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FREE PISTON ENGINE AND COMPRESSOR AND MEANS
FOR REGULATING THE OUTPUT THEREOF

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2 Sheets-Sheet 1

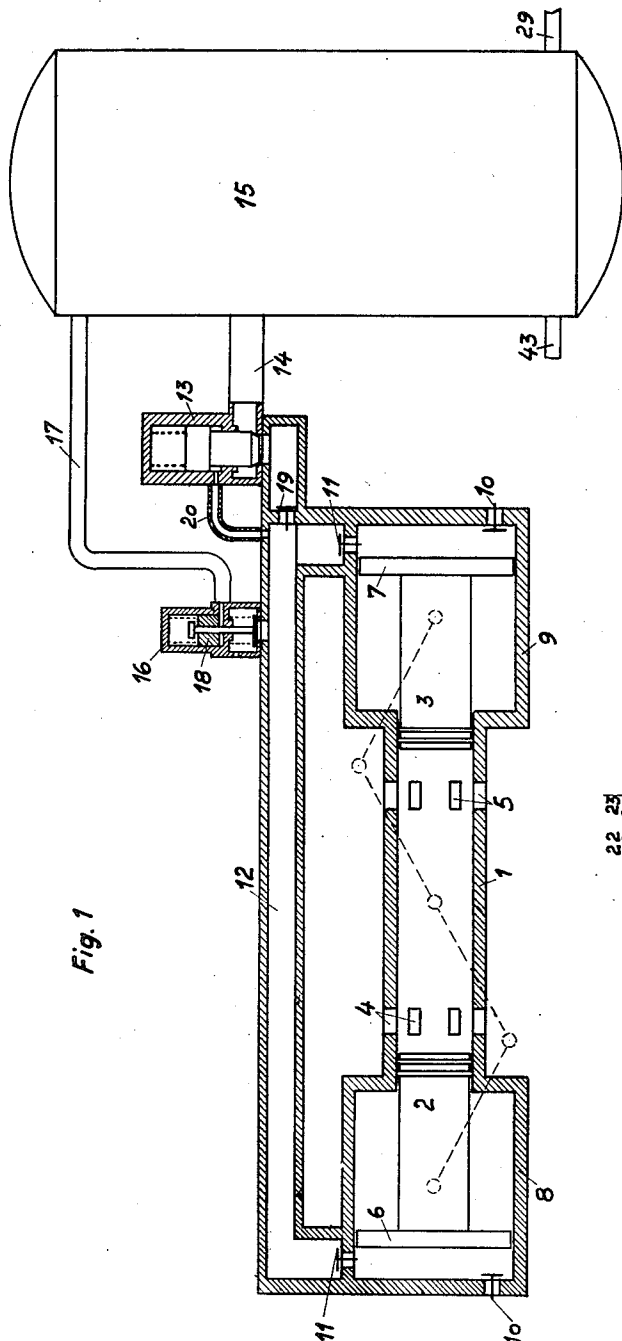


Fig. 1

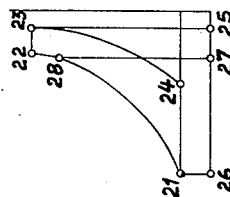


Fig. 2

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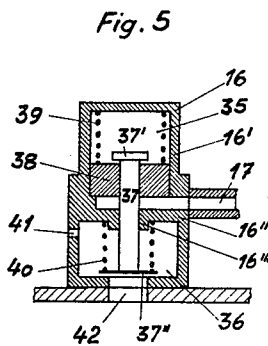
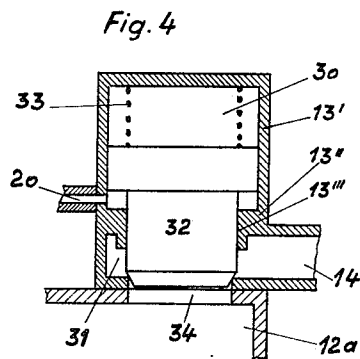
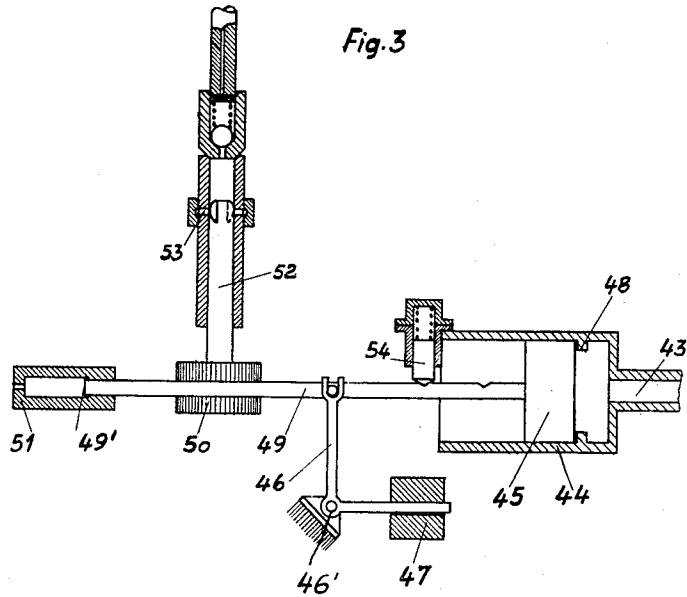
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FREE PISTON ENGINE AND COMPRESSOR AND MEANS FOR REGULATING THE OUTPUT THEREOF

