Feb. 4, 1941. R. PATERAS PESCARA 2,230,760

MACHINE WITH FREE PISTONS

Filed May 12, 1937 2 Sheets-Sheet 1

Fig. 1.

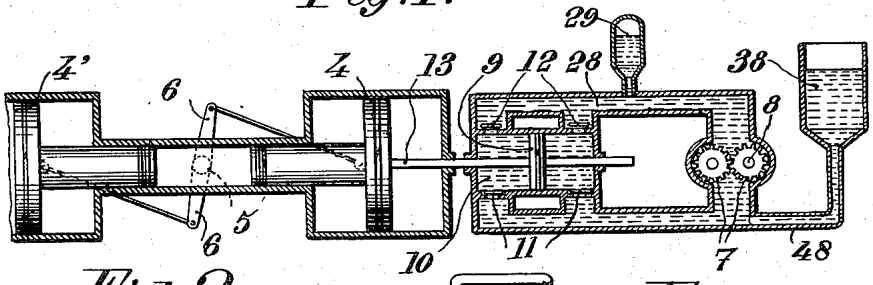


Fig. 2.

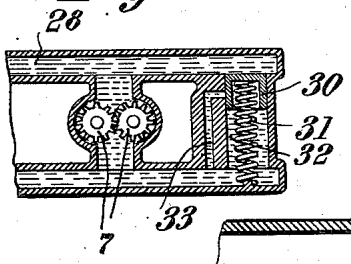


Fig. 3.

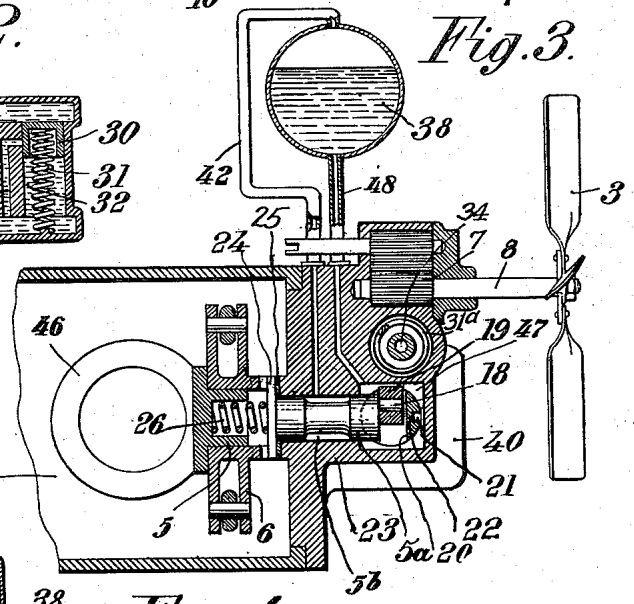
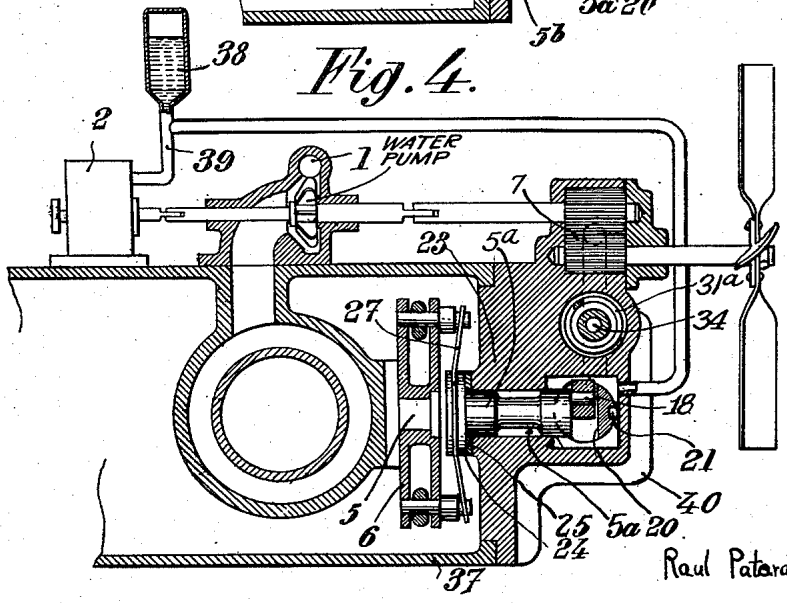


Fig. 4.



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Filed May 12, 1937 2 Sheets-Sheet 2

Fig. 5.

