

Sept. 17, 1940.

H. JÄNICKE

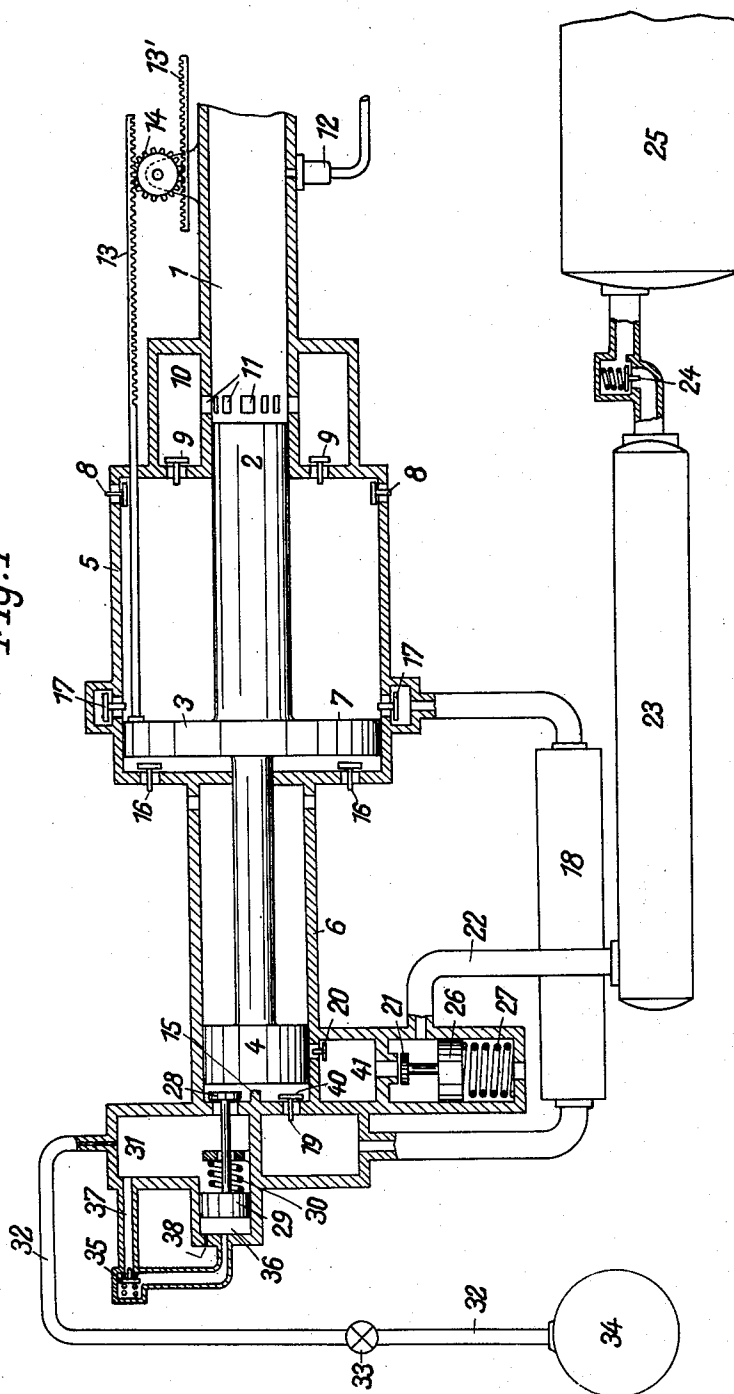
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MEANS FOR STARTING FREE PISTON MOTOR COMPRESSORS

Filed July 26, 1935

4 Sheets-Sheet 1

Fig. 1



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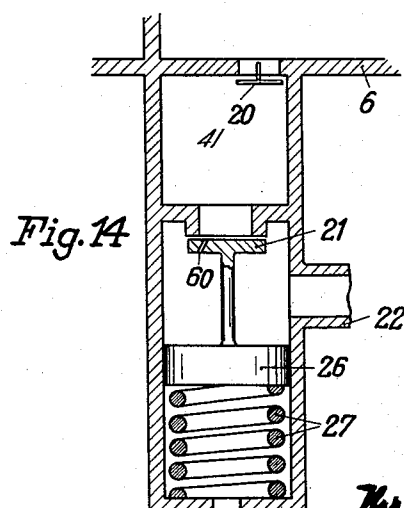
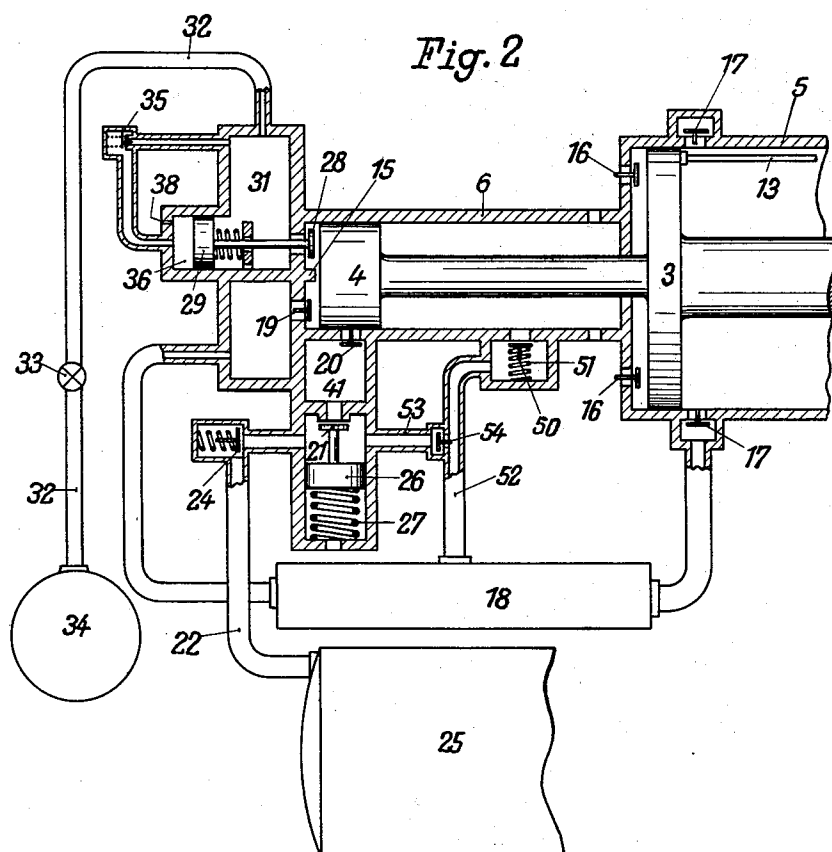
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MEANS FOR STARTING FREE PISTON MOTOR COMPRESSORS

