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PNEUMATIC STARTING DEVICE

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Fig. 1

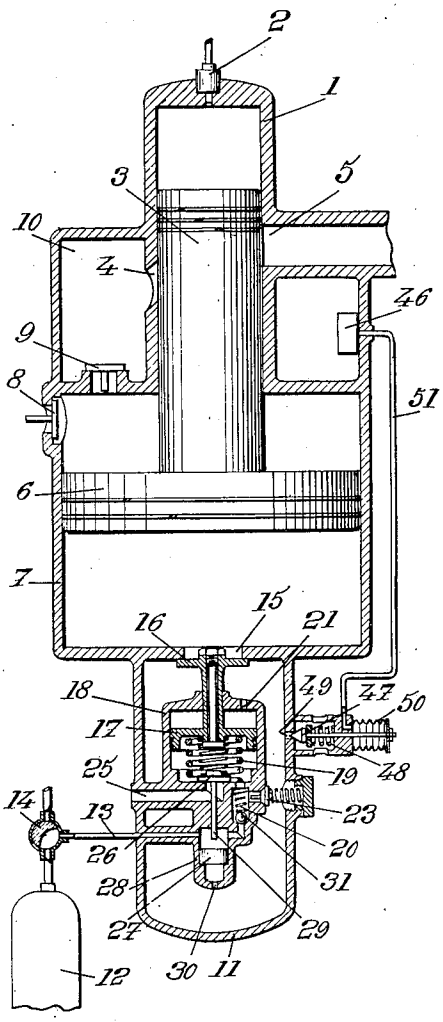
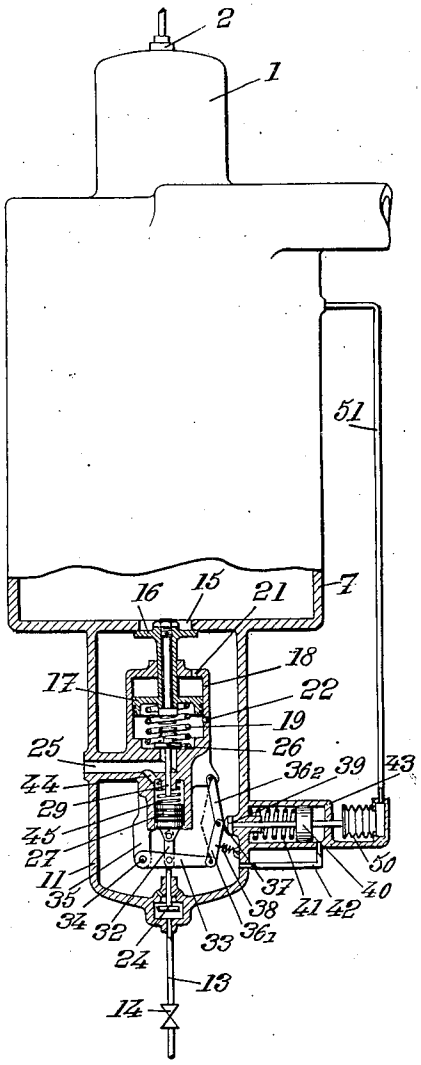



Fig. 2.




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## PNEUMATIC STARTING DEVICE

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6 Claims. (Cl. 60—14)

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The present invention relates to pneumatic starting devices for machines and more especially, although not exclusively, free piston machines (motor compressors or auto-generators).

Its object is to provide a device of this kind which is better adapted to meet the requirements of practice than those used for the same purpose up to the present time.

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings, 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 according to the invention;

Fig. 2 is a similar view of a machine of the same kind provided with a starting device made according to another embodiment of the invention.

The auto-generators to which the invention is applied in the examples hereinafter described are of a conventional type. For instance, that shown by Fig. 1 includes a motor cylinder 1 provided with a fuel injector 2 and air inlet orifices 4 (for scavenging and fuel mixture supply) and exhaust orifices 5 (for the mixture formed by the combustion gases and the excess of said air, this mixture constituting the gas to be supplied by the auto-generator).

In this cylinder 1 works a motor piston 3, which controls the inlet ports 4 and exhaust ports 5, and this motor piston is rigid with a compressor piston 6, which cooperates with a compressor cylinder 7 so as to divide the latter into two chambers. One of these chambers (that nearer to the motor cylinder, which will be hereinafter called "inner" chamber) is provided with an inlet valve 8 and an outlet valve 9 and constitutes the compressor space proper, in which is compressed the air intended for scavenging cylinder 1 and mixing with fuel therein. This air flows past valve 9 into a reservoir 10 which surrounds cylinder 1. The other of the two above mentioned chambers, or "outer" chamber, constitutes, during normal operation of the auto-generator, a pneumatic energy accumulator capable of storing up energy during the outward stroke of pistons 3 and 6 and of delivering this energy to said pistons for their inward stroke.