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2 Claims. (Cl. 230—11)

In free piston engines and compressors the output of which is regulated by change of stroke care must be taken that at the return stroke the work derived from the dead space of the compressor and effecting the compression within the motor cylinder is kept within suitable limits when the length of the stroke and the dead space in the compressor change. These limits must be chosen in such a way that the value of compression within the motor cylinder remains approximately at the same level. It is known that under a certain proportion of the pressures in the cylinder (suction pressure in proportion to final pressure) this work in case of changes of the length of the stroke remains within admissible limits while in surpassing this proportion which amounts to about 1 to 3 the work will inadmissibly increase when the stroke decreases or in falling below this proportion the work, when the stroke decreases, will decrease in such a way that ignition no longer is effected in the cylinder of the Diesel engine. In using pressure proportions which on decrease of the length of the stroke cause a rise of the work effecting the compression in the motor cylinder therefore besides other means it has been proposed to decrease the counter pressure of the compressor in correspondence with the decrease of the length of the stroke. These means however are only applicable to compressors working with a simultaneous decrease of the service pressure. Compressors working under such conditions are used f. i. in operating dependent pressure-gas-machines having an output which is also controlled by change of the working pressure. In connection with other free piston engines and compressors which are supposed to furnish a practically constant discharge pressure even when partially loaded (f. i. those as used in operating pneumatic tools), these means are however not applicable.

The invention refers to means for regulating by change of the length of the stroke the output derived from free piston engines and compressors furnishing by means of a pressure check valve compressed gas of approximately constant pressure. The method according to the invention consists in supplying to the engine unit of the plant in dependency on the pressure existing behind the pressure check valve exclusively either the quantity of fuel corresponding to the full load operation level or only a quantity of fuel corresponding to the no load operation level, so that the accordingly decreased length of the stroke will effect a compression pressure which is always lower than the pressure at which the pressure check valve opens. By the term "no load operation level of the compressor" as indicated in the specification and in the claims such range of operation is to be understood in which the compressor discharges no compressed air to the outside of the plant, hereby taking no account of the pneumatic drive auxiliary devices such as fans and the like.

It is a further object of the invention to carry into practice the aforesaid method in such a way that the engine unit is furnished with a quantity of fuel corresponding to the full load range whenever the pressure existing behind the pressure check valve lowers below a pre-determined value and that the said motor unit receives the quantity of fuel corresponding to the no load range as soon as the prefixed value of pressure is attained again.

A further object of the invention is a free piston en-

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gine and compressor plant adapted to carry into practice the method as described above.

In case that the compressor plant should work some considerable time in the no load range it might occur that owing to small leakages of the discharge valve gas under pressure will flow back from the space between the pressure check valve and the discharge valve into the compressor cylinder hereby causing a rise of the final pressure in the compressor cylinder beyond the desired value. In order to avoid this the invention provides to arrange a further valve in the space between the pressure check valve and the discharge valve, respectively, said valve having an outlet to the space outlet of the system. When the plant is working in the full load range such additional valve maintains a pressure which is somewhat higher than that maintained by the normal pressure check valve. On rise of pressure behind the normal pressure check valve (f. i. in a dependent pressure cylinder) the additional valve however already attains its open position when the compressor causes a compression which corresponds to the no load range which effects that gas under pressure is allowed to flow out from the above mentioned space. A further check valve can be provided in front of the normal pressure check valve preventing gas under pressure being in the pressure cylinder from flowing back in case that the normal pressure check valve should not close in time.

The invention will be better understood by the following description in connection with the drawing showing a preferred embodiment of means for working the same.

In the drawing are:

Fig. 1 a diagrammatical view partly shown in section showing a free piston engine and compressor plant,

Fig. 2 a diagram of the pressure in relation to the stroke for the full and the no load range,

Fig. 3 a diagrammatical view partly shown in section showing the control means of the fuel supply pump,

Fig. 4 a diagrammatical section view of the normal pressure check valve shown in an enlarged scale and

Fig. 5 a diagrammatical section view of the additional pressure check valve also shown in an enlarged scale.