Filed July 26, 1935

4 Sheets-Sheet 2



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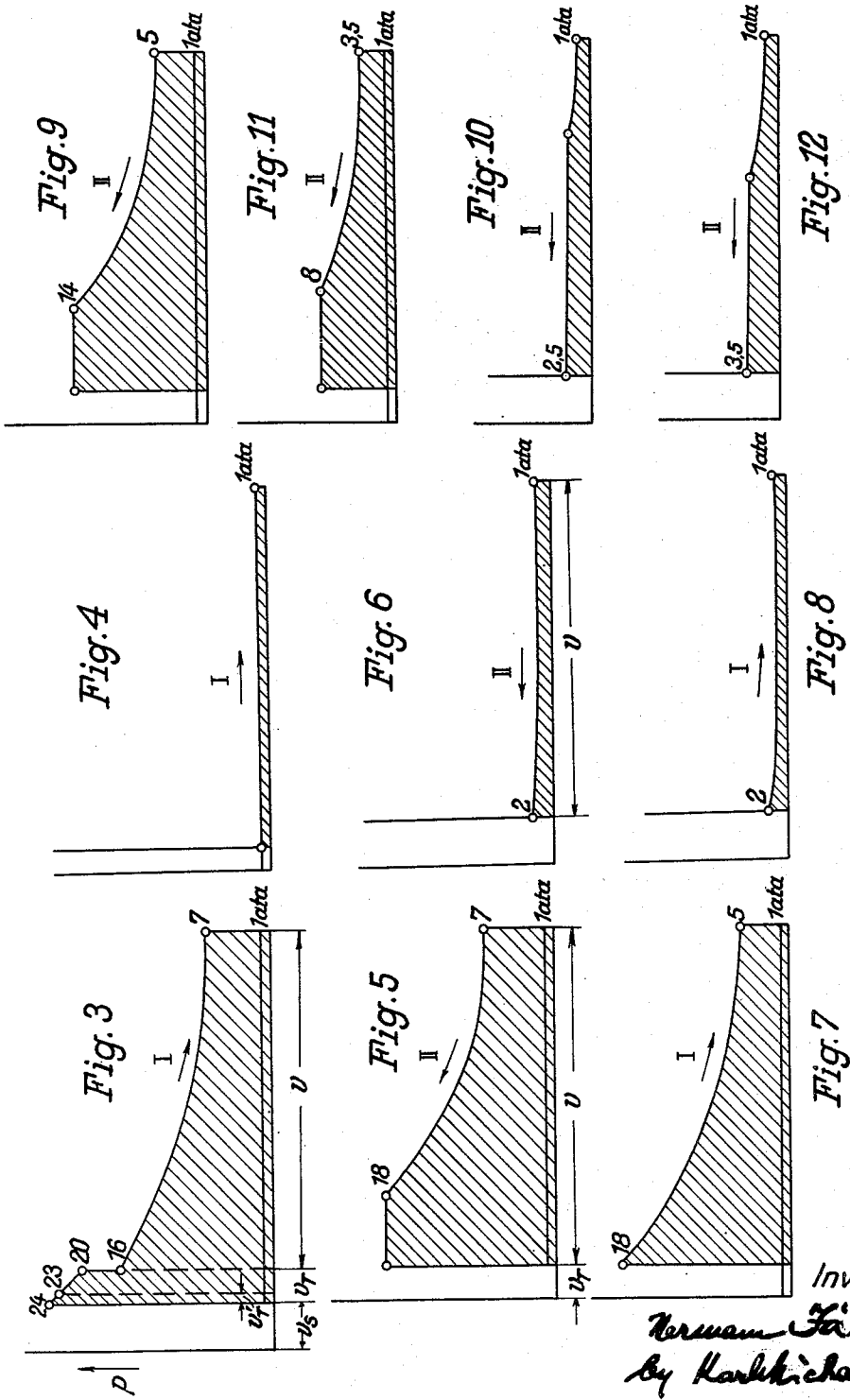
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MEANS FOR STARTING FREE PISTON MOTOR COMPRESSORS

