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FREE PISTON MACHINE PROVIDED WITH PNEUMATIC STARTING MEANS

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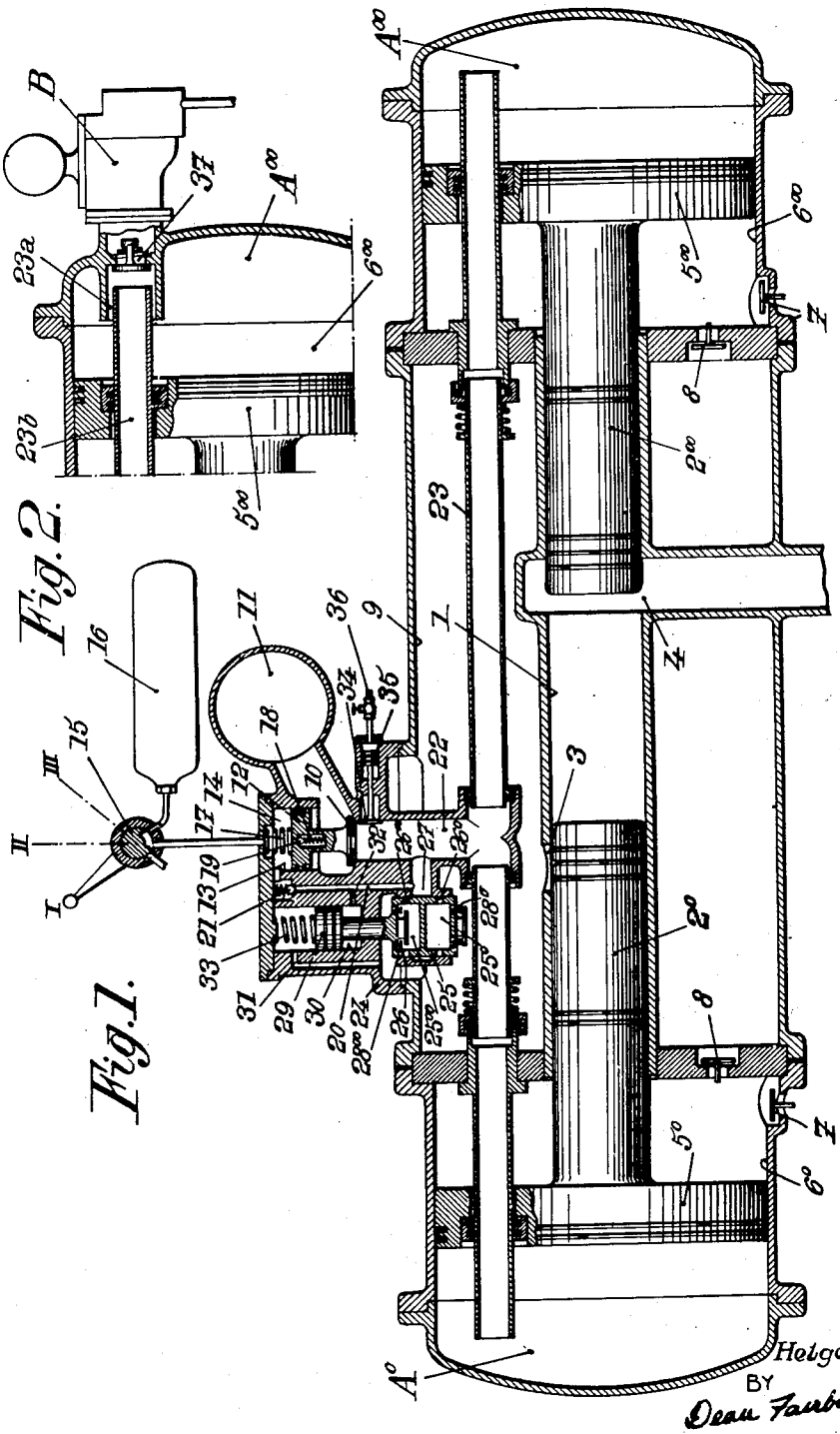


Fig. 2.

