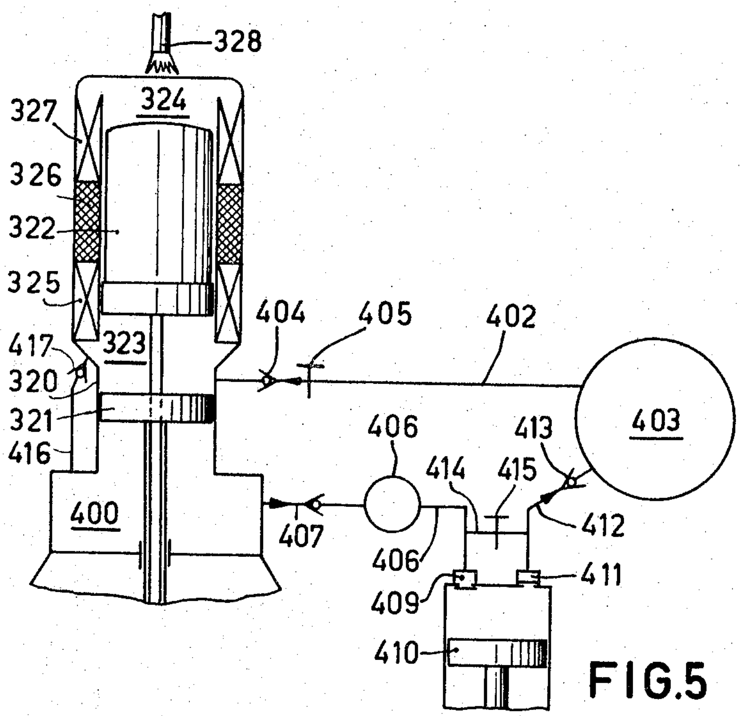

FIG.5

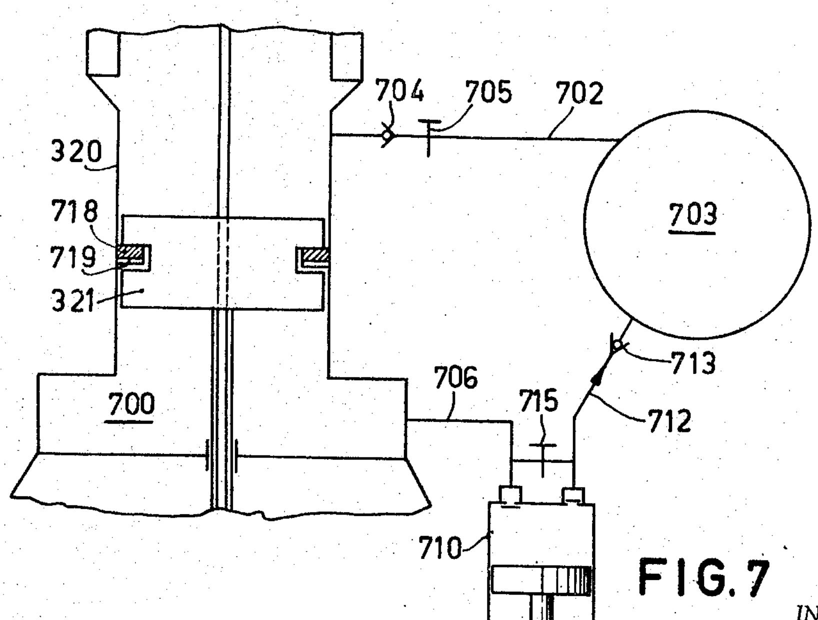

FIG.7

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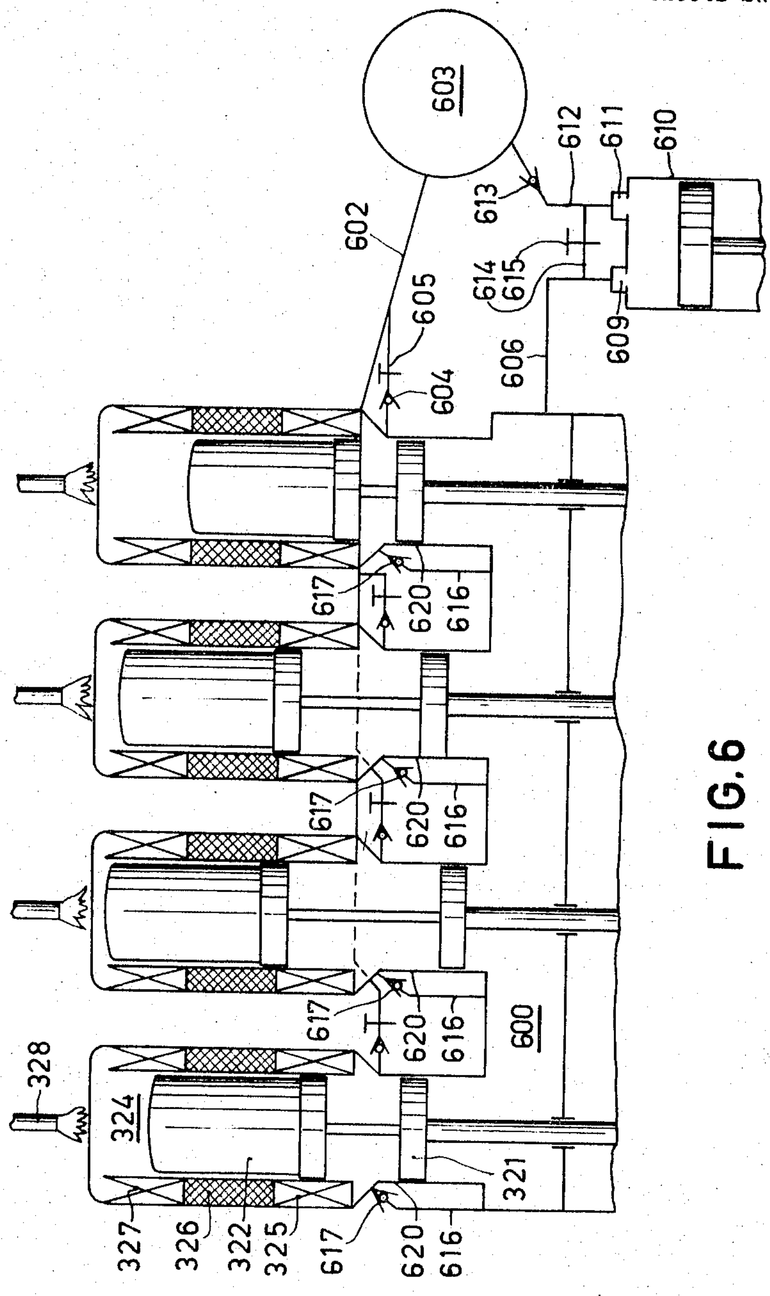

FIG. 6

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HOT-GAS RECIPROCATING ENGINE

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5 Claims. (Cl. 60—24)

The invention relates to a hot-gas reciprocating engine, particularly a hot-gas motor, comprising a device for varying the quantity by weight of medium in a working space, in which engine the working space can be made to communicate, through a medium inlet duct provided with a controllable cock and a check valve, with a storage container for working medium, a medium outlet duct comprising at least one check valve communicating with the working space, the other end of the said outlet duct communicating with the inlet aperture of a compressor, the outlet aperture of the compressor communicating through a duct with the storage container.

In a known engine of the type to which the present invention relates, the medium outlet duct between the working space and the inlet aperture of the compressor also comprises a controllable cock. The result of this is that, when said cock is closed, so when the engine is in normal operation, the pressure in the medium outlet duct will decrease to a very low level dependent upon the compression ratio maximally to be reached. The pressure in the working space of the compressor varies between the very low pressure in the medium outlet duct and the high pressure in the storage container. This large pressure variation involves great drawbacks.

The object of the hot-gas reciprocating engine according to the invention is to mitigate the above-mentioned drawback and for that purpose it is characterized in that the duct between the outlet aperture of the compressor and the storage container also comprises a check valve, a duct communicating with said duct between the said valve and the outlet aperture of the compressor, the other end of the said duct opening into the medium outlet duct between the inlet aperture of the compressor and the check valve, a controllable cock which during the decrease of the quantity by weight of medium in the working space can be closed and otherwise can be opened being provided in the said communication duct, the medium outlet duct having such a volume, that in the opened condition of the cock substantially no pressure variations occur therein.