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4 Sheets-Sheet 3



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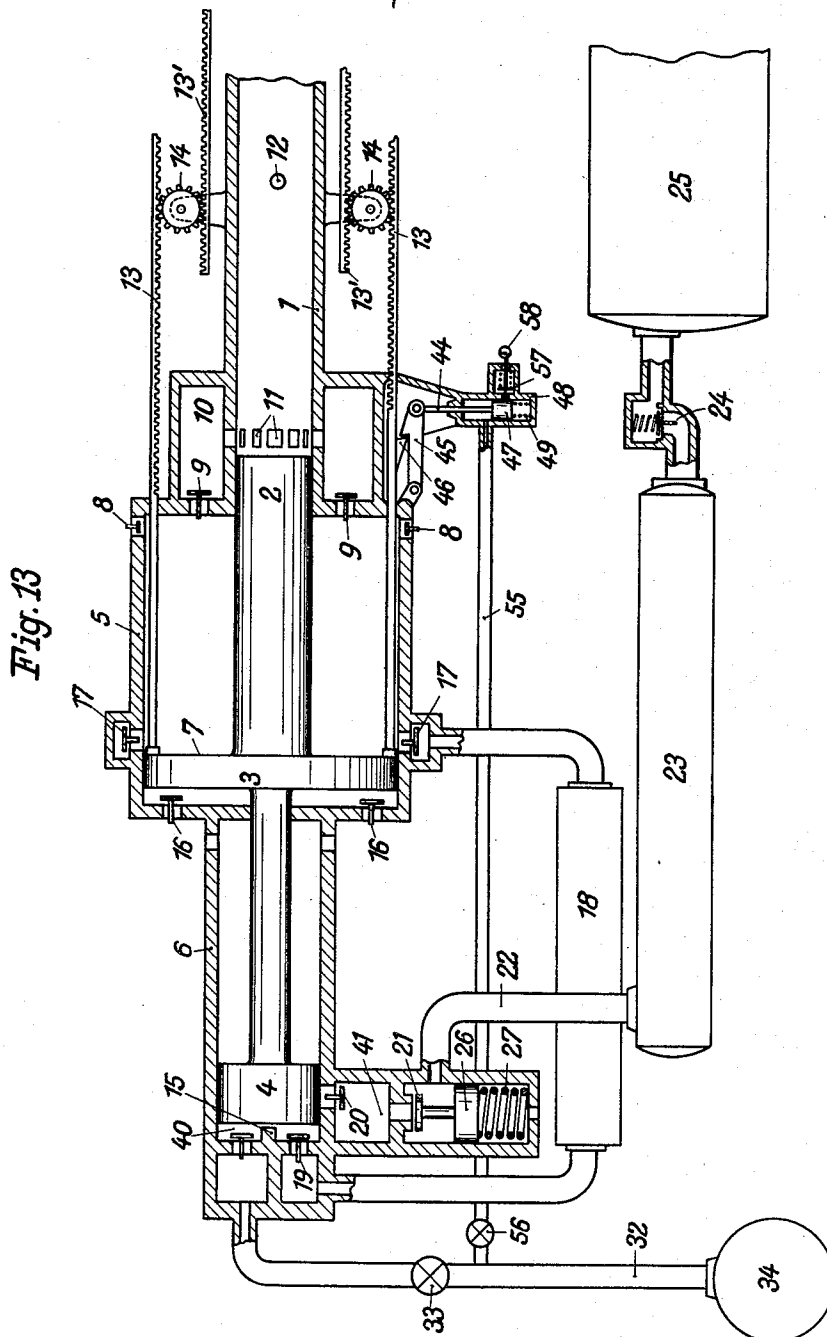
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MEANS FOR STARTING FREE PISTON MOTOR COMPRESSORS

Filed July 26, 1935

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,215,326

MEANS FOR STARTING FREE PISTON
MOTOR COMPRESSORS

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In Germany August 11, 1934

11 Claims. (Cl. 230—56)

My invention relates to the starting of multi-stage free piston motor compressors which shall be started from the side of the compressor with the aid of gas under pressure. Hitherto such free piston motor compressors have been started by first arresting the freely moving masses in the starting position, for instance by means of a pawl or the like, placing them under pressure by means of a compressed gas on the side of the compressor and thereafter releasing them by removing the pawl in order to enable compression to take place and the motor charge to be ignited.

It has also been suggested to start single-stage free piston motor compressors by first placing the freely moving masses in a position which substantially corresponds to their position at the beginning of the compression of the motor charge and thereafter setting them moving by suddenly acting on the compressor pistons with compressed gas.