Fig. 1.

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FREE PISTON MACHINE PROVIDED WITH PNEUMATIC STARTING MEANS

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The present invention relates to free piston machines provided with pneumatic starting means.

An object of my invention, being given a machine of this kind in which the free pistons move in opposed directions and are kept in synchronism with each other, each piston cooperating with what will hereinafter be called a "starting space," into which the air used for starting the machine is to be introduced, is to provide means for equalizing the pressures in said starting spaces, especially during the starting period.

Another object of my invention is to provide means for safely ensuring, in operation, the due closing of the valve that controls the feed of starting air to the starting space or spaces of the machine.

The invention is to be applied more especially, but not exclusively, to motor compressors and free piston auto-generators, that is to say machines for feeding a gas under pressure.

Preferred embodiments of the present invention will be hereinafter described with reference to the accompanying drawing, given merely by way of example, and in which:

Fig. 1 is a diagrammatic axial sectional view of a free piston auto-generator provided with a starting device made according to the present invention; and

Fig. 2 shows a modification.

The machine shown by the drawing includes a motor cylinder 1 in which move two pistons 2^0 and 2^{00}, coacting respectively, when they get close to the outer ends of their strokes, with inlet and outlets ports 3 and 4, respectively.

Each of these motor pistons carries a compressor piston, 5^0, 5^{00} respectively, and these compressor pistons move in compressor cylinders 6^0, 6^{00}, respectively, so as to ensure, on their inner sides, through inlet and discharge valves 7 and 8 respectively, the feed of air under pressure to a fluidtight casing 9 which surrounds cylinder 1.

These two sets of pistons are caused to move in synchronism through any suitable means (not shown in the drawing as having no direct bearing on the object of my invention).

During the outward (energy producing) strokes of the pistons, energy is stored up in the energy accumulators A^0, A^{00}, constituted by chambers of variable volume limited by the outer faces of pistons 5^0, 5^{00} and the fluid tight ends of cylinders 6^0, 6^{00}.

This machine is, of course, provided with fuel injection means, not shown by the drawing, as usual.

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The energy accumulators A^0, A^{00} serve also to receive the starting air. They therefore constitute what I will call the "starting spaces." For this purpose, I provide a conduit 23 located on the inside of the machine and eccentrically with respect to the axis thereof, the ends of this conduit extending through the compressor pistons 5^0, 5^{00}, which are therefore slidingly guided by this conduit. Said conduit is, for instance, fixed to the walls that carry discharge valves 8. It is open at both ends and therefore affords constant communication between accumulators A^0 and A^{00}, whereby the pressures in these accumulators are always practically equal.

To this conduit 23 is connected, through a conduit 22, the starting device, which includes a valve 10 adapted to control the communication between a starting air reservoir 11 and the inside of said conduit. Valve 10 is rigid with a piston 12 movable in a cylinder 13. The chamber 14 of this cylinder that is located on the side of piston 12 opposed to valve 10 may at will be connected, through a valve 15 or the like, either with a source 16 of gas under pressure or with the atmosphere. A spring 17 tends to keep valve 10 in the closed position. A conduit 18, provided for instance in piston 12, with a check valve 19, permits the flow of gas from chamber 14 toward reservoir 11, but not in the opposed direction.

If the source 16 of air under pressure is connected, through valve 15, with chamber 14, valve 10 remains closed and air under pressure passes through conduit 18 into reservoir 11, which is thus filled. It now suffices, by acting on valve 15, to bring chamber 14 into communication with the atmosphere for causing valve 10 and piston 12 to be moved in the upward direction under the effect of the pressure existing in reservoir 11. Valve 10 is thus opened and the starting air is fed to the accumulators and causes the machine to start. The pressures existing in these accumulators A^0 and A^{00}, and consequently the starting forces brought into play on either side of the machine are always respectively equal, owing to the constant communication constituted by conduit 23.