In order to start this auto-generator, I introduce into one of the above mentioned chambers, for instance the pneumatic energy accumulator constituted by the outer chamber of compressor cylinder 7, a certain amount of air previously stored up in a reservoir 11, filled from a source

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12 of air under pressure, a conduit 13 with a valve or cock 14 being interposed between source 12 and reservoir 11.

I provide, to bring the inside of reservoir 11 into communication with the inside of the starting chamber of the auto-generator, an orifice 15 controlled by a valve 16 rigid with a piston 17 movable in a cylinder 18 provided inside reservoir 11, a spring 19 tending to keep valve 16 closed.

Concerning the two chambers formed inside cylinder 18 on either side of piston 17, in the embodiment of my invention illustrated by Fig. 1, one of these chambers (the lower one) is connected with a conduit 20 in communication with the compressed air inlet and the other of these chambers (the upper one) is connected with the inside of reservoir 11 through an orifice 21. In the other embodiment of my invention, illustrated by Fig. 2, both of these chambers are in communication with the inside of reservoir 11, respectively through calibrated orifice 22 and orifice 21. Thus, while reservoir 11 is being filled and prior to the working of the starting device, the air pressures on opposite sides of piston 17 balance each other and valve 16 is strongly applied against its seat by spring 19. I may further provide a check valve in the air inlet conduit to reservoir 11. Thus, in the embodiment of Fig. 1, such a valve 23 is provided in the passage leading from conduit 20 to reservoir 11. In the embodiment of Fig. 2, check valve 24 is provided at the outlet of conduit 13 into reservoir 11.

With a starting device such as above described, operation of the starting device is obtained by suddenly reducing the pressure acting upon the side of piston 17 opposed to valve 16. This causes valve 16 to be moved away from its seat and the air under pressure present in reservoir 11 suddenly enters the starting chamber to push pistons 3—6 toward their inner dead center positions, near which fuel is injected and ignited.

In order to obtain correct starting operation, the air under pressure present in the chamber of cylinder 18 opposed to valve 16 must be evacuated very quickly. Otherwise, valve 16 might drop back onto its seat 15 before the whole of the compressed air stored up in reservoir 11 has entered the starting chamber of cylinder 7.

Up to the present time, in starting devices of this kind, the exhaust of air under pressure from the above mentioned chamber of cylinder 18 took place through the conduit 13 used for filling reservoir 11 from source 12, cock 14 being so devised that, in one of its positions, it places this cham-

ber of cylinder 18 in communication with the atmosphere. In order to obtain a quick outflow of air under pressure from said chamber, conduit 13 is to be given a large section, especially when cock 14, which is located at the plant control station, is at a relatively great distance from reservoir 11. However, for practical purposes, it is often difficult to find the room necessary for conduits 13 of large diameter. The question of the available space becomes still more difficult to solve when the plant includes several auto-generators the starting of which is to be controlled from a central station.

In order to obviate these difficulties, according to a feature of my invention, I provide an exhaust conduit 25 distinct from inlet conduit 13. This discharge conduit 25 which can, without any difficulty, be made very short and of relatively large section, directly connects with the atmosphere the chamber of cylinder 18 that is directly opposed to valve 16. Furthermore, I provide this discharge conduit 25 with a control valve 26.

When valve 26 is opened, said chamber of cylinder 18 is immediately and completely discharged into the atmosphere so that any danger of accidental closing of valve 16 before the desired time is wholly eliminated.

The opening of valve 26 may be performed either under the effect of manual means or automatically, for instance in response to a given variation of the pressure in reservoir 11.

Fig. 1 shows an embodiment of an arrangement for manual operation of the device. With this arrangement, valve 26 is operated by a servomotor means constituted by a piston 27 movable inside a cylinder 28, this piston being adapted to act upon the stem 29 of valve 26 under the action of the air under pressure present in the chamber of cylinder 28 opposed to stem 29. This last mentioned chamber communicates with the inside of reservoir 11 through a calibrated orifice 30. Furthermore, manually operated cock 14 is arranged in such manner that after it has been rotated through an angle of 90° from the position shown by Fig. 1, this cock, while cutting off the communication between conduit 13 and the source 12 of air under pressure, places conduit 13 in communication with the atmosphere. Finally, I provide, at the inlet of conduit 20 (belonging to the means for supplying air under pressure to reservoir 11) a check valve 31.