A hot-gas reciprocating engine is to be understood to mean herein a hot-gas motor and in addition a cold-gas refrigerator and a heat pump, the latter two operating according to the reversed hot-gas reciprocating engine principle. In all these machines a gaseous working medium is periodically reciprocated between a warmer and a colder chamber by means of piston-like members, the medium on its way from one space to the other and conversely passing through one or more regenerators.

In a further favourable embodiment of the hot-gas reciprocating engine according to the invention which is provided with a buffer chamber, said buffer chamber forms part of the medium outlet duct, at least one check valve being arranged between the working space and the buffer chamber, said valve opening in the direction of the buffer chamber. So in this embodiment the volume of the medium outlet duct is increased by that of the buffer chamber. This requires such a volume that the volume variations caused by the piston which separates the buffer chamber from the working space together with those caused by the compressor piston produced only very low pressure variations.

In a further embodiment the buffer chamber communicates with the working space through a check valve opening in the direction of the said chamber, the medium outlet duct again communicating with the buffer chamber through a check valve. In this embodiment the volume of the outlet duct must be so large that the volume variations caused by the piston of the compressor substantially result in no pressure variations. The outlet duct itself may already have a sufficiently large volume. Should this not be the case a container may be arranged in the outlet duct.

According to a further favourable embodiment of the hot-gas reciprocating engine according to the invention, the check valve between the buffer chamber and the working space is constituted by one or more piston rings arranged in the piston, said rings co-operating on their sides facing the buffer chamber with means preventing a full engagement of that side with the grooved wall in question. In this manner, the seal of the piston is combined with the check valve required for the control.

The invention further relates to a hot-gas reciprocating engine comprising several working spaces and associated buffer chambers. In this engine all buffer chambers communicate with one another, each of the buffer chambers communicating with an associated working space through at least one check valve opening in the direction of that chamber. In this embodiment all the buffer chambers form part of the medium outlet duct which communicates with the inlet aperture of the compressor.

In this engine a very even pressure prevails in the buffer chambers and consequently also in the outlet duct communicating therewith.

In order that the invention may readily be carried into effect, certain embodiments thereof will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 diagrammatically shows the control device of a known hot-gas motor,

FIGURE 2 also diagrammatically shows a hot-gas motor with improved control device.

FIGURE 3 shows a more structural construction of the hot-gas motor shown in FIGURE 2,

FIGURES 4 to 7 diagrammatically show hot-gas motors which are provided with a buffer chamber and in which the medium outlet duct communicates with the said buffer chamber.

In FIGURE 1, reference numeral **101** denotes a working space of a hot-gas motor. This working space communicates through a duct **102** with a storage container **103**. The working space **101** and the storage container **103** are both filled with a working medium. The duct **102** is provided with a check valve **104** and a controllable cock **105**. In addition a medium outlet duct **106** communicates with the working space **101**. Said duct also comprises a check valve **107** and a controllable cock **108**. The duct **106** communicates at its other end with the intake aperture **109** of a compressor **110**. The outlet duct **111** of the compressor communicates with the container **103** through a duct **112**.

The pressure in the container **103** is adjusted so as to be invariably higher than the minimum pressure occurring in the working space.

By opening the cock **105**, medium will flow from the container **103** to the working space **101** so that the output power of the motor will increase. If, on the contrary, the cock **108** is opened, medium will flow from the working space **101** to the container **103** through the compressor **110**. The weight of working medium in the working space

110 decreases and the output power of the motor will decrease.

In normal operation the cocks 105 and 108 are closed. The compressor 110 then exhausts the duct 106 to a low pressure, which of course depends upon the compression ratio of the compressor 110. The pressure in the working space of the compressor will vary between the pressure in the duct 106 and the pressure in the container 103. This large pressure variation is associated with a large force variation which is very harmful for the compressor.

The hot-gas motor diagrammatically shown in FIG. 2, comprises a working space 201, which through a duct 202 communicates with a storage container 203. A check valve 204 and a controllable cock 205 are arranged in the duct 202. A medium outlet duct 206 comprising a check valve 207 communicates with the working space 201. At its other end the duct 206 communicates with the intake aperture 209 of a compressor 210. The outlet aperture 211 of the compressor communicates with the container 203 through a duct 212. The duct 212 comprises a check valve 213. The part of the duct 212 between the outlet aperture 211 and the check valve 213 communicates through a duct 214 with the part of the duct 206 between the intake aperture 209 and the check valve 207. A controllable cock 215 is arranged in the duct 214.