In both cases it is intended that the pressure of the compressed gas to be used for starting be reduced after the end of the first starting stroke (i. e., the stroke for compressing the motor charge which shall hereinafter be termed "return stroke") to the suction pressure of the compressor space used for starting, which means that in a single-stage compressor it will as a rule be reduced to atmospheric pressure. Consequently, the pressure of the gas used for starting practically corresponds to the end pressure produced in the regular operation of the compressor. If this mode of starting were applied to multistage compressors, each stage would have to be acted upon with compressed gas under the end pressure arising in this stage during regular operation and therefore each compressor stage would have to be provided with a storer for the compressed starting gas, the pressure in which corresponds to the final pressure arising in that compressor stage. Obviously the provision of bodies of compressed gas under several different pressures would be very inconvenient and it has therefore been suggested to supply all stages of a multistage compressor with starting gas under the same pressure, which should be so chosen that the total effort exerted by the pistons in starting be substantially as high as in the normal operation during the beginning of the return stroke. This pressure is however comparatively low and therefore very large storers and pipes and valves of large cross sectional area would be required which it would be difficult,

if not impossible, to accommodate, more especially in the higher stages.

According to the present invention these difficulties and drawbacks are obviated by using only part of the compressor stages for starting purposes and introducing into these stages gas under a pressure, which is higher than the pressure attained in these stages of the compressor under normal operating conditions. The use of starting gas under a higher pressure than the normal operating pressure in the stage used for starting offers the advantage that the storer for the starting gas and the pipes and valves connected with it may be of smaller size than in the case where the gas were placed under the same pressure as normally attained in the compressor stage used for starting.

According to this invention starting of the compressor can be effected in such manner that the starting process is already ended in a single cycle, i. e. after a single compression stroke of the motor charge and a single working stroke of the motor piston have been gone through. I may however also start the motor compressor in accordance with this invention by causing the compressed gas supplied to part of the compressor stages to expand and to be compressed again in a plurality of consecutive cycles, and at the end of each compression part of this starting gas is discharged from the compressor cylinder, so that the final pressures attained in the consecutive compression steps become lower and lower until they have finally dropped down to the end pressures arising under normal operation in the stages used for starting, while on the other hand the end pressure in the other stages, which are not used for starting, rises from one cycle to the other until the normal operating pressure has been reached.

In applying this mode of starting for example to a two-stage compressor, the compressor pistons of the second stage serving for starting are supplied with gas under a pressure, which corresponds substantially to the double or treble of the final pressure arising during normal operation in the second compressor stage. When a starting pressure of such magnitude is used, the starting gas can flow particularly quickly through the ports under control, so that there is imparted to the freely moving masses a high initial velocity for the compression stroke of the motor charge, which is particularly advantageous in a starting process in which the freely moving masses are not locked in their position by a pawl or the like.

I may however also use for the starting such stages of the compressor, the operating end pressure of which is lower than the highest end pressure arising during operation. In that case the starting gas under pressure may be withdrawn from a higher stage of the compressor, which is not used for starting. In the case that in this process several compressor stages shall be used for starting, these stages are preferably supplied with starting gas under equal pressure, which is however higher than the highest end pressure arising in the normal operation of these stages, so that the starting gas under pressure may be stored in a single reservoir, which can moreover be filled directly from a higher stage of the compressor. Here also the starting process may already be ended after the first cycle, but it may also extend over a plurality of cycles. In the latter case the pressures in the working spaces of the starting stages near the end of the compression stroke and the amounts of energy accumulated in the bodies of gas in the dead spaces of the compressor drop from one cycle to the other down to the magnitudes corresponding to normal operation, while in the spaces of the compressor stages, which are not used for starting, these values gradually rise from the magnitudes corresponding to rest up to the magnitude of normal operation.

In the drawings affixed to this specification and forming part thereof, free piston motor compressors embodying my invention are illustrated diagrammatically by way of example.

In the drawings,

Fig. 1 is an axial section, partly in elevation, of the left-hand half of a two-stage free piston motor compressor with permanently movable, i. e. never locked masses which move in opposite senses.

Fig. 2 is a similar illustration of a compressor in which the starting process is ended within one cycle.

Figs. 3 to 12 are pressure-volume diagrams of a starting process extending over several cycles, Figs. 3, 5, 7, 9 and 11 being the diagrams of the second compressor stage used for starting, while Figs. 4, 6, 8, 10 and 12 are the diagrams of the first compressor stage, which is not used for starting.

Fig. 13 is a view, similar to that shown in Fig. 1, of a two-stage free piston motor compressor, in which the freely moving masses are locked in their starting position by means of a pawl.

Fig. 14 is an axial section, drawn to a larger scale, of a pressure-controlled exhaust valve for the compressor stage used for starting.

Throughout the figures of the drawing similar parts are marked with similar reference numerals.

Referring first to Fig. 1, 1 is the motor cylinder, 2 is the motor piston, which is directly connected with the compressor piston 3 of the first stage and the compressor piston 4 of the second stage, these latter pistons moving in the compressor cylinders 5 and 6, respectively. The rear face 7 of the compressor piston 3 serves as a scavenging pump, the scavenging air being sucked during operation into the cylinder 5 through the suction valves 8 and forced through the pressure valves 9 into the scavenging air reservoir 10, from which it flows through the scavenging ports 11 of the motor cylinder 1, which are controlled by the piston 2. Fuel is introduced through a nozzle 12 into the cylinder

charge, which is highly heated by compression, and ignited by the heat of compression.