The device illustrated by Fig. 1 works in the following manner. Reservoir 11 and both of the chambers of cylinder 18 have first been filled with air under pressure, admitted past check valves 31 and 23. To start the auto-generator, valve 14 is placed in the position connecting conduit 13 with the atmosphere. This causes a sudden drop of the pressure which, up to then, had kept servomotor piston 27 at a distance from the stem 29 of valve 26, and the pressure acting upon the opposed face of this piston 27 pushes it against stem 29, thus causing valve 26 to open and to bring the chamber of cylinder 18 located under piston 17 into communication with the atmosphere through large conduit 25. Consequently, piston 17 and valve 16 move downwardly under the effect of the pressure in the upper chamber of cylinder 18, thus placing the starting chamber of cylinder 7 in communication with reservoir 11.

In the embodiment of Fig. 2, the opening of valve 26 is automatically ensured as soon as the pressure in reservoir 11 reaches a predetermined value. For this purpose servo-motor piston 27,



which controls valve 26 in the same manner as in the embodiment of Fig. 1, is connected through a link 32 with a lever 33 pivoted at 34 to a fixed arm 35, the other end of said lever 33 being normally locked by a knuckle device (links $36_1$,$36_2$) in a position for which piston 27 is held at a distance from the stem 29 of valve 26. The joint 37 of the links in question is normally applied by a spring 38 against an abutment 39 rigid with a piston 40 one of the faces of which is subjected to the action of a spring 41, whereas the other face is subjected to the action of the pressure existing in reservoir 11, transmitted through a conduit 42 extending between said reservoir 11 and the outer chamber of the cylinder 43 of said piston 40.

Furthermore, check valve 24, provided between inlet conduit 13 and reservoir 11 is arranged to coact with link 32 or lever 33 in such manner as to be kept in the open position as long as piston 27 is kept away from valve stem 29.

This device works as follows:

Reservoir 11 is filled with air under pressure. At the beginning, abutment 37 (urged by spring 41 which acts upon piston 40), knuckle device $36_1$—$36_2$, lever 33 and piston 27 are in the position shown by Fig. 2. In this position, servomotor piston 27 is prevented from moving toward valve stem 29, despite the fact that the face of this piston opposed to said valve stem is subjected to the action of the pressure existing in reservoir 11, whereas its other face is subjected to the atmospheric pressure supplied through conduit 44, which opens into conduit 25.

As soon as the pressure in reservoir 11 reaches a predetermined value, it causes piston 40 to move toward the left, thus bringing the knuckle system into its other position, shown in dotted lines. Lever 33 and servomotor piston 27 are no longer locked in the position of Fig. 2 and the pressure in reservoir 11 pushes piston 27 against the stem 29 of valve 26, whereby said valve opens and the air under pressure imprisoned in the lower chamber of cylinder 18 suddenly escapes to the atmosphere through conduit 25. Valve 16 opens and the auto-generator is started.

At the latest when the machine is stopped, when the air cushion is emptied, the spring 45 which acts upon piston 27 and the springs 38 and 41 which act respectively upon system $36_1$–$36_2$ and piston 40, bring back these parts into their initial positions shown by Fig. 2, and the starting device is ready for further operation.

According to another feature of my invention, means are provided for adjusting in accordance with the thermic state of the machine to be started, the pressure under which the starting air is supplied to the starting space of this machine.

For this purpose, I provide on the machine, at a place where the temperature varies in accordance with the general thermic state of the machine, for instance in casing 10, a thermostat 46 adapted to act upon means for adjusting the pressure of the starting air in reservoir 11.

The means in question may for instance include a valve for limiting the pressure in reservoir 11 by allowing air to escape from said reservoir into the atmosphere as soon as the pressure in said reservoir exceeds a predetermined value.

Such a valve is shown at 47 in Fig. 1. Valve 47 is normally kept by a spring 48 in the position that closes orifice 49 provided in the wall of reservoir 11. Valve 47 is further subjected to the action of a deformable box or bellows 50 con-

nected with the thermostat through a conduit 51, whereby the pressure inside said box 50 is adjusted by thermostat 46 as a function of the temperature acting on said thermostat, said box 50 being mounted in such manner that its action is opposed to that of spring 48. The higher the temperature in casing 10 and therefore the pressure in deformable box 50, the smaller the force tending to keep valve 47 closed. Therefore, the maximum pressure of the starting air in reservoir 11 is the lower as the general thermic state of the machine to be started is higher.

