

July 6, 1937.

H. JÄNICKE

2,086,162

FREE PISTON MOTOR COMPRESSOR

Filed Feb. 23, 1935

4 Sheets-Sheet 1

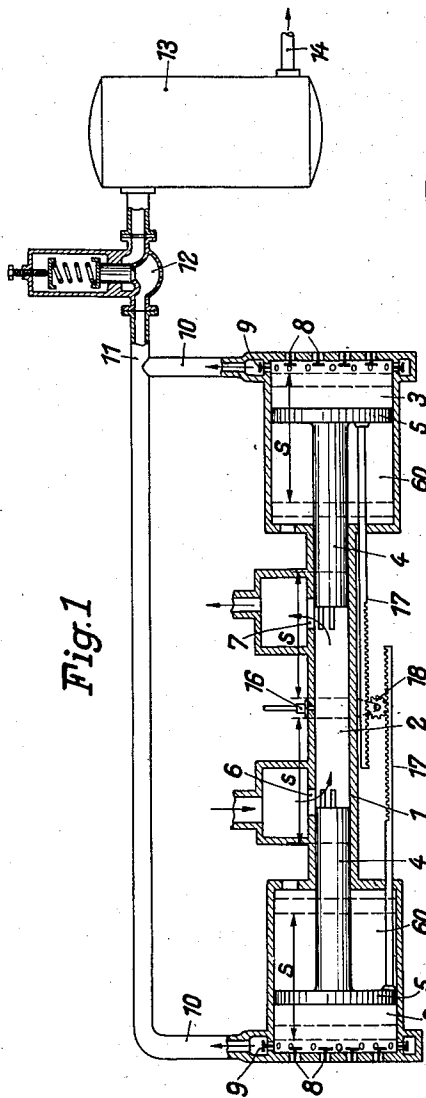


Fig. 1

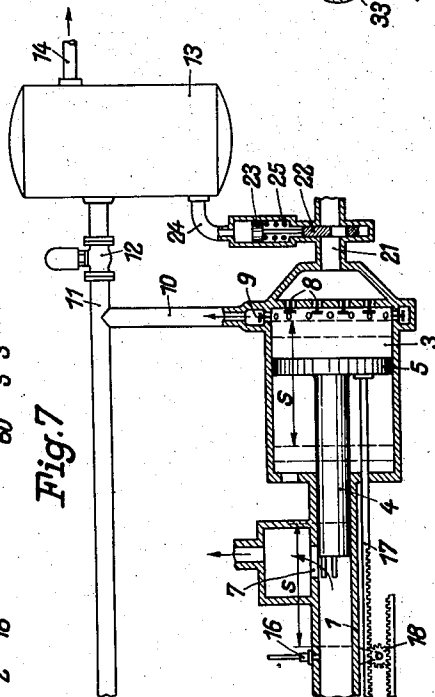


Fig. 7

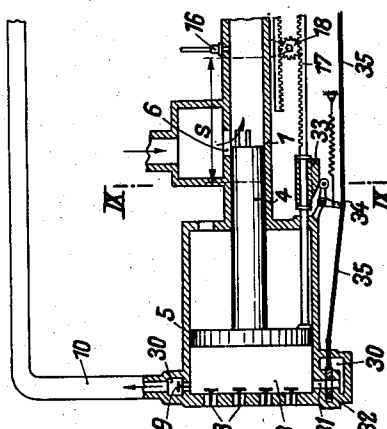


Fig. 8

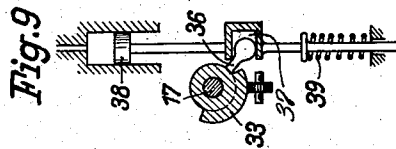


Fig. 9

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4 Sheets-Sheet 2

Fig. 2

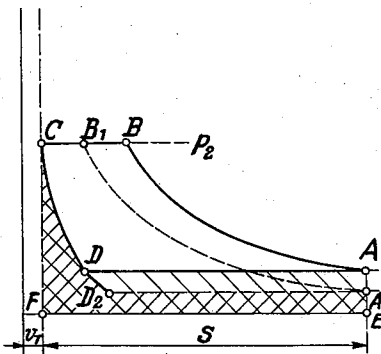


Fig. 3

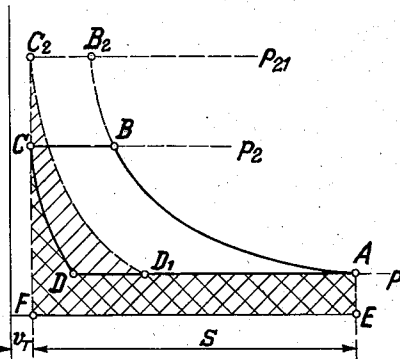


Fig. 4

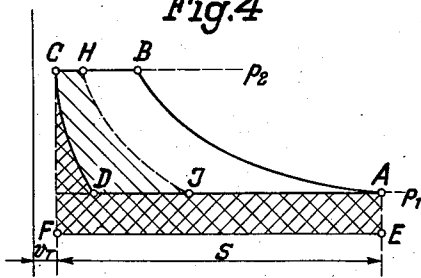


Fig. 5

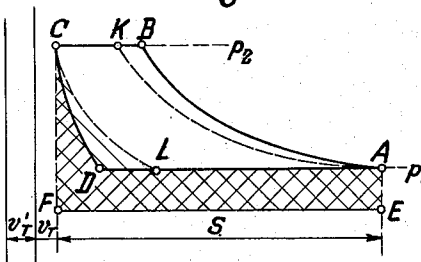
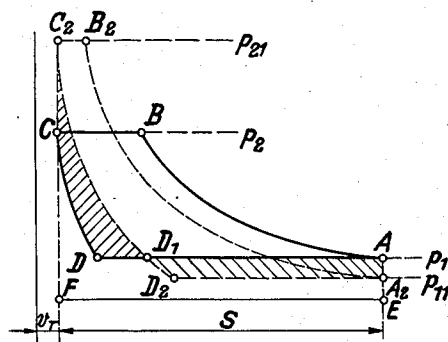


