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P. MÜLLEJANS ET AL

2,423,720

STARTER FOR FREE PISTON MOTOR COMPRESSORS

Filed Nov. 12, 1941

2 Sheets-Sheet 1

Fig. 1.

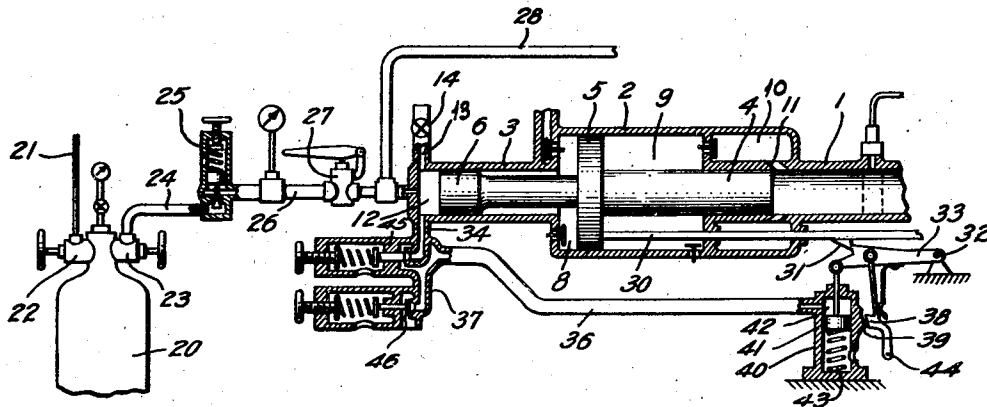
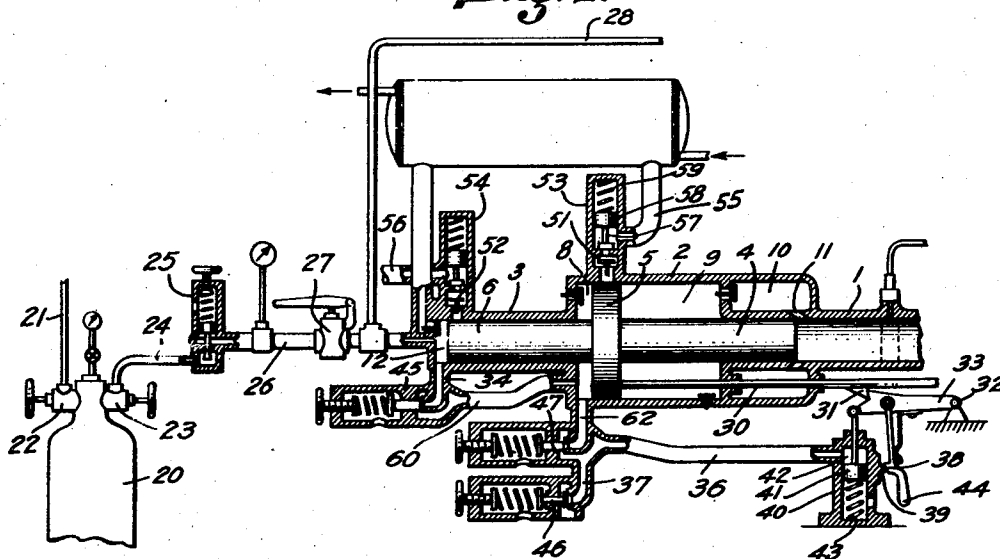


Fig. 2.