Fig. 1 shows a single stage free piston compressor plant having means for working the invention. Within the cylinder 1 there are slidably mounted the opposed running pistons 2 and 3 of a Diesel engine which are linked together by a transmission (shown in dotted lines). The cylinder 1 of the engine is provided with scavenging slots 4 and exhaust slots 5. The piston 2 of the engine is provided with compressor piston 6 and the piston 3 of the engine is connected with the compressor piston 7. The compressor cylinders 8 and 9 are provided with suction valves 10 and discharge valves 11. The gas under pressure coming from the cylinders 8 and 9 is supplied after passing the discharge valves 11 into the receiver 12 and after passing the pressure check valve 13 arranged in the usual way and the tube 14 flows into the airtight container 15 from which it may be delivered for use at 29. The pressure check valve 13 which is more clearly shown in Fig. 4 is adjusted to the discharge pressure desired in the full load range, which pressure may be higher but by no means lower than that existing in the airtight container 15.

The normal compression check valve 13 consists in a cylindrical valve case 13', which by means of an intermediate bottom 13'' having a central opening 13''' is divided into two cylindrical spaces 30 and 31 lying one above the other. Within these two cylindrical spaces and in the central opening 13''' of the intermediate bottom 13'' and sliding longitudinally in the same there is provided a piston-like valve body 32 varying in diameter. The upper part of the valve body 32 having the larger diameter is arranged within the cylindrical space 30 above the intermediate bottom 13'' and is loaded by a pressure spring 33. The lower part of the valve body 32 is tightly fitted in the opening 13''' and formed in such a way as to be able to close with its lower end an opening 34 leading to the space 12a. Furthermore the

upper part of the cylindrical case 13' is connected near the intermediate bottom 13'' by a tube 20 with the space 12, while the lower part of the cylindrical case is connected by tube 14 with the pressure container 15. Besides this the receiver 12 is provided with an additional pressure check valve 16, Figures 1, 5, having an outlet to the space outside of the system and consisting in the same way in a case 16' having an upper cylindrical space 35 and a lower cylindrical space 36 separated therefrom by the intermediate bottom 16''. The intermediate bottom 16'' has a central opening 16''' serving as guide for a longitudinally sliding rod 37 having at its upper end a head 37' and at its lower end a valve body 37''. In the upper cylindrical space 35 a piston 38 is slidably arranged. Said piston surrounds the rod 37 and can be moved with respect to the same until coming into touch with the head 37'. The piston 38 and the valve body 37'' are loaded by a pressure spring 39 and by a pressure spring 40, respectively. Below the piston 38 the tube 17 leading to the pressure container 15 is connected to the upper cylindrical space 35, whilst the lower cylindrical space 36 is connected by an opening 41 for example with the outer air and by another opening 42 which may be locked by the valve body 37'' with the receiver 12.

The valves 13 and 16 cooperate in the following manner: The valve 13 maintains the working pressure of the system and does not open before the compressor discharges into the receiver 12 with the effect that the pressure therein rises above the normal working pressure of for example 6 kg/cm². The spring 33 is adjusted in such a way so as to counter-balance approximately the working pressure acting on the lower part of the valve body 32 and in addition thereto on the free lower surface of its upper part of a larger diameter. When the valve 32 is open the gas under pressure is discharged into the container 15.

In case that no or only a small amount of compressed gas is consumed, which effects a rise of the pressure up to a pre-determined value such as f. i. 6.3 kg/cm², the fuel pump will be automatically regulated so as to only supply the amount of fuel which is necessary for working the engine in the no load range. Such regulation will be described in detail further below. By the supply of such a reduced amount of fuel the stroke of the pistons 2, 6 and 3, 7 is reduced to such an extent that the pressure obtained in the compressor drops below the normal working pressure level. Hereby the discharge valves 11 will remain closed until the pressure in the container 15 drops below the pre-determined limit whereby the fuel pump is again adjusted to furnish the quantity of fuel needed in full load working.

When the engine is working for some time within the no load range it may occur that caused by small leakages of the discharge valves 11 air coming from the receiver 12 and having the normal working pressure will flow back into the compressor cylinders 8, 9. In order to avoid this the valve 16 is provided which operates as follows. If the pressure in the container 15 rises and in consequence thereof the fuel pump is regulated so as to furnish only the quantity of fuel needed for the no load range, this pressure at the same time is acting through the tube 17 on the lower part of the piston 38. The piston 38 moves in a direction which is contrary to the action of the spring 39 until it reaches the head 37' hereby transmitting a pre-load to the valve 37'' in a sense which is contrary to the force of the spring 40 and causing the opening of the valve 37'' already at a pressure which approximately corresponds to the pressure attained when the engine is working in the no load range. Hereby a part of the compressed gas is allowed to pass from the receiver 12 through the opening 41 out of the device for example into the open air, whereby the pressure in the receiver 12 and therefore the forces holding the valve 13 in its open position are reduced so that the same is allowed to close quickly. Further means to avoid flowing back of gas from the container 15 into the receiver 12 and from there for example into the open air are provided by the check valve 19.