Fig. 6



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4 Sheets-Sheet 3

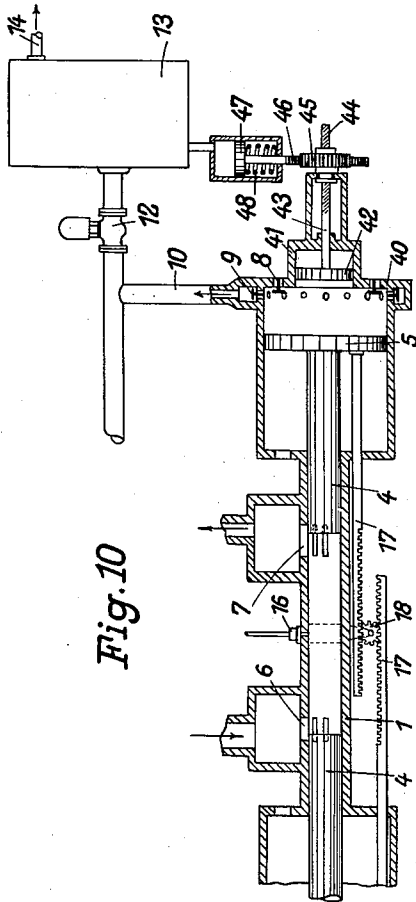


Fig. 10

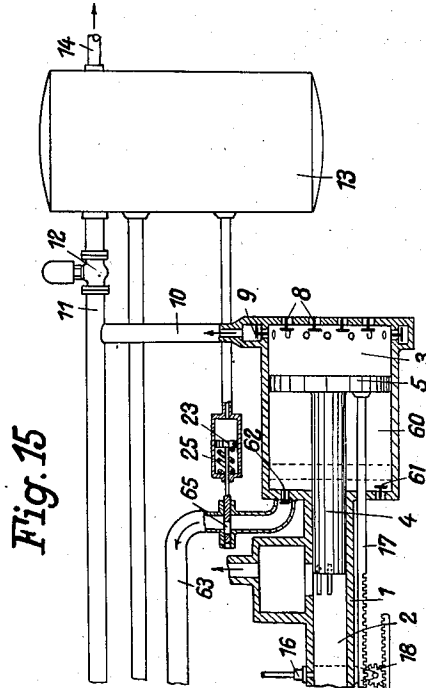


Fig. 15

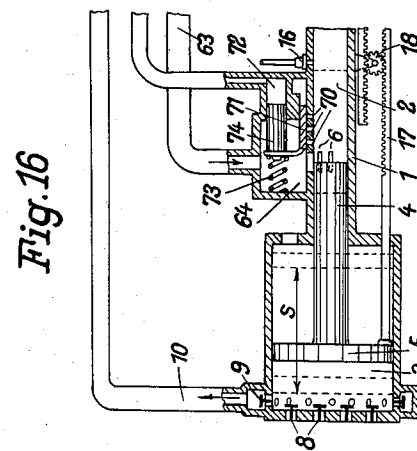


Fig. 16

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2,086,162

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4 Sheets-Sheet 4

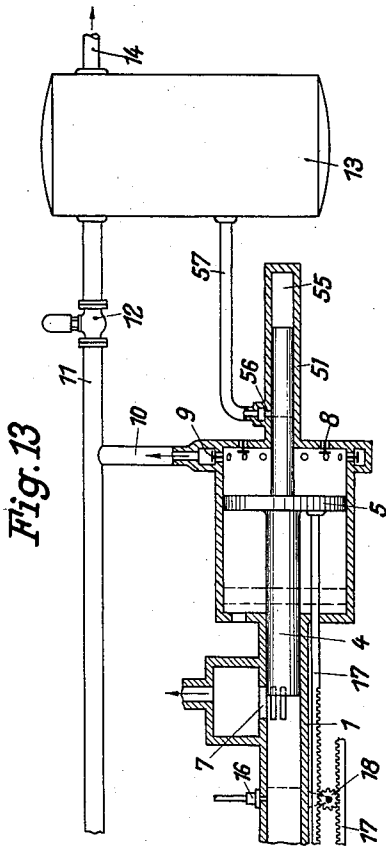


Fig. 13

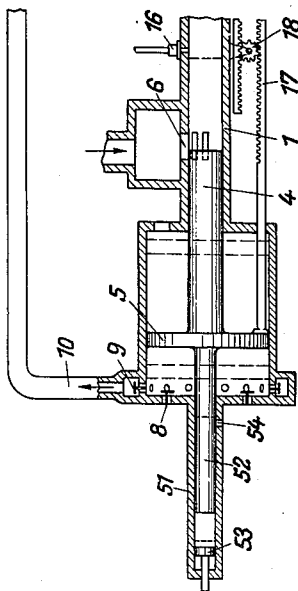


Fig. 11

Fig. 14

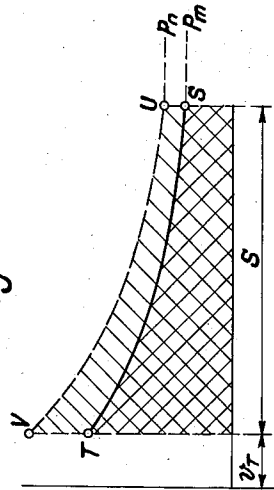
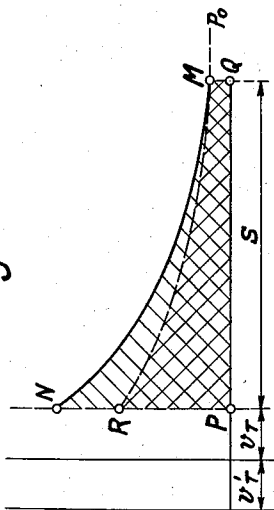


Fig. 12



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UNITED STATES PATENT OFFICE

2,086,162

FREE PISTON MOTOR COMPRESSOR

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many

Application February 23, 1935, Serial No. 7,788
In Germany March 9, 1934

13 Claims. (Cl. 230—56)

My invention relates to free piston motor com-
pressors and has for one of its objects to provide
means, whereby the output of such motor com-
pressors can be varied within wide limits.

5 In my copending U. S. application Serial No.
710,483 I have disclosed a method of controlling
a free piston motor compressor by varying the
length of stroke and the pressures thereof, e. g.
the suction or discharge pressure or a combina-
10 tion of both these pressures. My copending U. S.
application Serial No. 7,786 discloses the control
of a free piston motor compressor by means of a
variation of the dead space and the fuel supply,
while my copending U. S. application Serial No.
15 7,787 discloses the regulation of a free piston
motor compressor by means of a variation of the
pressures, i. e. the suction or delivery pressure or
a combination of both these pressures, and of
the fuel supply to the motor cylinder of the motor
20 compressor.

In both the aforesaid U. S. applications Ser.
Nos. 7,786 and 7,787 the variation of the fuel
supply is adapted to the variation of the com-
pressor output and is carried out in such a man-
25 ner that the length of the piston stroke always
remains approximately constant.