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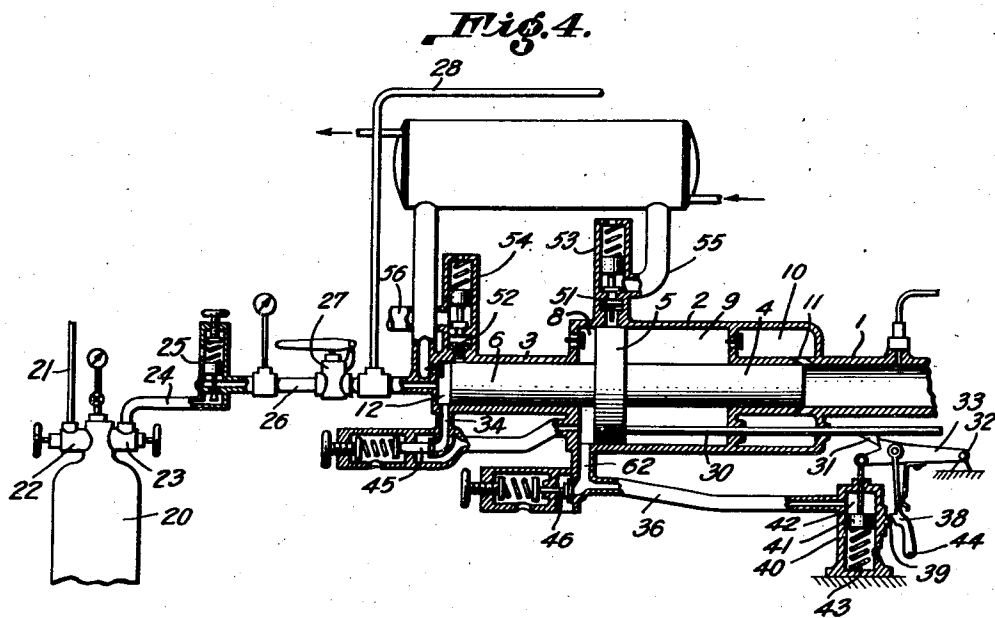
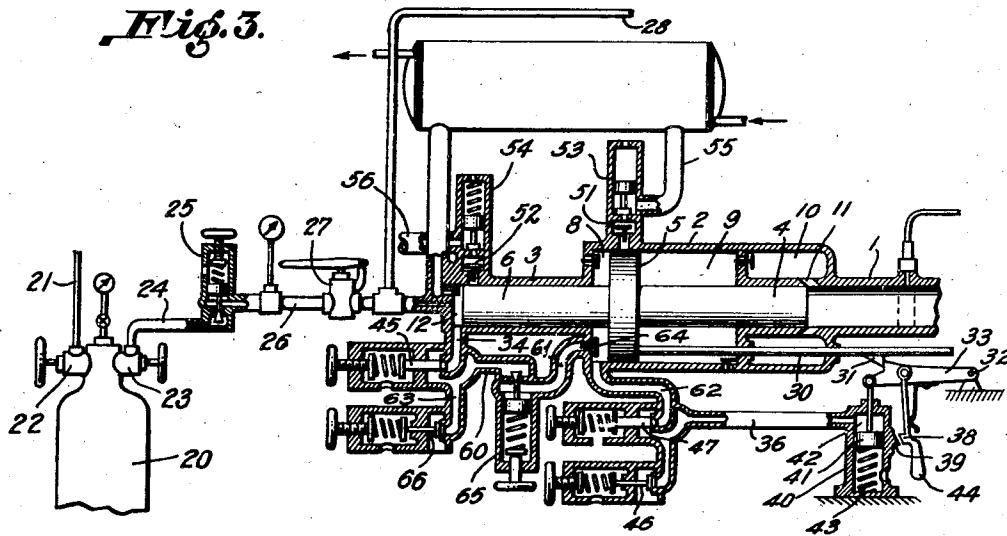
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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STARTER FOR FREE PISTON MOTOR COMPRESSORS

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ney General of the United States

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In Germany November 29, 1940

10 Claims. (Cl. 230—56)

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This invention relates to a device for starting free piston motor compressors by means of a fluid under pressure.

It is well known in the art to start free piston motor compressors wherein the motor cylinder charge is subjected to compression before its combustion, in the following manner: The flying mass is fixed in the starting position by a locking device; and a starting space, in which a piston forming part of the flying mass operates, is filled with the starting fluid under pressure. Then the locking device is released. Now the fluid under pressure is capable of displacing the flying mass, whereby it expands, doing work, thus effecting the compression of the cylinder charge immediately or after reversal of the direction of motion.

Furthermore, it is well known in free piston motor compressors with multistage compression to utilize all or one of the working spaces of the stages of compression as starting spaces.

The upper and lower limits of the pressure of the starting fluid, existing in the starting space immediately before setting the flying mass going are positively controlled.