In order to secure synchronism of the two freely moving masses, each mass carries a rack 13, 13', which meshes with a toothed wheel 14. By rotating the wheel 14, for instance by means of a crank to be mounted on its axle, the freely moving masses may be placed by hand into the starting position shown in the drawings, in which they almost touch the stop 15 mounted on the cover of the cylinder of the second compressor stage.

During normal operation atmospheric air is sucked through the valves 16 during the return stroke in the first compressor stage and forced during the working stroke of the motor through valve 17 into the receiver 18. From here the air flows through the intake valves 19 into the cylinder 6 of the second compressor stage to be compressed further, whereupon it is forced through the exhaust valves 20, 21 and pipe 22 into the receiver 23, from which it is conveyed through a spring-acted valve 24 into the reservoir 25. The valve 21 is mounted on a piston 26, the end face of which is larger than that of the valve disc and which is acted upon by a spring 27 tending to close the valve. In the wall of the dead space of the second compressor stage is arranged a starting valve 28, which controls the passage of the compressed starting gas from a storer 31 into the compressor cylinder 6. The disc of this valve is mounted on a piston 29 having a larger end face than the disc and being acted upon by a spring 30, which tends to close the valve.

This compressor is started as follows: first of all the movable pistons 2, 3, 4 (only one of which is shown in the drawings) are moved asunder by means of a crank handle placed on the axis of the toothed wheel 14 (or by other suitable means) until they meet the stops 15. Now the starting gas storer 31 is filled from a source of gas under pressure 34 through the pipe 32 and valve 33 which may also be replaced by a cock or the like. While this is being done, the starter valve 28 is still prevented from opening since the pressure of the starting gas acting on the differential surface of the piston 29 and the force of the spring 30 keep the valve 28 closed. As soon however as the starting gas in the storer 31 has attained the pressure required for starting, the spring-actuated valve 35 in the conduit 37 leading from the storer 31 to the space 36 adjoining the rear side of piston 29 will open. The valve 35 might also be replaced by a manually operated member such as a cock or the like. The pressures acting from opposite sides on the piston 29 are now balanced and the pressure of the starting air in the storer 31, which acts on the valve disc 28, causes the valve to open quickly. The starting air now acts on the compressor piston 4 and shifts the freely moving mass with great velocity towards the right, the charge in the motor cylinder being at the same time compressed. This compression in the combustion chamber is followed by combustion and expansion of the combustion gases, which cause the first working stroke of the motor to take place. After the starting gas has left the storer 31, the valve 28 is closed by the spring 30. A narrow vent opening 38 in the wall of the chamber 36 or some other venting device of a well known kind is provided for allowing air to escape from this chamber.

I am now going to describe the first cycles of

operation of a two-stage motor compressor serving to start same, having reference to the diagrams shown in Figs. 3 to 12. In these diagrams the arrows I indicate return strokes serving to compress the motor charge, while the arrows II indicate working strokes of the motor.

Fig. 3 illustrates the sequence of pressures in the compressor cylinder of the second stage during the first starting stroke, the starting gas in the storer 31 (having the volume v_s) being placed under a pressure of 24 atms. As soon now as the starting valve 28 opens, the starting gas flows into the space 40 (dead space v_r) and expands therein, the pressure dropping to about 23 atms. Under this pressure the freely movable mass starts moving and on the way to the uncovering of the exhaust valves 20 by the piston 4 (the volume v_r being enclosed between the compressor cover and piston) a further expansion of the starting gas down to about 20 atms. takes place. As soon as the piston 4 has uncovered the ports of the exhaust valves 20, the starting gas expands into the space 41 between the valves 20 and 21, its pressure dropping to about 16 atms. In the further course of the first compression stroke for the motor charge (return-stroke) the starting gas expands down to about 7 atms. While this occurs, air or gas of atmospheric pressure has been sucked into the first compressor stage (Fig. 4). After ignition of the motor charge the gas in the compressor cylinder 6 (of the second stage) is recompressed during the first motor working stroke from 7 atms. upwards (Fig. 5). The curve of compression is somewhat steeper than the curve of expansion in Fig. 3, since in consequence of valve 28 closing, the storer 31 is cut off from the compressor cylinder, so that the compression must take place within a smaller total space than the preceding expansion. One thus obtains near the end of the compression a pressure (for instance of 18 atms.) in the cylinder 6 and in the space 41, which is higher than the highest pressure (16 atms.) prevailing in the space 41 during the return stroke. The tension of the spring 27 acting on the valve 21 is now so adjusted, that this valve opens at this higher pressure (of 18 atms.), so that part of the recompressed starting gas is discharged into the receiver 23, this being illustrated in the diagram of Fig. 5 by the horizontal discharge line. Fig. 6 illustrates the compression of the gas sucked into the first compressor stage to about 2 atms. during the first working stroke of the motor piston. The freely movable mass is moved back into its former position by the energy stored in the body of compressed gas stored in the dead spaces of the compressor. During this return stroke (compression stroke for the motor charge) the gas in the cylinder of the second compressor stage expands from 18 atms. to about 5 atms. (Fig. 7), while in the compressor space of the first stage the pressure of the gases drops again to atmospheric pressure (Fig. 8). In consequence of the discharging of part of the starting gas through valve 21 into the conduit 22 and the receiver 23, which already occurs during the first motor working stroke, the pressure in these spaces has also been increased. This increased pressure now acts on the differential surface of the piston 26 counter to the action of the spring 27 and in consequence thereof the valve 21 will, during the second motor working stroke (Fig. 9), already open at a pressure of 14 atms. in the compressor cylinder 6,