In free piston motor compressors comprising
a combustion chamber and one or a plurality of
compression chambers and freely reciprocating
30 pistons forming the freely movable mass it has
been proposed, in order to control the output of
the compressor, to change the length of stroke
of the movable mass, while the energy, by which
the movable mass, after its working stroke, is
35 returned into its initial position (the so-called
return energy) is kept constant. This change
of stroke involves certain drawbacks in so far as
the control of the internal combustion engine
which is derived from the motion of the freely
40 movable mass, is subjected to corresponding
changes. Therefore a method of operation is
desirable which allows varying within a wide
range the output of the compressor and keeping
the return energy approximately constant with-
45 out substantially changing the stroke of the
freely moving mass.

According to the present invention this is ac-
complished by simultaneously changing at least
two of the variables which at a predetermined
50 constant stroke of the piston determine the
value of the quantity of gas discharged by the
compressor (the output of the compressor) as
well as of the energy fed by the compressor to
the freely moving mass during the return stroke
55 (the return energy), these variables being chosen

so as to affect the output of the compressor in
equal senses, the return energy in opposite senses,
partly increasing and partly reducing this en-
ergy so that when the output changes the in-
fluences acting upon the return energy com- 5
pensate each other, this energy being kept
approximately constant. The fuel delivery to the
combustion chamber of the free piston com-
pressor should be adapted to the output by means
10 of hand-operated mechanism or, if desired, auto-
matically, for instance in dependency upon the
stroke of the freely moving mass or upon the
pressure of the gas contained in a storage tank
connected to the compressor.

The output of the compressor may be influ- 15
enced, for instance, by means of the following
variables:

(a) The suction pressure, on the reduction of
which the output is reduced as well as the return
20 energy,

(b) The discharge pressure, on the increase of
which the output will be reduced, while the re-
turn energy will increase,

(c) The part of the compression chamber uti-
lized for discharging (the so-called efficient dis- 25
charge volume), on the diminution of which the
output will be reduced, the return energy being
increased,

(d) The volume of the dead space of the com-
pressor, on the increase of which the output is 30
reduced and the return energy increased.

Thus in varying the output of the compressor
the return energy may be approximately kept
constant by simultaneously changing, besides the
value mentioned under (a), at least one of the 35
values (b) to (d).

In free piston motor-compressors comprising
a plurality of compression chambers these cham-
bers may either be arranged so as to effect the
compression in all chambers at a time or in some 40
chambers during the working stroke of the pis-
tons, in the others during the return stroke.

In the case first mentioned the output of the
compressor is controlled, according to this inven-
tion, by varying in the compression chambers 45
some of the variables in such manner that the
amounts of return energy delivered by these
chambers partly increase and partly decrease,
while their sum total remains approximately
constant.

In the second case the output of the compressor
is controlled by changing in the several com-
pression chambers those variables, the variation
of which causes the return energy delivered from
50 some of the chambers to the freely moving mass 55

during the return stroke to be changed in the same sense as the compression energy delivered to the other chambers by the freely moving mass during the same stroke. Thus these energies will decrease or increase together, the difference between them remaining approximately constant.

Besides the compression chambers there may further be provided auxiliary devices adapted for the storing or returning of energy, such as pneumatic or mechanical buffers for stabilizing the running of the compressor, scavenging pumps or the like. These auxiliary devices may either be arranged so as to feed energy or to withdraw energy from the freely moving mass during its return stroke. In pneumatic buffers the amount of this energy partly depends upon the same variables, viz. those mentioned hereabove under (c) and (d), as in the compression chambers, and further upon the amount (product of the pressure and volume) of the gas enclosed in the buffer chamber. In mechanical (spring) buffers the amount of energy depends upon the mass of and the load acting on the elastic material. Thus by varying one or a plurality of these values the amounts of energy taken up or delivered by the buffers during the return stroke of the freely moving mass may be changed. Here again one or a plurality of the variables determining the output of the compressor and one or a plurality of the variables determining the energy taken up and/or delivered by the auxiliary devices are chosen to approximately keep constant at any output of the compressor the arithmetical sum total of the amounts of energy which during the return stroke are delivered to the freely moving mass (positive amounts) or are discharged by said mass (negative amounts), this sum representing the amount of energy available for the compression of the charge of air and fuel in the combustion chamber.

Still another means of compensating the variation of the return energy due to a change of output of the compressor consists in designing the motor portion of the free piston compressor in such manner that the energy taken up by it during the return stroke varies approximately in proportion to the return energy delivered by the compression chambers. This may be accomplished, for instance, by redischarging in a well known manner a greater or smaller part of the charge from the cylinder, before compression has started, through a discharge port held open for a suitable period of time.