The lower limit is determined by the fact that the motor cylinder charge is to be subjected to the compression required for regular ignition, i. e., for initiating the first motor-working stroke (which is especially important when the motor part as in the usual case works according to the Diesel process). The lower limit of pressure is further determined by the fact that the spaces used for starting must be able to intercept the energy produced in the first working stroke of the motor part by a sufficiently strong cushion of compressed fluid. This is especially important when separate spaces are used for starting, as in the case of multistage compressors, because then the outlet pressure corresponding to normal operation in these compression spaces is only gradually established in the course of a plurality of strokes.

The upper limit of pressure is of course determined, on the one hand, by the strength of the walls confining these spaces (for instance, in case that a compressor space working with low outlet pressure in the normal operation is used, this pressure cannot be chosen higher or essentially higher than this outlet pressure). On the

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other hand this upper limit is also determined by the fact that the compression of the motor cylinder charge must not exceed a certain value, as otherwise the pressures of combustion would become so high that the motor part could be damaged.

The importance to be imputed to the right adjustment of the pressure of the starting fluid in the starting spaces, as regards safe starting as well as avoiding detrimental disturbances, makes it desirable to provide efficient safety guards for maintaining the right pressure in the starting spaces.

Therefore an object of this invention is to provide means for automatically maintaining the right starting pressure so that the pressure of the fluid existing in the starting spaces immediately before setting in motion the flying mass does not surpass a predetermined upper or lower limit. These limits are generally remote from each other, but may also coincide.

As means to prevent exceeding the upper limit of pressure there are considered:

(1) A pressure controlling device (pressure reducing valve) inserted into the line for admitting fluid under pressure from a container to the starting space which device throttles an optional pressure of compressed fluid automatically down to a pressure corresponding to the upper limit of pressure in the starting space;

(2) An overflow valve inserted into the line connecting the starting space with a space of lower pressure and opening as soon as a predetermined pressure in the starting space is attained thereby allowing fluid under pressure to enter the space of lower pressure;

(3) A safety valve inserted into an outlet of the starting space or behind the overflow valve and opening a passage to the open air as soon as a predetermined pressure in the starting space, or in the space behind the overflow valve respectively, is attained.

Means to prevent exceeding the lower limit of pressure are:

(a) A releasing member charged with the pressure of the fluid under pressure coming from the starting space and releasing a locking member retaining the flying mass only after this pressure has attained a predetermined minimum

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value (the effective pressure of the releasing member). Therefore the pressure of the fluid in the starting space must be at least equal to the pressure required for releasing the locking member.

(b) An overflow valve in the line between the starting space and a space of lower pressure, for instance, the working space of a releasing member, the effective pressure of which is lower than the opening-pressure of the overflow valve. This valve prevents the fluid under pressure from flowing off to a space of lower pressure or to the releasing member, before the starting space is filled with the fluid under pressure up to the lower limit of pressure.

By the indicated means even a double safety guard may be obtained against an excessively high or low starting pressure. With such double safety guard a disturbance can only occur when both safety members fail to operate at the same time. The probability of such a disturbance is very remote in case of a simple safety guard. This is especially true when both safety members are of different kind, as safety members of the same kind may in certain cases be liable to the same defect and therefore may fail simultaneously more easily than two members of different kind.

As a double safety guard against excessive pressure, a pressure-reducing valve in the supply pipe and an overflow valve in an outlet of the starting space, may be provided in combination with a safety valve.

A double safety guard against too low pressure is formed by a releasing member connected over an overflow valve with the starting space, the effective pressure of said member approximating the opening pressure of the overflow valve.

The invention proves very valuable also in case that a plurality of starting spaces is provided in an engine, which spaces are to be filled with starting fluids of different pressure. In this case, the starting spaces are connected with one another, that is, the last starting space which contains the gas of the lowest pressure is connected with the releasing member by pipes having overflow valves inserted therein. Each of these overflow valves is adjusted to the lower limit of pressure of the starting space placed before it. On opening the compressed gas supply pipe connected with the starting space having the highest pressure, the single starting spaces then automatically fill with fluid under pressure up to the lower limit of pressure adjoined to each of the starting spaces and determined by its overflow valve.

Also in this case a double safety guard against excessive pressure is possible for each starting space by inserting, into the pipe between the overflow valve of the one starting space to the next one, a pressure controlling device adjusted to the highest starting pressure admissible for the subsequent starting space.