whereupon another portion of the starting gas is exhausted into the receiver 23. While this is going on, the gas in the first compressor stage (Fig. 10) has been compressed to 2.5 atms. This sequence of operations, according to which the pressures prevailing at the end of the motor working stroke (or compression stroke of the compressor) in the working chamber of the second compressor stage serving for starting and the amounts of energy stored in the bodies of compressed gas in the dead spaces of the compressor drop, while the same values gradually rise in the first stage of the compressor, which is not utilized for this starting, will now be repeated until the pressure in the receiver 23, which acts on the differential surface of the piston 26, has become so high as to overcome the pressure of spring 27, thus keeping valve 21 permanently open. At this point the normal operating condition illustrated in the diagrams of Figs. 11 and 12 is reached. According to Fig. 11 a compression of the gas from 3.5 atms. to the final operating pressure of 8 atms. is effected in the second stage, according to Fig. 12 a compression of the gas from 1 atm. to the operating end pressure of 3.5 atms. is effected in the first stage.

Fig. 2 illustrates a modified form of a starting device of the kind shown in Fig. 1, in which however the starting process as a whole can be carried through within a single cycle. Here a valve 50 is provided in the wall of the cylinder 6 of the second compressor stage serving for starting, this valve opening towards the outside and being held closed by a spring 51. The casing surrounding this valve communicates through pipe 52 with the receiver 18 of the first compressor stage and through pipe 53 enclosing a check valve 54 with the space enclosed between the disc of valve 21 and its piston 26.

With this device starting is effected as follows: The preparations for the start and the introductory steps for the compression stroke (return-stroke) for the motor charge occur similarly as described with reference to Fig. 1. However while in the device according to Fig. 1 no starting gas could escape from the cylinder 6 at the end of the first compression stroke for the motor charge, here part of the starting gas escapes near the end of the first compression stroke of the motor charge from the cylinder 6 through valve 50. The spring 51 acting on this valve is so dimensioned as to close the valve as soon as sufficient gas under pressure has escaped, that the residual gas in the compressor cylinder 6 merely possesses the normal operating pressure (for instance 3.5 atms. according to Fig. 11) at the end of the expansion of the body of gas in the compressor cylinder. The gas, which escapes through valve 51, now flows partly through check valve 54 into the casing surrounding valve 21 and acts on the piston 26. The surface of this piston is so dimensioned with respect to the surface of the valve disc 21, that the pressure exerted by the gas on this differential surface is able to overcome the resistance of spring 27 and to thus open the valve 21. The other part of the gas escaping through valve 51 flows through pipe 53 into the receiver 18 of the first compressor stage, at the same time expanding to the pressure prevailing in the receiver 18, which is equal to the normal operating pressure.

Since meanwhile the charge in the motor has been ignited, the first working stroke of the motor following combustion of the gases in the motor cylinder causes compression of the compressed

gas in the cylinder 6 (for instance according to Fig. 11) from 3.5 to 8 atms. and part of this gas is exhausted into the receiver 25 through the valve 24, which is normally held closed by a suitably dimensioned spring. Further, since the receiver 18 already contains gas under normal operating pressure (for instance 3.5 atms.) the gas sucked during the first motor charge compression stroke (return-stroke) into cylinder 5 of the first compressor stage is compressed from the beginning to the end operating pressure of this stage (for instance according to Fig. 12 from 1 atm. to 3.5 atms.), as illustrated by Fig. 12. Thus here the starting process has come to an end in a single cycle.

Fig. 13 illustrates the left-hand half of a two-stage free piston motor compressor with masses moving in opposite directions, which are shown in the starting position and can be locked in this position by means of a disengageable locking device.

This device here consists of a nose 46 formed on one of the racks 13 and a pawl 45 cooperating with it and hinged to the engine casing. In order that this pawl can be disengaged through the action of the starting gas, its free end is hinged to the rod 44 of a piston 47 movable in a cylinder 48 against the action of a spring 49, which tends to hold the pawl 45 in locking position. The cylinder 48 communicates by way of a pipe 55 and valve 56 with the starting gas reservoir 34. The pawl 45 can be locked in the position, in which it does not engage the freely movable mass, by a spring-loaded bolt 57, which can be moved into the path of the piston 47 as soon as this latter is depressed by the gas pressure. This locking of the piston is indispensable in order to prevent the pawl from passing during the operation of the compressor into locking position, whereby the compressor would be stopped.