The various means described hereabove for influencing the output of the compressor and the return energy may be combined with each other, if desired, in various ways.

In the drawings affixed to this specification and forming part thereof some embodiments of my invention are illustrated diagrammatically by way of example.

In the drawings

Fig. 1 is an elevation, partly in axial section, of a free piston motor-compressor operating according to my invention, while

Figs. 2-6 are pressure-volume diagrams serving to explain the operation of this compressor.

Figs. 7, 8, 10, 11, 13, 15, and 16 are elevations, partly in axial section, of further embodiments of this invention, each figure representing only one half of the compressor.

Fig. 9 is a cross section, drawn to a larger scale along the line IX-IX in Fig. 8.

Figs. 12 and 14 are pressure-volume diagrams serving to explain the operation of buffers operating according to my invention.

Referring to the drawings and first to Fig. 1, the free piston motor-compressor here shown comprises a casing 1, the mid-portion of which forms a combustion chamber 2, while a compression chamber 3 is provided at each end of the casing. There are further provided a pair of free pistons or freely moving masses, each comprising a motor piston 4 and a compressor piston 5 directly connected with each other. 6 and 7 are scavenging and exhaust ports, respectively, provided in the wall of the casing 1 and controlled by the motor pistons 4. The compressor pistons 5, during the return stroke, draw in through suction valves 8 the gas which is compressed during the working stroke and discharged through pressure valves 9, pressure pipes 10, and collecting pipe 11 to storage tank 13 from which it is discharged to the consumer (not shown) through a pipe 14. 12 is a spring-loaded non-return valve provided in the collecting pipe 11, by which the pressure in the compressor chambers 3 at the close of the compression will be maintained at a predetermined minimum value even if in consequence of the discharge of great quantities of gas the pressure in the tank 13 should drop below the said minimum value. The load on the valve 12 is so chosen that the corresponding final pressure of compression, upon which depends the amount of return energy, affords a return energy which suffices for warranting correct operation of the compressor. Valve 12 may be dispensed with if the pressure valves 9 are designed in such manner that they will be open only when the final pressure of compression reaches the minimum value required for warranting correct operation of the compressor. The gas remaining over in the dead spaces of the compression chambers, at the end of the working stroke in expanding, forces the masses 4, 5 towards each other. As soon as the pressure in the compression chambers has dropped to become equal to the suction pressure, fresh gas will be drawn in through the suction valves 8. At the same time the mixture in the combustion chamber 2 is compressed, fuel being delivered to said chamber by a suitable device 16, for instance, an injection nozzle. The charge is ignited and the products of combustion drive the masses asunder, whereby the gas in the compression chambers is compressed and discharged. In order to secure synchronous reciprocation of the freely moving masses, they are connected with each other by a suitable gearing such as racks 17 secured to the masses and engaging a pinion 18 rotatably mounted on the casing 1.

Fig. 1 shows in dotted lines the dead centre positions of the pistons 5, indicating the length of stroke which should be kept constant, as far as this is possible in view of the unavoidable slight variations of the stroke of the pistons, at any output of the compressor, which may vary within a wide range, from maximum discharge to zero.

This device operates as follows:

Fuel is periodically delivered to the combustion chamber 2 at the end of the return strokes of the pistons. The charge in the motor cylinder, after having been compressed, is ignited whereby the pistons 4, 5 are driven from their inner to their outer dead centre positions, the gearing 17, 18 providing for an exactly synchronous

movement of the pistons. During the outward (working) stroke the gas in the compression chambers 3 is compressed to the discharge pressure and is discharged through the valves 9 and pipes 10 and 11 to tank 13. During the latter part of the working stroke the exhaust ports 7 and scavenging ports 6 are opened so that fresh air can enter the combustion chamber 2 and the exhaust gases are discharged. The compressed gas remaining in the dead spaces of the compression chambers 3 at the end of the working stroke now re-expands and returns the pistons to their inner dead centre positions, fresh gas being drawn in through the suction valves 8 during the latter part of the return stroke. When the pistons have reached their inner dead centre positions, the cycle of operations is repeated.

Figs. 2-6 illustrate the manner in which by varying several determining variables, the output of the compressor and the amount of return energy may be influenced. In these figures the cycle ABCDA represents the compressor diagram at normal output, the gas being compressed from the suction pressure p_1 to the discharge pressure p_2 . The return energy is represented by the area CDAEFC.