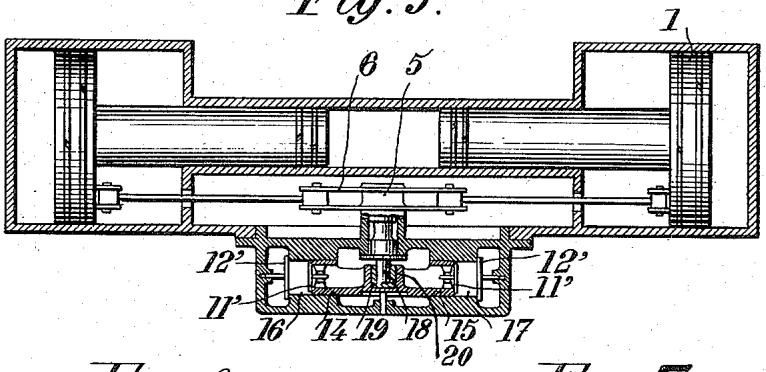


Fig. 6.

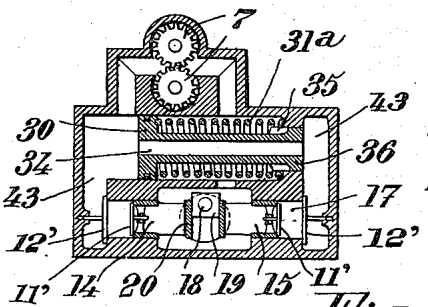


Fig. 7.

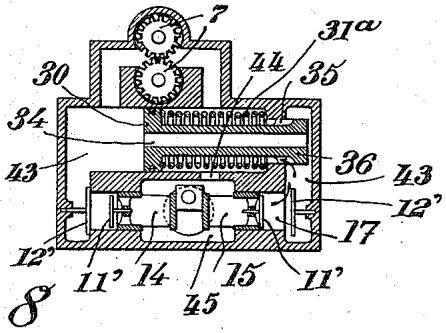
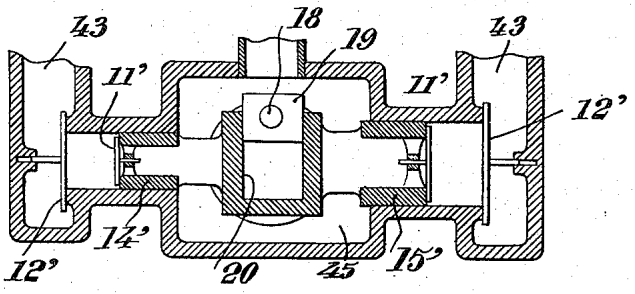


Fig. 8



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UNITED STATES PATENT OFFICE

2,230,760

MACHINE WITH FREE PISTONS

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Application May 12, 1937, Serial No. 142,311
In France May 12, 1936

10 Claims. (Cl. 60—19)

The present invention relates to machines with free pistons, and it is especially, although not exclusively, concerned with machines of this type at least a portion of the power of which is intended to drive at least one auxiliary receiving machine, more especially of the type having a continuous rotary movement and a gradual starting.

The object of the invention is to provide a machine of this type which is better adapted to meet the requirements of practice.

The essential feature of the present invention consists in attaching at least one of the reciprocating parts of a machine of the type above referred to with at least one of the pumps of a hydraulic transmission system, in such manner that it is possible, through said transmission system, either to transmit to at least one receiving machine a portion of the power supplied by the free piston machine, or to transmit to this last mentioned machine energy from the outside, for instance in order to bring said reciprocating parts into a position permitting the starting of said free piston machine.

Another feature of the present invention relates more especially, although not exclusively, to free piston machines in which the speeds of the free piston or the free pistons respectively on the forward and on the back stroke are different. This feature consists, while providing a hydraulic transmission system in combination with the machine as above set forth, in constituting the motive element of this system of at least one group of two cylinder and piston devices, acting respectively during the forward stroke and the back stroke of said movable parts of the engine, the two cylinders in question being made of different sections, and more particularly, in most cases, of sections such that both cylinder and piston devices have substantially the same mean instantaneous feed.