In an engine such as shown in Fig. 13, starting is effected as follows:

The freely movable masses are first of all shifted into starting position by means of a crank lever to be mounted on the axle of the toothed wheel 14 and the bolt 57 is now pulled back by means of the handle 58 to allow spring 49 to force the piston 47 upwardly and to thus shift the pawl 45 into locking position, wherein it engages the nose 46. Now the starting gas reservoir 34 is connected through valve 33 with the compressor cylinder 6 of the second stage. While this is going on, the freely movable masses are not set in motion, being still retained by the locking device 45, 46. Only after the valve 56 has been opened, and the starting gas pressure allowed to act on the piston 47 so as to depress it, the pawl 45 is disengaged from the nose and the freely movable masses are now free to move towards each other, being propelled by the gas pressure acting on the compressor pistons of the second compressor stage. During this movement the motor pistons compress the air for combustion in the motor working chamber for the first time. On fuel being injected near the inner dead centre position of the motor pistons, combustion takes place, followed by an expansion of the gases in the motor working chamber, whereby the first working stroke of the motor is brought about. For the rest the starting process occurs in the manner described with reference to Figs. 1 to 12.

As shown in Fig. 14, a narrow passage 60 is provided in the disc of valve 21, which allows starting gas under pressure to enter the spaces 22, 23 behind valve 21 already during the first

compression stroke for the motor charge. By this arrangement the starting process, which extends over a plurality of cycles, can be shortened in a simple manner. For in consequence of the inflow of starting gas under pressure from the beginning of the starting process the pressure acting on the piston 26 in the spaces 22, 23 rises more quickly and thereby forces the valve 21 to remain permanently open at an earlier moment, than if the passage 60 were not provided. This narrow passage 60 further has the purpose of rendering the starting still more reliable. It may happen that during the first motor working strokes (for instance owing to a still imperfect combustion) the stroke of the movable masses does not extend over its full length and that consequently also the compression end pressure required for the opening of valve 21 is not attained. Consequently, if the passage 60 were not provided, the valve 21 would remain closed, so that in such a case the engine could not be put into normal operation. The passage 60 offers a way for the compressed gas to enter the spaces 22, 23 to the rear of valve 21 in case that, owing to a too short stroke of the movable masses, the end pressure attained in cylinder 6 should not be sufficiently high to overcome the resistance of spring 27 and to open the valve 21. Owing to the passage of compressed gas through the passage 60 into the spaces 22, 23, the pressure in these spaces gradually rises until it suffices to keep the valve 21 permanently open. The passage 60 might as well be replaced by some other passage from the chamber 41.

In multistage free piston motor compressors, in which some or all compressor stages are subdivided in a plurality of compressor spaces, for instance in compressors of symmetrical design, my invention may be applied in such manner that only part of the compressor spaces of the same compressor stage is utilized for the starting process.

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. Means for starting multi-stage free piston motor compressors comprising a motor cylinder and two free pistons arranged in said motor cylinder for reciprocation in opposite directions, a first compressor cylinder at each end of said motor cylinder and a compressor piston at the outer end of each free piston arranged for reciprocation in the corresponding first compressor cylinder, another compressor cylinder to the rear of each first compressor cylinder, a piston connected with the corresponding compressor piston and arranged for reciprocation in such other compressor cylinder, a starting air storer to the rear of said other compressor cylinder, a source of starting air connected with said storer, a valve opening arranged to govern the admission of starting air from said storer to the outer end of said other compressor cylinder, a valve body arranged to cooperate with said opening and to open towards the dead space, an auxiliary piston connected with and having a larger effective end face than said valve body, a spring arranged to act on said auxiliary piston so as to close said valve, a permanently open communication between said storer and the end of said auxiliary piston adjoining said valve body and another valve arranged to establish communication between said storer and the other face of said auxiliary piston.

2. In a free piston motor-compressor, in combination, a motor working chamber, a plurality of compressor working chambers of different size and interconnected so as to form the working chambers of a multi-stage compressor; means for starting said motor-compressor, said means comprising a starting gas reservoir, means for connecting only during the first starting stroke a selected part only of the compressor working chambers with said reservoir, a body of gas provided in said reservoir under a pressure higher than the highest end pressure occurring, during normal operation, in said selected compressor chambers; exhaust valves for normal operation arranged on said compressor chambers and means for rendering inoperative, during the first starting stroke, the exhaust valves of said selected compressor stages; discharge conduits for the compressed gas associated with each of said selected compressor stages, a discharge valve in each of said conduits and comprising a valve body adapted to open outwardly and loaded for closing, and a valve piston, said valve piston being connected with, and having a larger active surface than, said valve body, the side of said valve piston facing the valve body being connected with a receiver through which gas discharged from the compressor flows; the loading of the said valve body and the area of the valve piston face being so chosen that the valve, as long as the pressure prevailing in said receiver has not yet reached the amount corresponding to normal operation, opens only, when the pressure prevailing in the discharge conduit of the compressor stage and acting on the valve, exceeds the end pressure corresponding to normal operation of the compressor stage wherein this valve is provided, but that it remains constantly open when the pressure in said receiver has reached the amount correspondingly to normal operation.