The invention is illustrated in the annexed drawings, of which

Fig. 1 is a vertical, axial cross-section of a starter constructed in accordance with the invention comprising two working spaces, a pressure reducing valve, an overflow valve, a safety valve and a locking and releasing device;

Fig. 2 is a similar cross-section of a starter in which the engine is formed as a multistage compressor;

Fig. 3 is a similar cross-section of an engine having a double safety guard against the formation of an excessive pressure in the low-pressure starting space and

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Fig. 4 illustrates a simplification in case the lower limit of pressure in the starting space having the lowest pressure is equal to zero.

The drawings show diagrammatically several modifications of the invention, in each case the left half of a free piston motor compressor provided with oppositely moving flying masses. Corresponding parts of the figures are denoted by the same reference letters.

In the arrangement shown in Fig. 1 a compression cylinder 2 is connected on the one hand with a motor cylinder 1 and on the other hand with a cylinder 3. The flying mass is composed of the motor piston 4, the compression piston 5 and a piston 6 operating in the cylinder 3. The compression cylinder 2 comprises two working spaces: the compression space proper 8 and the working space 9 turned toward the motor cylinder and working as a scavenging pump. The scavenging air flows from the space 9 to a container 10 and from here through the scavenging slots 11 into the motor working space. The working space 12 confined by the cylinder 3 and the piston 6 may be merely used for starting and is after starting connected with the open air through the pipe 13 by opening a shut-off member 14 provided in pipe 13, so that this part of the engine then runs idly. However the space 12 may also operate in the normal working of the engine, for instance, as a cushion or as a higher stage of compression. The compressed fluid for starting is stored under high pressure in a container 20 which may be refilled through a pipe 21 coming from a source of compressed fluid, for instance, a compressor and including a shut-off member 22. A second shut-off member 23 connects the container 20 with a withdrawal line 24 leading to a reducing valve 25 which throttles the pressure of the container down to the maximum pressure admissible in the starting space 12. From the reducing valve 25 a pipe 26 including a hand-operated starting valve 27 leads to the starting space 12. A pipe 28 branching off behind the hand-operated starting valve 27 leads to a similar starting space of the other half of the engine.

A rod 30 is firmly secured to the compression piston and conducted outwards, which rod may simultaneously form part of the connecting gear compelling the oppositely moving flying masses to synchronous motion. A tooth or catch 31 is fixed on the rod 30 which may engage a pawl 33 swingable about a stationary fulcrum 32. This pawl is connected with a piston 41 sliding in a stationary cylinder 40. Fluid under pressure may be supplied through the pipe 36 to the space 42 above the piston 41. A pressure spring 43 acts upon the back side of the piston. An auxiliary pawl 38 is further connected with the pawl 33 arranged to engage a stationary abutment 39 when pawl 33 is released from the tooth 31 against the action of the spring 43, whereby pawl 33 is prevented from catching again after being released. By means of a handle 44 provided on the auxiliary pawl 38 the latter may be released from the abutment 39 to initiate a new starting operation. From the starting space 12 a duct 34 leads to an overflow valve 45 connected with the pipe 36 from which a duct 37 is branched off which leads to the open air over a safety valve 46.

In order to make the operation of the contrivance as clear as possible, the following nu-

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merical values may be assumed for the single pressures:

	Superatmospheric pressure, atmospheres
Highest admissible pressure in starting space 12.....	25
Lowest admissible pressure in starting space 12.....	20
Correspondingly—	
The reducing valve is adjusted to.....	25
The overflow valve is adjusted to.....	20
Furthermore—	
The safety valve 46 may be adjusted to.....	5
The releasing member 41 may be adjusted to.....	2

The resulting operation is as follows:

The flying mass 4, 5, 6 is at first shifted to the left by means of rod 30 until the pawl 33 under the action of the spring 43 can engage the catch 31. The shut-off member 14 controlling the starting space 12 is closed and the shut-off valve on the container of compressed fluid 20 is opened. Now the hand-operated starting valve 27 is opened for a short time and thereby the starting space 12 is filled with fluid under pressure. As soon as the pressure in the space 12 has reached 20 atmospheres superatmospheric pressure, the overflow valve 45 opens, so that now fluid under pressure may enter the working space 42 of the releasing device 41. When the pressure in the space 42 has reached 2 atmospheres superatmospheric pressure, the piston 41 overcomes the action of the spring 43 and draws the pawl 33 away from the catch 31. The pressure now existing in the starting space 12 is able to displace the flying mass 4, 5, 6. The starting operation is thereby initiated. The pressure in the starting space 12 cannot surpass in this case the pressure of 20 atmospheres superatmospheric pressure, to which the overflow valve 45 is adjusted, because this valve opens as soon as this pressure is reached, and the excess of fluid will flow off to the releasing device or through the safety valve 46. Should this valve 45 fail to open, the pressure in space 12 would increase at most to the pressure of 25 atmospheres superatmospheric pressure, established by the reduction valve 25. This involves a double safety device against the formation of an excessive pressure in the starting space 12. A safety guard preventing the pressure in the space 12 from becoming too low is warranted by the fact that the releasing device 41 acts only when it is charged with a pressure of 2 atmospheres superatmospheric pressure, required for overcoming the pressure of the spring 43. This pressure, however, can only take place when the overflow valve 45 opens, that is when the starting space 12 is filled with fluid under pressure up to the lower limit of pressure (20 atmospheres superatmospheric pressure). Should the device 41 fail to release (for instance, by getting jammed or for another reason), the fluid under pressure flowing off over the overflow valve 45 may escape into the open air through the safety valve 46, as soon as the pressure behind the overflow valve 45 has increased to 20 atmospheres superatmospheric pressure. This means that also in this case an effective safeguard against the formation of an excessive pressure in the releasing space 42 is established.

Fig. 2 shows a modification in which the compressor part of the engine is formed as a multi-

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stage compressor, so that the cylinder 2 and the piston 5 with the working space 8 form the first stage of compression, and the cylinder 3 and the piston 6 with the working space 12 form the second stage of compression. In this case the working spaces 8 and 12 are to be used as starting spaces at the inner dead center position of the compressor pistons, the pressure of starting fluid to be admitted to these spaces corresponding to the outlet pressures of the stages of compression obtained in the normal operation. Therefore the space 8 is to be charged with compressed starting gas of an essentially lower pressure than the space 12. The pressure valves 51 and 52 are so arranged that the ducts leading from the compression working space to the ducts in which these valves are located are closed by the pistons 5 or 6, respectively, in the starting position of said pistons, as shown in Fig. 2. In order to prevent the compressed starting gas from flowing off at the subsequent starting stroke from the working spaces through these pressure valves into the discharge pipes yet free from pressure on starting, a so-called pressure maintaining valve 53 or 54 respectively is arranged behind the pressure valves of each compression stage. Each pressure maintaining valve comprises a valve disk 57 opening toward the discharge pipe 55 or 56, respectively, and a piston 58 which is charged on the valve side with the pressure of the discharge pipe and on the other side by a spring 59. The action of the spring is greater than the pressure of the starting gas acting on the valve disk. Consequently the pressure-maintaining valve remains closed on starting; but in the normal operation during which the full final pressure of the corresponding compression stage permanently prevails this valve is continuously kept open by this pressure.

The means for supplying fluid under pressure to the space 12 are similar to those shown in Fig. 1. The space 12 is again connected to the duct 34 leading to the overflow valve 45. From the latter a pipe 60 leads to the working space 8. This space is connected by a duct 62 to an overflow valve 47, from which a pipe 36 leads to the releasing space 42. Furthermore a pipe 37 is branched off from pipe 36 leading to the safety valve 46 which opens into the open air.

For the pressures the following numerical values may be assumed:

	Atmospheres superatmospheric pressure
Highest admissible pressure in the starting space 12.....	25
Lowest admissible pressure in the starting space 12.....	20
Highest admissible pressure in the starting space 8.....	6
Lowest admissible pressure in the starting space 8.....	4
Correspondingly—	
The reduction valve 25 is adjusted to.....	25
The overflow valve 45 is adjusted to.....	20
The overflow valve 47 is adjusted to.....	4
Furthermore	
The safety valve 46 may be adjusted to.....	2
The releasing member 41 may be adjusted to.....	1