A third feature of the present invention consists, while associating a machine of the type above mentioned with a hydraulic transmission system, in devising said system in such manner that it ensures the braking of the driving parts of said machine at the end of their stroke, especially in the case of too long strokes of said driving parts.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

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

Fig. 1 shows, in a diagrammatic manner, and in axial section, a free piston machine combined, according to the present invention, with a hydraulic transmission system;

Fig. 2 is a partial view of another embodiment of some parts of said hydraulic transmission system;

Fig. 3 is a partial sectional view illustrating, in a diagrammatic manner, another embodiment of the combination of the free piston machine and the hydraulic transmission system;

Fig. 4 is a view, analogous to Fig. 3, corresponding to still another embodiment of the invention;

Fig. 5 is a general sectional view corresponding to the two preceding figures;

Figs. 6 and 7 show two different positions of the transmission mechanism of Fig. 5;

Fig. 8 shows a modified form of pump.

In the following description I will consider the case of a free piston machine intended to transmit a portion of its power to the rotating parts of a receiving machine, that is to say, for instance, a water pump 1, as shown by Fig. 4, a lubricating pump 2, as shown also by Fig. 4, a fan 3, as shown by Figs. 3 and 4, and so on.

Concerning first the free piston machine considered as a whole, it is made in any usual or conventional manner. For instance, as shown by the drawings, it includes two driving parts 4 and 4' (pistons movable in corresponding cylinders) coacting with an oscillating shaft or spindle 5 through synchronizing crank arms 6.

As for the means for transmitting power from this machine to a receiving machine they are constructed in accordance with the following principles.

It is known, as disclosed for example in my Patent No. 2,075,133, March 30, 1937, that the driving elements of a free piston machine used for compressing gas are given reciprocating movements of freely variable stroke and that they reach their working speed nearly instantaneously as a consequence of the absence of a fly-wheel. These characteristics render such a machine unable to be mechanically coupled with receiving machines such as those above mentioned, that is to say machines adapted to start gradually and to work with a continuous rotary movement.

In order to obviate this drawback and according to the essential feature of the present invention, I make use, for constituting these means, of a hydraulic transmission system one of the driv-

ing or motive parts of which is attached to at least one of the reciprocating parts of the free piston machine. Advantageously, this hydraulic transmission system is fitted with a regulating device capable of storing up at least a portion of the power supplied by said free piston machine when said power exceeds the possibility of immediate absorption of the receiving machine or machines. Preferably, this regulating device is devised in such manner that, when the conditions are reversed, it permits of giving up to said receiving machine or machines at least a portion of the power previously stored up by said regulating device.

Accordingly, concerning first said hydraulic transmission system considered in a general manner, it is devised in such manner that its motive elements can be actuated by the reciprocating parts of the free piston machine and that its receiving elements are adapted to receive, in the form of rotary movement, the energy developed by said motive elements.

For this purpose, said receiving elements advantageously constitute at least one hydraulic motor of a known principle, such for instance as a gear pump or motor 7 one of the pinions of which is keyed on a shaft 8 driving the utilization machines, either through suitable kinematic connections, or, preferably, as shown by Fig. 4, directly, said machines being then keyed on said shaft 8.

Advantageously, according to the invention, the driving or motive means of the hydraulic transmission system consist of at least one pump, having at least one piston or equivalent part which is driven either directly by the reciprocating pistons of the free piston machine or through the oscillating parts of said machine. Such a pump may be given many different embodiments and especially one of those hereinafter described by way of example with reference to the drawings.

According to the first arrangement, illustrated by Fig. 1, the motive pump of the hydraulic transmission system includes a piston 9 cooperating, preferably with a double acting cycle, with a cylinder 10, and provided, for instance, with inlet valves 11 and outlet valves 12.

This piston 9 is attached directly to the driving piston 4 through a rod 13 which further serves to guide the displacement of said piston 9.

According to the other type of arrangement above referred to, illustrated by Figs. 3 to 8, the driving or motive pump of the hydraulic transmission system includes two hollow pistons 14 and 15, rigid with each other and of the same diameter, moving respectively in opposed cylinders 16 and 17. The flow of the liquid takes place through said pistons, the end of each of which is provided with an inlet valve 11', whereas the end of each cylinder is provided with a discharge valve 12'.

For the drive of said pistons, I provide a mechanism capable of transforming into a rectilinear reciprocating movement the pivoting oscillating movement of crank arms 6. Such a mechanism may be constituted, for instance, by connecting to the crank 6 oscillating around its axis 5 a shaft 5a coaxial to said axis and having a crank pin 18 on which is pivoted a slide member 19 having vertical sides adapted to coact with the corresponding sides of a slideway 20 provided in the common central body of pistons 14 and 15. Advantageously, I further provide means for guiding said pistons, said means consisting for instance of a lug 21 sliding in a groove 22, in such manner as to avoid any possible wedging of said slide member 19 in said slideway 20.