In order to obtain the above described operation, valve 15 is arranged in such manner as to permit:

a.— in position I, of filling reservoir 11 as above set forth;

b.— in position III, of bringing chamber 14 into communication with the atmosphere; and

c.— in position II, of placing this chamber 14

out of communication both with source 16 and the atmosphere.

As the spring 17 which serves to close valve 10 is generally not very strong, it cannot be relied upon with sufficient safety to close this valve once the starting air has been introduced into the starting spaces and valve 15 has been brought into position II. For this reason, in order to close valve 10 after the bringing of valve 15 into position II, the starting device is fitted with a conduit 20, provided with a check valve 21, adapted to permit the flow of gas from accumulators A^0, A^{00} toward chamber 14, but not in the opposed direction. Preferably, a weak spring is provided for applying check valve 21 against its seat.

Conduit 20, together with its check valve 21, acts as follows:

As soon as valve 15 is in position II, chamber 14 is filled, through conduit 20 and past valve 21, with gas at a pressure which is the closer to the maximum pressure in accumulators A^0, A^{00} as the strength of the spring of check valve 21 is smaller. This pressure, including the pressure exerted by spring 17, brings valve 10 back to its closed position and safely keeps it in this position if the spring that applies valve 19 against its seat is sufficiently strong for creating, between the two sides of piston 12, the necessary pressure difference.

Furthermore, the gas under pressure from the accumulators will pass from chamber 14 into reservoir 11 through conduit 18 and past check valve 19. This reservoir will thus be charged to a pressure close to the maximum pressure of the accumulators, whereby the consumption of starting air will be lower than if reservoir 11 remained empty between two startings of the machine.

According to a particularly advantageous embodiment of my invention, I fit on conduit 23, which constantly connects together the energy accumulators, not only the starting inlet device, but also a device for adjusting the pressures in said accumulators. This last mentioned device operates by varying, in response to variations of a working pressure of the machine (for instance the discharge or delivery pressure of the compressor portion of the machine) the weight of air present in the machine accumulators.

Preferably, the above mentioned devices for admitting starting air and for regulating the pressure in the accumulators are grouped into a single system carried by an element 24 which closes in a fluid tight manner an aperture provided in the lateral wall of casing 9.

The regulating device above referred to advantageously includes a piston valve 25 movable in a cylinder 26 in communication at both ends with the inside of casing 9. This slide valve includes two chambers 25^0, 25^{00}, respectively provided with ports 26^0, 26^{00} adapted to coact with a fixed aperture provided in cylinder 26, at 27, and in communication with conduit 22, this aperture 27 being closed in the neutral, or intermediate, position of piston valve 25 (position shown by Fig. 1).

In a wall of chamber 25^0 are provided apertures controlled by check valves 28^0 adapted to permit air to flow from chamber 25^0 into casing 9, whereas, in a wall of chamber 25^{00} are provided apertures controlled by check valves 28^{00} adapted to permit the flow of air from casing 9 into chamber 25^{00}.

This piston valve 25 is connected to a piston

29 slidably mounted in a cylinder 30. One of the faces of said piston is subjected to the pressure existing in casing 9, this pressure being transmitted through a conduit 31. The other face of the piston is subjected to the mean pressure of the accumulators transmitted through a conduit 32 of very small section directly connected with a conduit 20 in communication with conduit 22.

A spring 33 is provided to push piston 29 in the same direction as the pressure transmitted from casing 9.

The whole is arranged in such manner that a rise of the working pressure, other things being the same, causes port 26^{00} to be brought opposite aperture 27, and that, on the other hand, a drop of this pressure causes port 26^0 to be brought opposite this aperture 27. As soon as the mean pressure of the accumulators has assumed the value that corresponds to the working pressure of the machine, piston valve 25 is brought back into neutral position.