When the pressure in the high-pressure starting space 12 on supplying the fluid under pressure has attained 20 atmospheres superatmos-

pheric pressure, the overflow valve 45 opens and allows the fluid under pressure to pass to the low-pressure starting space 8. When therein the pressure has attained 4 atmospheres superatmospheric pressure, the overflow valve 47 opens and allows the fluid under pressure to flow through the pipe 36 to space 42 of the releasing device 41. This device releases the pawl 33 as soon as the pressure in pipe 36 has attained 1 atmosphere superatmospheric pressure. At this moment the high-pressure starting space 12 is filled with compressed fluid under a pressure of 20 atmospheres superatmospheric pressure, the low-pressure starting space 8 with compressed fluid under a pressure of 4 atmospheres superatmospheric pressure. This filling of the two starting spaces with compressed fluid under the pressure intended for them, respectively, automatically takes place on opening the hand-operated starting valve 27. Depending upon the pressure-reducing valve 25, the maximum pressure in the starting space 12 cannot exceed the value of 26 atmospheres superatmospheric pressure, in case the overflow valve 45 should fail to open. Likewise the pressure in the low-pressure starting space 8 cannot assume an excessive value should the releasing device 41 fail to operate, because it is allowed to drop owing to the overflow valve 47 and the safety valve 46; moreover the upper limit of the pressure in the releasing space 42 is also determined by the safety valve 46.

If it is desired to doubly safeguard the low-pressure starting space against excessive pressure, the arrangement shown in Fig. 3 may be adopted. Again the overflow valve 45 is connected to the outlet 34 of the high-pressure starting space 12. Into the pipe 60 coming therefrom a pressure-controlling device 65 is inserted, which is adjusted in such a manner that in its outlet 61 connected with the low-pressure starting space 8 only the highest pressure admissible in this space can occur. Further, a safety valve 66 communicating with the open air is connected to a pipe 63 branched off from pipe 60. At the point where the pipe 61 communicates with the space 8, advantageously a check-valve 64 may be provided in order to keep away the variations in pressure occurring in space 8 during the normal operation from the pressure-controlling device 65. The numerical example given in connection with Fig. 2 is therefore to be completed as follows:

	Atmospheres superatmospheric pressure
The pressure-controlling device 65 between the two starting spaces is adjusted to-----	6
The safety valve 66 before the device 65 may be adjusted to-----	18

In space 8 also on failing of overflow valve 47 to open no pressure exceeding 6 atmospheres superatmospheric pressure can occur. Should the pressure-controlling device 65 fail to open the fluid under pressure would escape into the open air from the space 12 over the valves 45 and 66.

If as in the examples according to Figs. 2 and 3 different working spaces that are filled with fluid under different pressures are used for starting, a simplification is possible in some cases, for example, if the lower limit of pressure in the starting space having the lowest pressure is equal to zero, i. e., if the engine scarcely starts at a pressure of 0 atmospheres superatmospheric pressure, existing in this starting space, but it is desired

that this working space also participate in the starting operation.

In this case the arrangement shown in Fig. 4 may be adopted which differs from that shown in Fig. 2 by the space 8 working with the lower starting pressure being immediately connected with the releasing space 42 over the pipe 36, without the intermediary of an overflow valve. To this pipe 36 merely the safety valve 46 leading to the open air is connected over the branchpipe 37.

For this example the following numerical values may be assumed:

	Atmospheres superatmospheric pressure
The highest admissible pressure in the high-pressure starting space 12 may be-----	25
The lowest admissible pressure in the high-pressure starting space 12 may be-----	20
The highest admissible pressure in the low-pressure starting space 8 may be-----	6
The lowest admissible pressure in the low-pressure starting space 8 may be-----	0
Correspondingly—	
The pressure reducing valve 25 is adjusted to-----	25
The overflow valve 45 is adjusted to-----	20
The safety valve 46 behind the low-pressure starting space is adjusted to-----	6
Further the releasing member 41 may be adjusted to-----	4

In this case the operation of the device is as follows:

In the normal case the pawl 33 is released when the pressure influencing the releasing member 41 has attained the value of 4 atmospheres superatmospheric pressure. The same pressure then acts in the low-pressure starting space 8, whereas in the high-pressure starting space 12 a pressure of 20 atmospheres superatmospheric pressure, is acting. Should it now occur that due to a defect of the releasing member as, for instance, relaxation in force of the spring 43, the releasing of the catch 33 takes place at a pressure essentially lower than the pressure of 4 atmospheres superatmospheric pressure, provided for this releasing operation, for instance, at $\frac{1}{2}$ atmosphere superatmospheric pressure, it is true that likewise only a pressure of $\frac{1}{2}$ atmosphere superatmospheric pressure, assists in starting, but the engine is nevertheless set in motion, because the starting pressure of 20 atmospheres superatmospheric pressure, existing in the high-pressure starting space 12 just suffices for starting.