For ensuring the fluid tight mounting of shaft 5a in the bearing 23 of the machine frame, I may make use of any usual suitable means. For instance, as shown by the drawings, I provide a collar 24 applied against a packing ring 25 by a spring. In the embodiment of Fig. 3, this spring is a spiral spring 26. Preferably, as shown by Fig. 4, this spring is a leaf spring 27, which is adapted to transmit the oscillating torque to the crankshaft 18, such an arrangement having the advantage of requiring a substantially less accurate adjustment of the whole of the transmission system with respect to the main machine.

Concerning now the regulating device to be used in combination with said hydraulic transmission system, it is mounted on the discharge conduit 28 of the driving pump.

According to a first embodiment, illustrated by Fig. 1, the excess of pressure on the output end of the pump is absorbed by an air cushion, in which case the regulating device essentially includes a fluid tight vessel 29 in which the liquid can accumulate temporarily when the discharge of the driving pump is greater than the possibility of immediate absorption of the receiving pump 7.

Preferably, as shown by Fig. 2, this excess of pressure is relieved by a piston 30 subjected to the opposed action of a spring 31, this piston being movable in a cylinder 32 mounted in shunt arrangement with respect to the discharge conduit 28. Advantageously, a safety device is provided, consisting for instance of a short-circuiting conduit 33 the communication of which with said cylinder 32 is opened by said piston 30 when a certain limit pressure is reached on the output side of the driving pump.

When the driving pump is of the type having two pistons such as shown in Figs. 3 to 5, I prefer to use a regulating device of the type shown in Figs. 6 and 7. This device includes a differential piston having a larger end 30 and a smaller end 36, this piston being urged in one direction by a spring 31a. A conduit 34 extends through the differential piston, and connects two chambers 43 which communicate with the two cylinders of the pump. The space between the pistons 30, 36 communicates with one side of the gear motor 7. There are also provided adjacent the piston 36 slots or grooves 35, so arranged that when the piston moves to the right as shown in Fig. 7 communication is established between the chamber at the right hand side and the space between the pistons in which the spring 31a is located.

If the delivery pressure of the pump exceeds a certain limit, the difference in pressure on pistons 30 and 36 because of the difference in their areas will move the differential piston mechanism from the position shown in Fig. 6 to that shown in Fig. 7. The slots 35 then connect the delivery chamber 43 of the pump with the space between the pistons, which space in turn is connected through opening 44 to the intake side of the pump. Therefore the gear motor 7 is short-circuited, and the pressure exerted thereon by the fluid is relieved.

In many cases the interior of the housing 41, which encompasses the motor cylinder 46, serves as a receptacle for the scavenging and charging air of the motor cylinder. Excess pressure then prevails in the interior of housing 41. It would

be injurious if air, notwithstanding the packing means, should penetrate through the bearing of shaft 5a to the interior of the housing 47, which contains the fluid of the hydraulic clutch mechanism.

In order to prevent penetration of air into chamber 47, shaft 5a is provided with a turned portion 5b. Connected with the free space thus formed between the bearing points proper of shaft 5a is a passage 42, which carries off air which tends to force through the inner bearing point of shaft 5a into the space 5b. For example, passage 42 goes to an elevated receptacle 38 which contains the fluid reservoir for the fluid of the hydraulic clutch.

On the other hand, I further provide, for compensation of the eventual liquid leakage and of the differences of expansion between said liquid and the metal, a reservoir 38 which is preferably branched on the intake of the driving or motive pump by means of a conduit.

It should be noted, by the way, that I may make use of the lubricant of the free piston machine as motive fluid, in which case, I advantageously provide a shunt conduit 39 on the discharge of the lubricating pump for feeding lubricant to said reservoir 38.

In all cases, I preferably arrange the various parts of the hydraulic transmission system in such manner as to constitute a compact unit which is preferably fitted with cooling fins 40 located in the zone of action of the fan 3 (Figs. 3 and 4).

In this way, I provide a combination of a free piston machine with means for transmitting to various rotary receiving machines at least a portion of the power of said free piston machine, the operation of said means during the period of starting of the system taking place in the following manner:

During the period of time necessary for the receiving machine to reach its normal working speed, liquid accumulates in the chamber of the regulating device and the pressure on the output side of the driving pump increases, which has for its result to facilitate the starting of the receiving machine or machines.

In addition with the combination above mentioned, I may make use of other arrangements according to the invention, such as those hereinafter described, capable eventually of being used separately and which will be supposed, in the following description, to be applied to a system of transmission such as that above described.