In this device a pressure is adjusted in the container 203 which is higher than the maximum pressure occurring in the working space 201.

When the cock 205 is opened, medium will again flow to the working space 201 so that the outlet power of the motor increases.

In normal operation, the cock 215 is opened and the duct 206, the duct 212, the communication duct 214 and the working space of compressor 210 constitute one space. The pressure in the duct 206 then lies between the maximum pressure in the working space of the hot-gas motor and the pressure in the storage container. The volume of the duct 206 is so large that in this duct and in the spaces communicating therewith, substantially no pressure variations will occur. If required, a container 206′ may be arranged in the duct 206 to increase the volume. As a result of the constant pressure level, no large force variations occur, so that the compressor will have a longer life and is less noisy.

If the motor is to supply less power, that is to say working medium must be dissipated from the working space 201, the cock 215 is closed. The compressor 210 now exhausts normally medium from the working space and supplies it in a compressed condition to the container 203.

FIGURE 3 diagrammatically shows how the system shown in FIGURE 2 can be constructed. Naturally, other structural embodiments are possible.

Reference numeral 320 denotes a cylinder of a hot-gas motor. In this cylinder a piston 321 and a displacer 322 move with a phase difference. These members are coupled to a gear not shown. The piston 321 and the lower face of the displacer 322 vary the volume of a compression space 323; the upper face of the displacer varies the volume of an expansion space 324. These two spaces communicate with one another through a cooler 325, a regenerator 326 and a heater 327. A burner 328 supplies the heat to the heater 327.

A medium supply duct 302 provided with a check valve 304 and a controllable cock 305 communicates with the working space constituted by the compression space 323 and the expansion space 324.

At its other end the medium outlet duct 302 opens into the storage container 303.

In addition a medium outlet duct 306 comprising a check valve 307 communicates with the working space. The duct 306 communicates at its other end with the intake aperture 309 of a compressor 310. The outlet aperture 311 of the compressor 310 communicates with the container 303 through a duct 312 comprising a check valve 313. The ducts 306 and 312 communicate with one another through a duct 314 comprising a controllable cock 315. The valves of the cocks 305 and 315 are both connected to a lever 330 which is supported by a spring 331. By an upwards or downwards movement of said lever, either the cock 315 or the cock 305 is opened, so that the required control is effected.

FIGURE 4 diagrammatically shows a hot-gas motor, of which the various components are denoted by the same reference numerals as in FIGURES 2 and 3. This hot-gas motor is provided with a buffer chamber 400 below the compression piston 321. The working space of the said hot-gas motor again communicates with the storage container 403 through a duct 402 comprising a check valve 404 and a cock 405. The motor further comprises a compressor 410 the outlet aperture 411 of which communicates through a duct 412 comprising a check valve 413 with the container 403. The buffer chamber 400 communicates through a duct 416 comprising a check valve 417 which can be opened in the direction of the buffer chamber with the working space. A medium outlet duct 406 communicates with the buffer chamber. The communication duct 414 with cock 415 communicates the ducts 406 and 412. So in this motor the buffer chamber 400 forms part of the medium outlet duct. In the opened condition of the cock 415 a space is available which is constituted by the buffer chamber 400, the duct 406, the working space of the compressor and the duct 412. The volume of these spaces together now is so large that the volume variations caused by the piston 321 and by the piston of the compressor substantially produce no pressure variations.

The cocks 405 and 415 can be operated again in the same manner as in the motor shown in FIGURE 3. In the closed condition of the cock 415, the compressor 410 will exhaust medium from the duct 406 and the buffer chamber 400 as a result of which the pressure decreases so that the check valve 417 opens and working medium flows from the working space to the buffer chamber.