We claim:

1. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a second pipe line connecting said selected working space with said releasing device; and means in said second pipe line for releasing fluid pressure from said selected space to said releasing device when the pressure in said space exceeds a predetermined limit.
2. In a device for starting a free piston motor

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compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a second pipe line connecting said selected working space with said releasing device; means in said second pipe line for releasing fluid pressure from said selected space to said releasing device when the pressure in said space exceeds a determined upper limit; and means for maintaining said released pressure below a second determined pressure limit lower than said first limit.

3. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a pressure-controlling valve in said pipe line, adjusted to maintain the pressure of said fluid in said selected working space below a determined upper limit; a releasing device; a second pipe line connecting said selected working space with said releasing device, and pressure controlling means in said second pipe for releasing pressure from said selected space into said releasing device at a pressure below said upper limit.

4. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a second pipe line connecting said selected working space with said releasing device; and an over-flow valve in said second pipe line, adjusted to maintain the pressure of said fluid in said selected working space below a predetermined limit.

5. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; an adjustable releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a second pipe line connecting said selected working space with said releasing device; and an over-flow valve in said second pipe line, adjusted to maintain the pressure of said fluid in said selected working space below a predetermined limit, said releasing de-

vice being adjusted to release said locking device when influenced by the fluid under a pressure above said predetermined limit.

6. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; an adjustable releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a second pipe line connecting said selected working space with said releasing device; an over-flow valve in said second pipe line, adjusted to maintain the pressure of said fluid in said selected working space below a predetermined limit, said releasing device being adjusted to release said locking device when influenced by the fluid under a pressure above said predetermined limit; and a safety valve in said second pipe line, between said over-flow valve and said releasing device, and adapted to permit escape of said fluid from said second pipe line when the pressure of said fluid in said line is above the pressure actuating said releasing device and above the said predetermined limit of pressure in the selected working space.

7. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a second pipe line connecting said selected one of said working spaces with a second selected one of said working spaces; a releasing device adapted to be influenced by said fluid under pressure and to release said locking device; and a third pipe line connecting said second selected working space with said releasing device.

8. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a second pipe line connecting said selected one of said working spaces with a second selected one of said working spaces; a releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a third pipe line connecting said second selected working space with said releasing device; and means for maintaining the pressure of said fluid in each of said two selected working spaces within determined limits.

9. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center

75 for holding said flying mass in its dead center

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position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a pressure-controlling valve in said pipe line, adjusted to maintain the pressure of said fluid in said selected working space below a determined upper limit; a second pipe line connecting said selected one of said working spaces with a second selected one of said working spaces; an over-flow valve in said second pipe line, adjusted to maintain the pressure of said fluid in said first selected working space above a determined lower limit; a releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a third pipe line connecting said second selected working space with said releasing device; and an over-flow valve in said third pipe line, adjusted to maintain the pressure of said fluid in said second selected working space above a determined lower limit.

10. In a device for starting a free piston motor compressor by means of fluid under pressure, said compressor having a flying mass formed by pistons displaceable in stationary cylinders and forming with said cylinders a plurality of working spaces, the combination of a locking device for holding said flying mass in its dead center position; a container filled with said fluid under pressure; a pipe line connecting said container with a selected one of said working spaces; a pressure-controlling valve in said pipe line, adjusted to maintain the pressure of said fluid in said selected working space below a determined upper limit; a second pipe line connecting said selected one of said working spaces with a second selected one of said working spaces; an over-flow valve in said second pipe line, adjusted to maintain the pressure of said fluid in said first selected working space above a determined lower limit; a pressure-controlling valve in said second pipe line,

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between said over-flow valve and said second selected working space, adjusted to maintain the pressure of said fluid in said second selected working space below a determined upper limit; a releasing device adapted to be influenced by said fluid under pressure and to release said locking device; a third pipe line connecting said second selected working space with said releasing device; and an over-flow valve in said third pipe line, adjusted to maintain the pressure of said fluid in said second selected working space above a determined lower limit.

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