It is known that in free piston machines, the forward stroke of the pistons is generally quicker than their return stroke. This may produce, in said transmission system, periodic shocks which are detrimental to the efficiency of the transmission and of the good working of the receiving machine or machines.

In order to obviate this drawback, I make use of an arrangement according to which, instead of constituting the driving pump by two pistons of the same section, as shown by Fig. 5, it is made of two pistons of different respective sections, 14' and 15', the sections of these pistons being in inverse ratio to the mean forward and backward speeds of the driving pistons of the main machine, in such manner that the smaller piston 14' works during the forward stroke and the larger piston 15' works during the backward stroke.

This arrangement permits of obtaining mean instantaneous flows which are substantially equal for the forward and backward strokes of the pistons of the free piston machine, this corresponding to a substantial improvement of the efficiency of the whole of the transmission system.

I might of course give different relative dimensions to said pistons, especially if it were desired to drive a machine or a mechanism the speed of which would vary periodically with a period equal to the period of oscillation of the driving pistons of the free piston machine.

Of course the arrangement above described could be employed for transmitting the movement of a free piston machine to a machine having a movement which is not a rotary continuous movement.

The invention also applied to the case in which the hydraulic transmission system would be used merely for setting in proper position the driving parts of a free piston machine.

It also applies to the case in which the intake of the pump would be kept under pressure, for instance by means of an additional pump further adapted to compensate leakage, which would permit of utilizing high pressures and reducing the space occupied by the plant.

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 device of the character described comprising, in combination, a free piston compressor including a free piston, a hydraulically operated auxiliary mechanism mounted for continuous rotation, a pump adapted to provide fluid pressure to said mechanism, means for transmitting fluid from said pump to said mechanism including pressure regulating means for rendering intermittently inoperative at least a part of said fluid pressure, and means for driving said pump by said piston.

2. A device as in claim 1, said means for driving said pump comprising a mechanical member interconnecting said piston and pump.

3. A device as in claim 1, said pump comprising a cylinder, a pump piston in said cylinder, and means for mechanically connecting said pump piston to said free piston.

4. A free piston compressor apparatus comprising two free pistons mounted for opposed movement in a cylinder, a linkage interconnecting said pistons to synchronize the movements thereof, a fluid pump, a rotatably operable auxiliary apparatus, hydraulic transmission means including automatic pressure regulating means for rotatably operating said auxiliary apparatus by said pump, and means for connecting said pump to said linkage for operation thereby.

5. In the combination of a free piston compressor and a pump operated thereby for driving an auxiliary apparatus through a hydraulic transmission connecting said pump to said auxiliary apparatus; said transmission comprising lead and return lines between said pump and apparatus, and a spring loaded differential piston interposed in said lead line for storing up a portion of the power delivered by said pump when said power exceeds the possible power use of said apparatus.

6. In the combination of claim 5, said differ-

ential piston having an axial passage therein for the flow of liquid from said pump, and means carried by said differential piston for short-circuiting said pump for a predetermined displacement of said differential piston.

7. A device of the character described comprising a free piston compressor, pump means operated by said compressor, a motor, a liquid circuit connecting said pump and motor, a liquid reservoir communicating with said circuit, a lubricating pump for said compressor, and a conduit connecting the output of said lubricating pump with said reservoir for feeding liquid thereto.

8. In combination with a free piston compressor including a free piston, a pump operatively connected to said piston, a motor, a liquid circuit connecting said pump to said motor, said circuit including a conduit connecting the output of said pump with the intake of said motor, a second conduit connecting the output of said motor with the intake of said pump, said pump including two cylinders, and valve means for causing said two pistons to discharge liquid successively through said circuit, said pistons being of different relative cross section.

9. In combination with a free piston compressor including two pistons mounted for opposed operation and movable at different speeds during their respective strokes in opposite directions, a pump operatively connected to at least one of said pistons and including two pump pistons, a motor, a liquid circuit connecting said pump to said motor, valve means for causing said pump pistons to discharge liquid successively through said circuit, and said pump pistons having individual cross sections in inverse ratio to the respective speeds of the strokes of said pistons included in said compressor

10. In the combination of a free piston compressor and a pump operated thereby for driving an auxiliary apparatus through a hydraulic transmission connecting said pump to said auxiliary apparatus; said transmission comprising lead and return lines between said pump and apparatus, a by-pass conduit between said lines for short-circuiting said pump, and a spring loaded piston arranged on said lead line to close, in its normal position, said by-pass conduit and to open the latter upon a predetermined displacement of said piston.

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