Fig. 2 illustrates the controlling of the output by reducing the suction pressure. $A_2B_1CD_2A_2$ is the diagram corresponding to the reduced suction pressure p_{11} . The output is represented by the distance B_1C which is smaller than the distance BC representing the normal output. The return energy corresponding to the reduced output is represented by the area CD_2A_2EFC which is smaller than the normal return energy by the amount DAA_2D_2D .

Fig. 3 illustrates the controlling of the output by increasing the discharge pressure. If this pressure is increased, for instance, to p_{21} , the diagram $AB_2C_2D_1A$ will be obtained, the suction length D_1A of which is smaller than the suction length DA corresponding to the normal output. In a similar proportion the amounts of gas will be changed which are drawn in and discharged. The return energy corresponding to the reduced output is represented by the area $C_2D_1AEFC_2$ which exceeds the normal return energy by an amount corresponding to the area $C_2D_1DCC_2$.

Fig. 4 illustrates the controlling of the output by allowing part of the previously compressed and discharged gas to flow back into the compression chambers. By thus reducing the output the starting point of the re-expansion is shifted from C to H. Re-expansion occurs along the curve HJ. There is thus obtained the diagram ABHJA, the return energy being represented by the area HJAEFCH which exceeds the normal return energy by the area HJDCH.

Fig. 5 illustrates the controlling of the output by changing the volume of the dead space. By increasing the normal dead space v_r by the amount $v'r$ the diagram AKCLA is obtained. The output represented by the distance KC is smaller than the normal output corresponding to the distance BC. The return energy represented by the area CLAEFC exceeds the normal return energy by the area CLDC.

Now the return energy may be kept approximately constant by simultaneously employing a plurality of controlling means which partly increase and partly reduce the return energy. An example of a control of this kind is shown in Fig. 6 which illustrates the simultaneous application of the modes of control shown in Figs. 2 and 3,

viz. the reduction of the suction pressure and the increase of the discharge pressure. Here compression starts at the reduced suction pressure p_{11} and goes on, till the increased discharge pressure p_{21} is reached, and the diagram $A_2B_2C_2D_2A_2$ is obtained. The return energy is increased by the area $C_2D_2DCC_2$ and reduced by the area $D_1AA_2D_2D_1$. If the control is carried through in such manner that these last two areas are equal, the return energy will remain constant. If desired, the means of control according to Figs. 4 and 5 may be used singly or in combination with each other, similarly as the means shown in Fig. 3, together with the reduction of the suction pressure according to Fig. 2.

Fig. 7 shows means for influencing the output of the compressor by varying the suction pressure. All the suction valves 8 are connected to a common suction pipe 21 containing a slide 22 connected to a piston 23 which is loaded, through pipe 24, with the pressure in the tank 13 tending to close the slide against the force of a spring 25 which is dimensioned in such manner that the slide is closed gradually in proportion as the pressure rises.

Figs. 8 and 9 illustrate means for varying the efficient discharge volume of the compressor by enabling gas to flow back into the compressor chambers at the beginning of the return stroke. The compression chamber 3 and an annular chamber 30 into which discharge the pressure valves 9, are connected with each other by a port 31 which may be opened and closed by means of a slide 32 actuated by a cam 33 mounted on the rack 17, a crank lever 34 and a rod 35. The cam 33 is undisplaceably, but rotatably secured to the rack 17, its protruding portion having different lengths in different radial planes so that by turning the cam the movement of the slide may be varied. As shown in Fig. 9, this may be effected by means of an arm 36 secured to the cam and engaging all through its stroke along with the rack 17 a channel 37 extending in parallel to the rack 17. The channel 37 is transversely adjustable, for instance in dependency on the pressure in the tank 13 by means of a piston 38 acted upon by this pressure and against the action of a spring 39. When it is desired to make the compressor operate at its maximal output, the cam 33 is adjusted in such manner that the slide 32 is not shifted and keeps the port 31 permanently closed. In order to reduce the output of the compressor the cam 33 is turned so that the slide 32 is displaced and the port 31 is opened when the compressor piston 5 approaches the dead centre position corresponding to the discharge end. On reversal of the movement of the piston compressed air will flow back from the chamber 30 to the compression chamber 3 until during the return stroke of the piston 5 the cam 33 comes out of reach of the crank lever 34.