3. In a free piston motor-compressor, in combination, a motor working chamber, a plurality of compressor working chambers of different size and interconnected so as to form the working chambers of a multi-stage compressor; means for starting said motor-compressor, said means comprising a starting gas reservoir, means for connecting only during the first starting stroke a selected part only of the compressor working chambers with said reservoir, a body of gas provided in said reservoir under a pressure higher than the highest end pressure occurring, during normal operation, in said selected compressor chambers; exhaust valves for normal operation arranged on said compressor chambers and means for rendering inoperative, during the first starting stroke, the exhaust valves of said selected compressor stages; discharge conduits for the compressed gas associated with each of said selected compressor stages, a discharge valve in each of said conduits and comprising a valve body adapted to open outwardly and loaded for closing, and a valve piston, said valve piston being connected with, and having a larger active surface than, said valve body, the side of said valve piston facing the valve body being connected with a conduit through which the gas from the stage provided with said discharge valve is passed; the loading of the said valve body and the area of the valve piston face being so chosen that the valve, as long as the pressure prevailing in said receiver has not yet reached the amount corresponding to normal operation, opens only, when the pressure prevailing in the discharge conduit

of the compressor stage and acting on the valve, exceeds the end pressure corresponding to normal operation of the compressor stage wherein the valve is provided, but that it remains constantly open when the pressure in said receiver has reached the amount corresponding to normal operation, said conduit being provided, at a point located behind the connection with said discharge valve, with a valve loaded for closing in a manner such that it affords passage to the gas when the pressure in said conduit has reached the amount corresponding to normal operation.

4. In a free piston motor-compressor, in combination, a motor working chamber, a plurality of compressor working chambers of different size and interconnected so as to form the working chambers of a multi-stage compressor; means for starting said motor-compressor, said means comprising a starting gas reservoir, means for connecting only during the first starting stroke a selected part only of the compressor working chambers with said reservoir, a body of gas provided in said reservoir under a pressure higher than the highest end pressure occurring, during normal operation, in said selected compressor chambers; exhaust valves for normal operation arranged on said compressor chambers and means for rendering inoperative, during the first starting stroke, the exhaust valves of said selected compressor stages; discharge conduits for the compressed gas associated with each of said selected compressor stages, a discharge valve in each of said conduits and comprising a valve body adapted to open outwardly and loaded for closing, and a valve piston, said valve piston being connected with, and having a larger active surface than, said valve body, a second discharge conduit arranged in the cylinder wall of the compressor stage provided with said discharge valve in a manner such that it is laid open by the piston moving in said stage when the piston has travelled over at least a large part of its first starting stroke; a loaded, outwardly opening valve in said second discharge conduit, the loading being so chosen that after this second discharge conduit is opened by the said piston, this valve permits of the discharge of the starting gas contained in said compressor stage at the end of the first starting stroke, until its pressure has dropped to that prevailing in this compressor stage, and with this position of the piston, during normal operation; this second discharge conduit being connected with a conduit leading from said compressor stage to the one in front of it, and with that side of said valve piston facing said valve body; the loading of the said valve body and the area of the valve piston face being so chosen that the valve, as long as the pressure prevailing in said receiver has not yet reached the amount corresponding to normal operation, opens only, when the pressure prevailing in the discharge conduit of the compressor stage and acting on the valve, exceeds the end pressure corresponding to normal operation of the compressor stage wherein this valve is provided, but that it remains constantly open when the pressure in said receiver has reached the amount corresponding to normal operation.

5. A free piston motor-compressor according to claim 1, comprising openings for the discharge of gas provided in the cylinder walls of the compressor stages used for starting, these openings adapted to cooperate with the piston moving in each such compressor stage so that they are

closed when said piston is brought into its initial position for the starting process.

6. A free piston motor-compressor according to claim 1, comprising compressor chambers provided with a gas storing space, a source of gas under pressure adapted to be connected to said storing space, a conduit leading from the storing space to the working space of the compressor stage and an automatically acting gas inlet valve in said conduit, said inlet valve including a valve body opening toward the working space and loaded for closing, and a piston connected with the valve body, the effective face of the piston being larger than that of the valve body, the side of the piston facing the valve body being constantly exposed to the pressure in the storing space, the other side of the piston being connected, through a valve loaded for closing and opening toward the piston, with the storing space, and through a narrow passage, with the atmosphere, the loading of the last-named valve, and the loading of the valve body being so chosen, that the inlet valve opens when the pressure in the storing space reaches the amount required for discharge, and closes, when this pressure has dropped on account of pressure gas passing over into the working space of the compressor stage.
7. A free piston motor-compressor according to claim 1, comprising means for supplying, to all compressor stages used for starting purposes,

starting gas under the same pressure which exceeds the highest end pressure occurring in these compressor stages during normal operation.

8. A free piston motor-compressor according to claim 1, wherein compressor stages are used for starting which have a lower end pressure than other stages, comprising means for supplying, for starting purposes, the stages designed for starting with gas from the connecting and discharge conduits of the stages of high pressure which are still filled with gas from a preceeding operation of the machine.

9. A free piston motor-compressor according to claim 1, comprising compressor stages including several compressor working spaces which, in regard to the transportation of gas, are provided in parallel, only part of the compressor working spaces belonging to a compressor stage used for starting being provided with the starting device.

10. A free piston motor-compressor according to claim 1, comprising means for locking the free piston in the initial position for the starting process, and means for rendering the locking means inoperative.

11. A free piston motor-compressor according to claim 1 wherein the valve body is provided with a narrow passage.

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