If again such a quantity of compressed gas is consumed from the container 15 that the pressure in the same drops below 6 kg/cm² the pressure acting on the bottom part of the piston 38 drops accordingly enabling the valve 37' to close under the action of the spring 40.

The fuel-regulation in dependency of the pressure existing in the container 15 is effected by means as shown in Fig. 3. The container 15 is connected by means of

a tube 43 with a cylinder 44 so that the pressure existing in the container 15 acts upon the piston 45. If the pressure existing in the container 15 attains a value below the pre-determined pressure limit of for example 6 kg/cm², the piston 45 will be pressed against the stop 48 by means of a counter force created for example by the weight 47 attached to the bell-crank 46 which is pivoted at 46'. If, on the other hand, the pressure in the container 15 rises up to a value of for example 6.3 kg/cm² the piston 45 moves quickly to the left (Fig. 3) until the free end 49' of the rack 49 contacts the bottom of the jacket 51. By such movement the rack 49 turns by means of gear wheel 50 the piston 52 of the fuel pump into an angular position in which the piston 52 by means of the bevelled edge of its upper surface effects on its fuel supplying stroke an earlier closure of the fuel inlet 53 with the consequence that only such amount of fuel will be discharged which corresponds to the no load range. If on the other hand the pressure within the container 15 drops the piston 45 is returned into its initial position. By such movement the piston of the fuel pump is turned into the angular position in which it discharges a quantity of fuel corresponding to the full load range of the engine.

In order to secure a jerk-like operation of the fuel regulating device a spring loaded tenon 54 is provided which engages with one of two recesses on the rack 49 when the rack has reached the end of its way in either direction. The tenon 54 stops the rack 49 until the pressure upon the piston 45 is sufficient to overcome the locking effect of the tenon 54.

Fig. 2 shows a diagram relating to the operation of the compressor in the full load and in the no load range. Curve 21—22—23—24—21 represents the full load range. The work supplied by the compressor at the inward directed or return stroke of the pistons corresponds to the area 23—25—26—21—24—23. The diagram 21—28—21 corresponds to the no load range of the engine. In this case the work mentioned above is represented by the area 21—28—27—26—21. The position of point 28 depends on the pressure maintained by the valve 16.

Having thus described a specific embodiment of this invention it will be understood that other modifications and variations come within the spirit and scope thereof.

What I claim is:

1. A compressor arrangement comprising, in combination, a free piston combustion engine and gas compressor unit; a container adapted to hold and to discharge a gas; conduit means connecting said unit with said container for supply of compressed gas to said container; pressure check valve means located in said conduit means adapted to open when said unit supplies compressed gas at a predetermined pressure; fuel supply means supplying fuel to said combustion engine and compressor unit, said fuel supply means being shiftable between a full load position and an idling position, said engine and compressor unit operating at a constant normal stroke when said fuel supply means are in said full load position so as to produce a pressure sufficient to open said check valve means, said unit operating at a constant smaller stroke when said fuel supply means are in said idling position so as to produce a lower idling pressure insufficient for opening said check valve means; and pressure responsive actuating means communicating with said container so as to be actuated when the pressure in the same exceeds a predetermined higher level, and when said pressure in said container drops below a predetermined lower level due to discharge from said container, said pressure responsive actuating means being connected to said fuel supply means and shifting the same to said full load position when the pressure in said container drops below said predetermined level, and to said idling position when said pressure in said container exceeds said predetermined higher level.

2. A compressor arrangement comprising, in combination, a free piston combustion engine and gas compressor unit; a container adapted to hold and to discharge a gas; conduit means connecting said unit with said container for supply of compressed gas to said container; pressure check valve means located in said conduit means adapted to open when said unit supplies compressed gas at a predetermined pressure; fuel supply means supplying fuel to said combustion engine and compressor unit, said fuel supply means being shiftable between a full load position and an idling position, said en-

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gine and compressor unit operating at a constant normal stroke when said fuel supply means are in said full load position so as to produce a pressure sufficient to open said check valve means, said unit operating at a constant smaller stroke when said fuel supply means are in said idling position so as to produce a lower idling pressure insufficient for opening said check valve means; pressure responsive actuating means communicating with said container so as to be actuated when the pressure in the same exceeds a predetermined higher level, and when said pressure in said container drops below a predetermined lower level due to discharge from said container, said pressure responsive actuating means being connected to said fuel supply means and shifting the same to said full load position when the pressure in said container drops below said predetermined level, and to

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said idling position when said pressure in said container exceeds said predetermined higher level; and operation control means associated with said pressure responsive actuating means for effecting a rapid switching of said fuel supply means between said idling and full load positions.

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