Fig. 10 illustrates a device for influencing the output of the compressor by changing the volume of the dead space. The end wall 40 of the compression cylinder is formed with a cylindrical extension 41 in which a piston 42 is slidably arranged. The rod 43 of the piston 42 is formed with a thread 44 engaged by the internally threaded hub of a toothed wheel 45 which is axially undisplaceable and engaged by the toothed rod 46 of a piston 47 acted upon by the pressure in the tank 13 against the action of a spring 48. When the pressure in the tank 13 exceeds its normal value, i. e. when the output of the compressor exceeds the demand for com-

pressed gas, the piston 47 is forced downwardly against the action of the spring 48, the toothed wheel 45 being rotated and shifting the piston 42 to the right, thereby increasing the dead space of the compression cylinder and correspondingly reducing the output.

In the embodiments shown in the following figures there are provided, besides the compression chambers, auxiliary chambers such as buffers or the like which are connected with devices for influencing the return energy available for the compression of the charge in the combustion chamber.

In the embodiment shown in Fig. 11 a buffer connected to the compressor and comprising a cylinder 51 and piston 52 takes up energy during the working stroke and feeds it back during the return stroke. The end wall of the cylinder 51 is formed by a piston 53 allowing the volume of the dead space of the buffer to be varied. The piston 53 may be adjusted by hand or, if desired, automatically in dependency on the pressure in the tank in a similar manner as shown in connection with the piston in Fig. 10.

Fig. 12 illustrates the diagram of the buffer shown in Fig. 11. The initial pressure is always equal to p_0 . If this pressure is equal to that of the atmosphere, a small port 54 in the wall of the buffer cylinder near the dead centre position corresponding to the beginning of the working stroke will be sufficient for maintaining this pressure. With a small dead space v_r of the buffer compression will occur along the curve MN, the return energy fed by the buffer corresponding to the area NPQMN. If the dead space of the buffer is increased by the amount v_r , compression will occur along the curve MR situated beneath the curve MN, the return energy of the buffer being reduced to the area RPQMR.

If the return energy fed by the compressor decreases, as the output is reduced, for instance in throttling the gas drawn in by the compressor according to Figs. 2 and 7, the portion of the return energy which is fed by the buffer, must increase. In that case the device shown in Fig. 11 should be designed in such manner that the dead space of the buffer decreases when the output of the compressor drops, and vice versa.

If, on the other hand, the return energy of the compressor increases on the output being reduced, for instance according to Figs. 3-5, the dead space of the buffer must become smaller as the output drops.

Fig. 13 illustrates another embodiment of a device for varying the portion of the return energy fed by the buffer. The working chamber 55 of the cylinder 51 of the buffer is formed with a port 56 in the cylinder wall near the inner dead centre position of the piston, this port connecting the working chamber to a pipe 57 leading to the tank 13.

The operation of this device will be understood from the diagram shown in Fig. 14. If the pressure in the tank 13 has its normal value p_m , the compression in the chamber 55 of the buffer will occur along the curve ST. If, however, the pressure in the tank 13 rises to the value p_n , the curve of the compression is represented by UV, the return energy fed by the buffer being increased by the amount corresponding to the area VTSUV.

A buffer, an additional compressor or the like may be provided, if desired, to take up energy (negative return energy) during the return stroke of the freely moving mass and to feed this

energy back during the working stroke. If the compressor piston is larger than the motor piston (as is shown in Fig. 1), the differential piston surface and the chamber 60, in which the latter runs, may constitute a buffer or an additional compressor. The amount of energy taken up by this buffer or additional compressor during the return stroke of the freely moving mass may be varied, in dependency on the variation of output of the compressor, by means such as described hereabove in connection with the ordinary buffer or the main compressor, to afford a resultant return energy which is at least approximately constant.

An example of such an embodiment is shown in Fig. 15. The chamber 60 adjoining the left hand side of the compressor piston 5 is designed as a scavenging pump and provided with suction valves 61 and pressure valves 62. A pipe 63 connecting the pressure valve 62 to a scavenging air tank 64 shown in Fig. 16 is provided with a throttling device 65 actuated by the pressure in the tank 13 in a similar manner as described hereabove in connection with Fig. 7, exerting a throttling action in proportion as this pressure increases, and vice versa. If desired, the throttling device may also be adjusted by means of a hand-operated device.

Fig. 16 illustrates means for varying the taking up of energy in the combustion chamber. 70 are ports arranged in alignment in the wall of the cylinder 1 near the scavenging ports 6. They may be covered or uncovered by a slide 71 connected to a piston 74 displaceably arranged in a cylinder 72 and acted upon on one side by the pressure in the tank 13 and on the other by a spring 73.