If the buffer chamber has too small a volume with respect to the volume variations caused by the lower side of the piston 321, the exhaust duct 406 may be made to communicate again, as shown in the embodiment in FIGURE 5, with the buffer chamber through a check valve 407. To increase the volume of the duct 406, a container 406′ is arranged in the said duct. As a result of this, in the opened condition of the cock 415, a substantially constant pressure level is ensured in the ducts 406 and 412 and in the working space of the compressor. FIGURE 6 diagrammatically shows a four-cylinder motor. The four cylinders 620 communicate with a common buffer chamber 600. This buffer chamber 600 communicates with each of the four working spaces through ducts 616 including check valves 617. A medium outlet duct 606 communicates with the buffer chamber which duct communicates with the intake aperture 609 of the compressor 610. The outlet aperture 611 communicates with the storage container 603 through the duct 612 including the check valve 613. The ducts 606 and 612 communicate with one another through a duct 614 with a controllable cock 615. The container 603 communicates through a duct 602, controllable cocks 605 and check valves 604 with each of the four working spaces.

The cocks 605 are simultaneously opened or closed through a control device.

After this explanation the operation of said motor need no further explanation.

Since the pistons of the four cylinders move with a phase difference of approximately 90° it will be clear that the volume of the buffer space is hardly influenced by the movements of the said pistons. As a result of this substantially no volume variations will occur. In the opened condition of the cock 615, volume variations of the space constituted by the buffer chamber 600, ducts 606 and 602, and the working space of the compressor are caused by the piston of the compressor only. However, said variation relatively is so small with respect to the total volume that substantially no pressure variations will occur.

In FIGURES 4, 5 and 6 the communication between the buffer space and the working space is constituted by a duct and ducts respectively including check valves.

Instead of said duct including a check valve, the construction shown in FIGURE 7 may advantageously be used. In this embodiment a piston ring **718** is arranged in the piston **321** which ring, on its side facing the buffer chamber **700**, is provided with grooves **719** which prevent a full engagement of that side of the piston ring with the piston. This means that the piston ring **718** counteracts flow of medium in the direction of the working space but permits flow of medium in the direction of the buffer chamber. Now, if compressor **710** exhausts medium from the buffer space because the cock **715** is closed, the medium in the working space may force the piston ring downwards so that medium can flow from the working space to the buffer chamber. This piston ring operating as a check valve provides a considerable simplification in construction.

What is claimed is:

1. An apparatus including a hot-gas reciprocating engine provided with a working space and a working medium therein, comprising a compressor, a storage container for said working medium communicating with the working space of said engine, said communication being an inlet duct provided with a first check valve, a medium outlet duct provided with a second check valve communicating at one end with said working space and at the other end with an inlet aperture of said compressor, a first duct between said storage container and the outlet aperture of said compressor including a third check valve, a second duct communicating with said first duct and with said medium outlet duct between said inlet aperture of said compressor and said second check valve, a controllable valve arranged in said second duct, said controllable valve being closed when the quantity by weight of said medium in said working space decreases and otherwise being open, the medium outlet duct having such a volume that when said controllable valve is open substantially no pressure variations occur therein.

2. An apparatus including a hot-gas reciprocating engine as claimed in claim **1** further comprising a buffer chamber forming part of said medium outlet duct, and said second check valve opening in the direction of said buffer chamber and arranged between said working space and said buffer chamber.

3. An apparatus including a hot-gas reciprocating engine as claimed in claim **2**, wherein said medium outlet duct communicates with said buffer chamber through said second check valve, said medium outlet duct having such a volume that in the open condition of said controllable valve substantially no pressure variations occur.

4. An apparatus including a hot-gas reciprocating engine as claimed in claim **2** wherein said second check valve is located between said buffer chamber and said working space and is constituted by at least one piston and one piston ring therein.

5. An apparatus including a hot-gas reciprocating engine comprising a plurality of working spaces in said engine and a plurality of buffer chambers therein, a compressor, a storage container for said working medium communicating with the working space of said engine, said communication being an inlet duct provided with a first check valve, a medium outlet duct provided with a second check valve communicating at one end with said working space and at the other end with an inlet aperture of said compressor, a first duct between said storage container and an outlet aperture of said compressor including a third check valve, a second duct communicating with said first duct and with said medium outlet duct between said inlet aperture of said compressor and said second check valve, a controllable valve arranged in said second duct, said controllable valve being closed when the quantity by weight of said medium in said working space decreases and otherwise being open, the medium outlet duct having such a volume that when said controllable valve is open substantially no pressure variations occur therein, each of said buffer chambers communicating at least through one check valve opening in the direction of said chamber with the working space associated with said buffer chamber, all of said buffer chambers being in open communication with one another and forming part of said medium outlet duct which communicates with said inlet aperture of said compressor.

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