Therefore, when the working pressure rises, air passes from casing 9 into the accumulators, and vice-versa, provided, of course, that the curve of variation of the pressure in the accumulators is such that the working pressure has a value ranging between the extreme values of the pressures in the accumulators.

The operation of this device will be analogous when the mean pressure of the accumulators, and not the working pressure, undergoes a variation, with the only difference that the direction of displacement of the slide valve is reversed.

Finally, I may also provide a valve 34 adapted, when it is desired, previous to the starting of the machine, to bring the pistons into the position that corresponds to this starting, to place the inside of the accumulators into communication with the atmosphere. Advantageously, this valve will be disposed on the wall of conduit 22 and arranged in such manner as to open inwardly when a piston 35, asociated with said valve 34, is subjected to the action of compressed air fed through a tube 36 controlled through a valve located within reach of the operator's hand.

This valve 34, together with its piston 35 is advantageously included in the system above described, constituted by the starting and regulating devices, so that no supplementary conduit will be necessary.

In the apparatus illustrated by Fig. 1, the starting air inlet device is located substantially in the middle part of the machine. But in some cases it may be of interest to fit this device on the end of one of the accumulators, as shown by Fig. 2, in which this device is designated by reference character B.

In this case, there exists a considerable difference between the distances which separate this device B from the accumulators A^0 and A^{00}, respectively. In order to obtain, despite this difference, substantially the same loss of pressure between device B and each of the accumulators, so that these accumulators develop the same work when starting the machine, it is advantageous to make use of the special arrangement illustrated by Fig. 2. According to this arrangement, one of the portions of the communication conduit through which the starting air is fed to the accumulators, to wit the portion between the feed of air and the accumulator located in close vicinity with the starting air inlet device B, is throttled or otherwise made of

smaller cross section that the other portion extending from device B to the other accumulator.

For this purpose, in the embodiment illustrated by Fig. 2, the portion 23_a of the conduit in question through which starting air is fed to accumulator A^{00} is of annular section, and smaller than the circular section of the portion 23_b of the communication conduit that conveys starting air to accumulator A^0. The whole of these portions 23_a and 23_b constitutes the communication conduit which constantly connects together accumulators A^0 and A^{00}.

In the embodiment illustrated by Fig. 2, I provide, between the starting air inlet device and the communication conduit 23_a23_b, a check valve 37 which allows starting air to flow only toward the accumulators. The presence of this check valve prevents gas interchanges, to be avoided in operation, between the communication conduit and the starting air inlet device, especially when the starting device is not provided with means for ensuring, after starting the closing of valve 10 (as in the case of Fig. 1).

An analogous check valve might of course be provided in the device of Fig. 1.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, conduit means for permanently connecting together said starting spaces, and a single starting device for feeding gas under pressure to a point of said conduit means, the portions of said conduit means that extend from this point to said starting spaces respectively being of different lengths and the shorter one having at least a part of smaller cross section than the other, so as to equalize the respective pressure drops therethrough.

2. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, said starting spaces being arranged to contain gas cushions so as to act as pneumatic energy accumulators for ensuring the inward stroke displacements of said pistons, conduit means for permanently connecting together said starting spaces, and a single starting device for feeding gas under pressure to a point of said conduit means, the portions of said conduit means that extend from this point to said starting spaces respectively being of different lengths and the shorter one having at least a part of smaller cross section than the other, so as to equalize the respective pressure drops therethrough.

3. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, means for permanently connecting together said starting spaces, a single starting device for feeding gas under pressure to said last mentioned means, and a check valve between said starting device and said conduit means, opening toward said conduit means.

4. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, said starting spaces being arranged to contain gas cushions so as to act as pneumatic energy accumulators for ensuring the inward stroke displacements of said pistons, conduit means for permanently connecting together said starting spaces, a single starting device for feeding gas under pressure to said conduit means, and a check valve between said starting device and said conduit means, opening toward said conduit means.

5. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, conduit means for permanently connecting together said starting spaces, a single starting device for feeding gas under pressure to a point of said conduit means, the portions of said conduit means that extend from this point to said starting spaces respectively being of different lengths and the shorter one having at least a part of smaller cross section than the other, so as to equalize the respective pressure drops therethrough, and a check valve between said starting device and said conduit means, opening toward said conduit means.

6. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, said starting spaces being arranged to contain gas cushions so as to act as pneumatic energy accumulators for ensuring the inward stroke displacements of said pistons, conduit means for permanently connecting together said starting spaces, a single starting device for feeding gas under pressure to a point of said conduit means, the portions of said conduit means that extend from this point to said starting spaces respectively being of different lengths and the shorter one having at least a part of smaller cross section than the other, so as to equalize the respective pressure drops therethrough, and a check valve between said starting device and said conduit means, opening toward said conduit means.

7. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means, including a compressor piston, associated with each of said motor pistons

for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding pistons, a conduit for permanently connecting together said starting spaces, said conduit extending through said compressor pistons and being arranged to act as eccentric guiding means for said compressor pistons, and a single starting device for feeding gas under pressure to said conduit means.

8. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means, including a compressor piston, associated with each of said motor pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding pistons, said starting spaces being arranged to contain gas cushions so as to act as pneumatic energy accumulators for ensuring the inward stroke displacements of said pistons, a conduit for permanently connecting together said starting spaces, said conduit extending through said compressor pistons and being adapted to constitute eccentric guiding means for said compressor pistons, and a single starting device for feeding gas under pressure to said conduit means.

9. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, said starting spaces being arranged to contain gas cushions so as to act as pneumatic energy accumulators for ensuring the inward stroke displacements of said pistons, conduit means for permanently connecting together said starting spaces, a single starting device for feeding gas under pressure to said conduit means, and a device for regulating the weight of air of said energy accumulators opening into said conduit means, said two last mentioned devices being grouped into a single unit.

10. A machine which comprises, in combination, a motor cylinder, two motor pistons freely movable in said cylinder in synchronism with each other, means associated with each of said pistons for the pneumatic starting of said machine, each of said means forming a starting space adapted to coact with the corresponding piston, means located within said machine for permanently connecting together said starting spaces, and a single starting device for feeding gas under pressure to said last mentioned means.

11. A machine which comprises, in combination, a motor cylinder, at least one motor piston freely movable in said cylinder, means associated with said piston for starting said machine, said means forming a starting space adapted to

coact with the piston, a reservoir for feeding gas under pressure to said starting space, a valve interposed between said reservoir and said starting space for controlling the communication between them, a cylinder communicating at one end with said reservoir and closed at the other end, a piston in said last mentioned cylinder, valve means for connecting the chamber existing between the last mentioned piston and the closed end of the corresponding cylinder either with a source of compressed gas or with a medium at lower pressure, conduit means extending across said last mentioned piston for connecting said chamber with said reservoir, a check valve in said conduit means opening toward said reservoir, means in said machine forming a space filled with gas under pressure, conduit means between said last mentioned space and said chamber, and a check valve in said last mentioned conduit means, said last mentioned check valve opening toward said chamber.

12. A machine which comprises, in combination, a motor cylinder, at least one motor piston freely movable in said cylinder, means associated with said piston for starting said machine, said means forming a starting space adapted to coact with the piston, a reservoir for feeding gas under pressure to said starting space, a valve interposed between said reservoir and said starting space for controlling the communication between them, a cylinder communicating at one end with said reservoir and closed at the other end, a piston in said last mentioned cylinder, valve means for connecting the chamber existing between the last mentioned piston and the closed end of the corresponding cylinder either with a source of compressed gas or with a medium at lower pressure, conduit means extending across said last mentioned piston for connecting said chamber with said reservoir, a check valve in said conduit means opening toward said reservoir, conduit means between said starting space and said chamber, and a check valve in said last mentioned conduit means, said last mentioned check valve opening toward said chamber.

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