The output of the compressor shall be reduced as the pressure in the tank 13 rises.

If the compressor is adjusted in such manner that the return energy increases when the output is reduced, for instance as illustrated in Figs. 3-5, the slide 71 and the piston should be arranged, as shown in the drawing, in such manner that on the pressure in the tank 13 rising the ports 70 are closed one after the other by the slide 71, whereby a steadily decreasing part of the charge will be returned into the scavenging air tank before being compressed, so that the energy required for compression is increased correspondingly.

If the compressor is controlled by throttling the suction according to Fig. 2, the return energy will drop when the output is reduced. In this case the slide 71 and the piston 74 should be arranged to uncover the ports 70 one after the other when the pressure in the tank 13 rises, and the amount of charge subjected to compression and the energy required for this compression will then decrease correspondingly. This mode of control is particularly recommendable since the quantity of the charge is varied in the same sense as the output to be delivered by the motor portion of the compressor.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described for obvious modifications will occur to a person skilled in the art.

I claim:—

1. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side thereof, a free piston in each cylinder comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being di-

rectly connected with each other, means for varying at least two of the variables determining the taking up and delivery of energy in said compressor cylinder in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

2. A free piston motor compressor comprising in combination, a motor cylinder, a main and an additional compressor cylinder arranged on either side thereof, a free piston in each of said cylinders, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying at least two of the variables determining the taking up and delivery of energy in the said main and additional compressor cylinders in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

3. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying the discharge pressure and at least one other variable determining the taking up and delivery of energy in said compressor cylinder in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

4. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying the suction pressure and at least one other variable determining the taking up and delivery of energy in said compressor cylinder in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

5. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying the useful discharge volume and at least one other variable determining the taking up and delivery of energy in said compressor cylinder in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

6. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying the clearance volume and at least one other variable determining the taking up and delivery of energy in said compressor cylinder in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

7. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying at least two of the variables determining the output of the compressor and the variations of which influence the feed-back energy in opposite senses, in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

8. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying the suction and discharge pressures in said compressor cylinder in opposite senses and in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

9. A free piston motor compressor comprising in combination, a motor cylinder, a plurality of compressor cylinders arranged on either side thereof for compression during the motor working stroke, a free piston in each of said cylinders, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for varying at least two of the variables determining the taking up and delivery of energy in the said compressor cylinders in such manner that the feed-back energy in part of said compressor cylinders is increased and in another part of said cylinders reduced in such manner that the energy available for compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

10. A free piston motor compressor comprising in combination, a motor cylinder, a plurality of compressor cylinders arranged on either side thereof, one on either side being arranged for the compression to take place during the motor working stroke, while another one on the same side is arranged for compression to take place during the return stroke, a free piston in each of said

5 cylinders, said pistons being operatively connected with each other, means for varying at least two of the variables determining the taking up and delivery of energy in the said compressor cylinders in such a manner that the amounts of energy delivered during the return stroke in one of said compressor cylinders vary in the same sense as the amounts of energy taken up during the return stroke in another compressor cylinder and that 10 the difference of energy available for compression of the motor charge is substantially constant independently from the output, and means for at the same time varying the supply of fuel to the said motor cylinder in such manner that the 15 length of the piston stroke remains substantially constant.

11. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side 20 thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, a buffer arranged to deliver the energy, accumulated during 25 the working stroke, again during the return stroke, means for varying at least one of the variables determining the output of the said compressor and at least one of the variables determining the taking up of energy of the said buffer

in such manner that the resulting amount of energy available for the compression of the motor charge remains approximately constant, and means for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant. 5

12. A free piston motor compressor comprising in combination, a motor cylinder and at least one compressor cylinder arranged on either side 10 thereof, a free piston in each cylinder, comprising a motor piston and a compressor piston arranged on the same side of the motor cylinder being directly connected with each other, means for regulating the output of said compressor, means for 15 varying the resistance energy to be overcome in said motor cylinder on the return stroke to substantially the same extent as the feed-back energy is varied by the variation of the output, and means 20 for at the same time varying the supply of fuel to said motor cylinder in such manner that the length of the piston stroke remains substantially constant.

13. The free piston motor compressor of claim 12 in combination with means connected with the 25 motor cylinder for enabling part of the motor cylinder charge to be discharged before compression is started.

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