In the embodiment of Fig. 2, the thermostatic deformable box 50 acts upon abutment 39, this deformable box acting in the same direction as the pressure in reservoir 11 transmitted through conduit 42. The action is the same as in the preceding embodiment since the deformable box influences the value of the pressure in reservoir 11 for which lever 33 will cease to be locked in the position preventing the opening of valve 26.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my 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 accompanying claims.

What I claim is:

1. A pneumatic starting device for a free piston machine which comprises, in combination, a source of gaseous fluid under pressure, a reservoir to contain this fluid for starting said machine, valve means between said reservoir and said machine, means forming a variable volume chamber for operating said valve means, said valve operating means being responsive to variations of the fluid pressure in said chamber normally to keep said valve means closed as long as said fluid pressure is above a given value and to open said valve means in response to a drop of the pressure in said chamber below said value, means for placing said source in communication with both said reservoir and said chamber, servomotor means operative by the fluid pressure in said reservoir for discharging fluid from said chamber through a path wholly distinct from the means for placing the source in communication with the reservoir and the chamber, and means for cutting off said communication at least substantially simultaneously with the discharging of said fluid from said chamber.

2. A pneumatic starting device for a free piston machine which comprises, in combination, a source of gaseous fluid under pressure, a reservoir to contain said fluid for starting said machine, valve means between said reservoir and said machine, means forming a variable volume chamber for operating said valve means, said valve operating means being responsive to variations of the fluid pressure in said chamber normally to keep said valve means closed as long as said fluid pressure is above a given value and to open said valve means in response to a drop of the pressure in said chamber below said value, means for placing said source in communication with both said reservoir and said chamber, an outlet conduit between said chamber and the atmosphere, a valve to control said conduit, servomotor means operative by the fluid pressure in said reservoir for opening said valve and means for cutting off the communication between said source and said reservoir and said chamber at least substantially simultaneously with the opening of said last mentioned valve.



3. A pneumatic starting device for a free piston machine, which comprises, in combination, a source of gaseous fluid under pressure, a reservoir to contain said fluid for starting said machine, valve means between said reservoir and said machine, means forming a variable volume chamber for operating said valve means, said valve operating means being responsive to variations of the fluid pressure in said chamber normally to keep said valve means closed as long as said fluid pressure is above a given value and to open said valve means in response to a drop of the pressure in said chamber below said value, means for placing said source in communication with both said reservoir and said chamber, an outlet conduit between said chamber and the atmosphere, a valve to control said conduit, manually controlled servomotor means operative by the fluid pressure in said reservoir for opening said valve and means for cutting off the communication between said source and said reservoir and said chamber at least substantially simultaneously with the opening of said last mentioned valve.

4. A pneumatic starting device for a free piston machine which comprises, in combination, a source of gaseous fluid under pressure, a reservoir to contain said fluid for starting said machine, valve means between said reservoir and said machine, means forming a variable volume chamber for operating said valve means, said valve operating means being responsive to variations of the fluid pressure in said chamber normally to keep said valve means closed as long as said fluid pressure is above a given value and to open said valve means in response to a drop of the pressure in said chamber below said value, means for placing said source in communication with both said reservoir and said chamber, an outlet conduit between said chamber and the atmosphere, a valve to control said conduit, a cylinder in said reservoir, a piston in said cylinder, a conduit opening into one end of said cylinder, passages connecting said end of said cylinder with said reservoir and said chamber, check valves in said passages to permit the flow of fluid only from said cylinder end toward said reservoir and said chamber, the other end of said cylinder being in permanent communication with said reservoir, means operative by displacement of said piston toward the first mentioned end of said cylinder for opening said last mentioned valve and manual valve means for connecting said conduit alternately with said source of fluid and with the atmosphere.

5. A pneumatic starting device for a free piston machine which comprises, in combination, a source of gaseous fluid under pressure, a reservoir to contain this fluid for starting said machine, valve means between said reservoir and said machine, means forming a variable volume chamber for operating said valve means, said valve operating means being responsive to variations of the fluid pressure in said chamber normally to keep said valve means closed as long as said fluid pressure is above a given value and to open said valve means in response to a drop of the pressure in said chamber below said value, means for placing said source in communication with both said reservoir and said chamber, an outlet conduit between said chamber and the atmosphere, a valve to control said conduit, automatic servomotor means operative by the fluid pressure

in said reservoir for opening said valve in response to a rise of the pressure in said reservoir to a predetermined value and means for cutting off the communication between said source and said reservoir and said chamber simultaneously with the opening of said last mentioned valve.

6. A starting device according to claim 2 further including a discharge valve for limiting the maximum pressure inside said reservoir, spring means for elastically opposing the opening of said valve, and thermostatic means responsive to variations in the temperature of said free piston machine for automatically adjusting said spring means.

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