Sept. 22, 1964 G. F. CUDAHY 3,149,773

APPARATUS FOR COMPRESSING FLUIDS

Filed Oct. 21, 1963

2 Sheets-Sheet 1

FIG-1

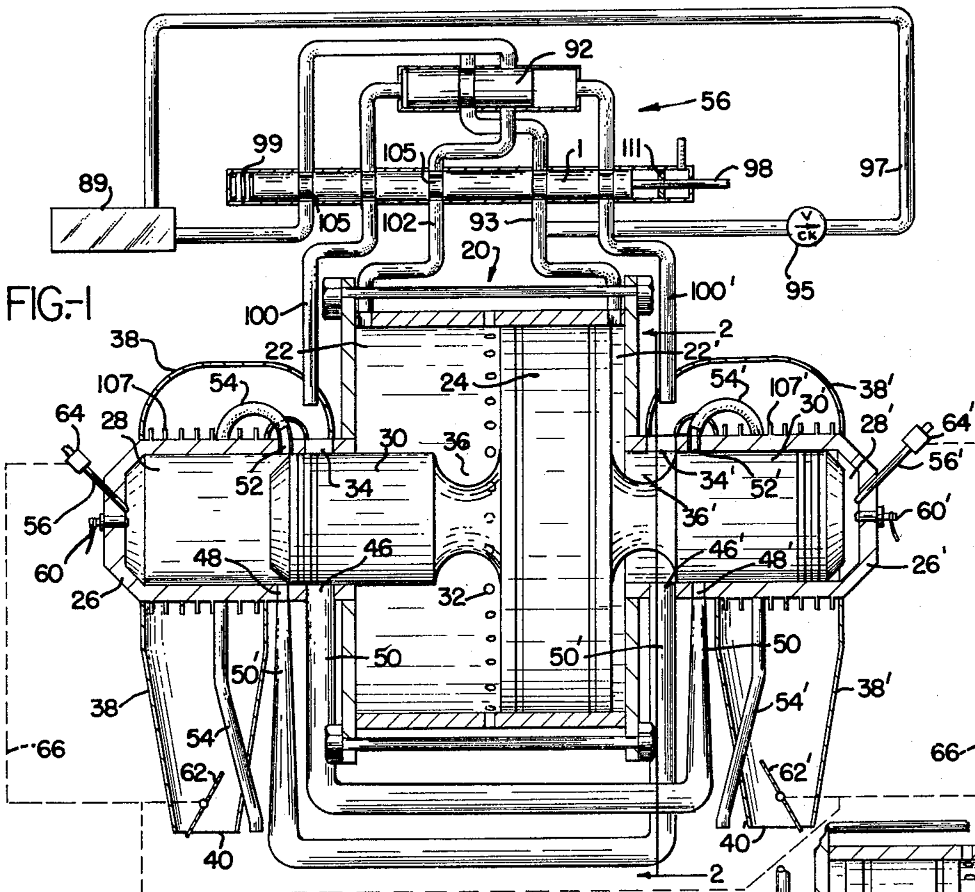


FIG-2

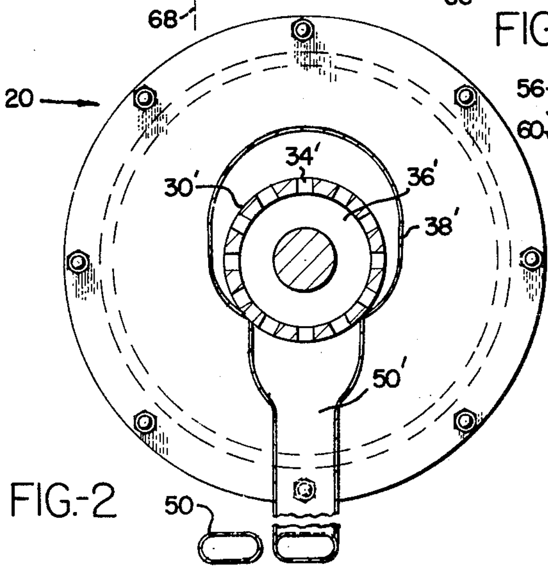
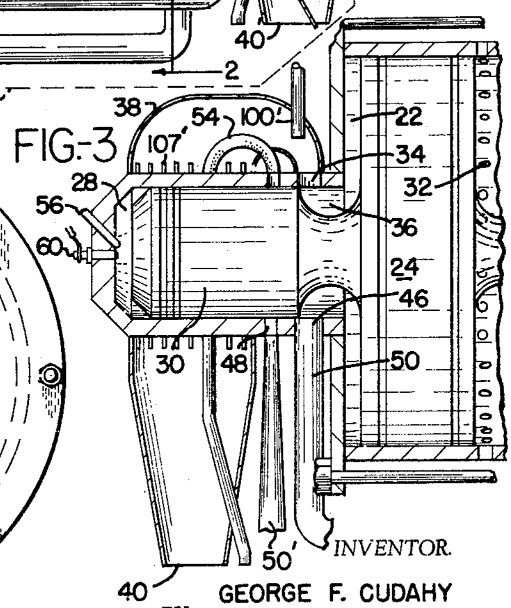


FIG-3



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APPARATUS FOR COMPRESSING FLUIDS

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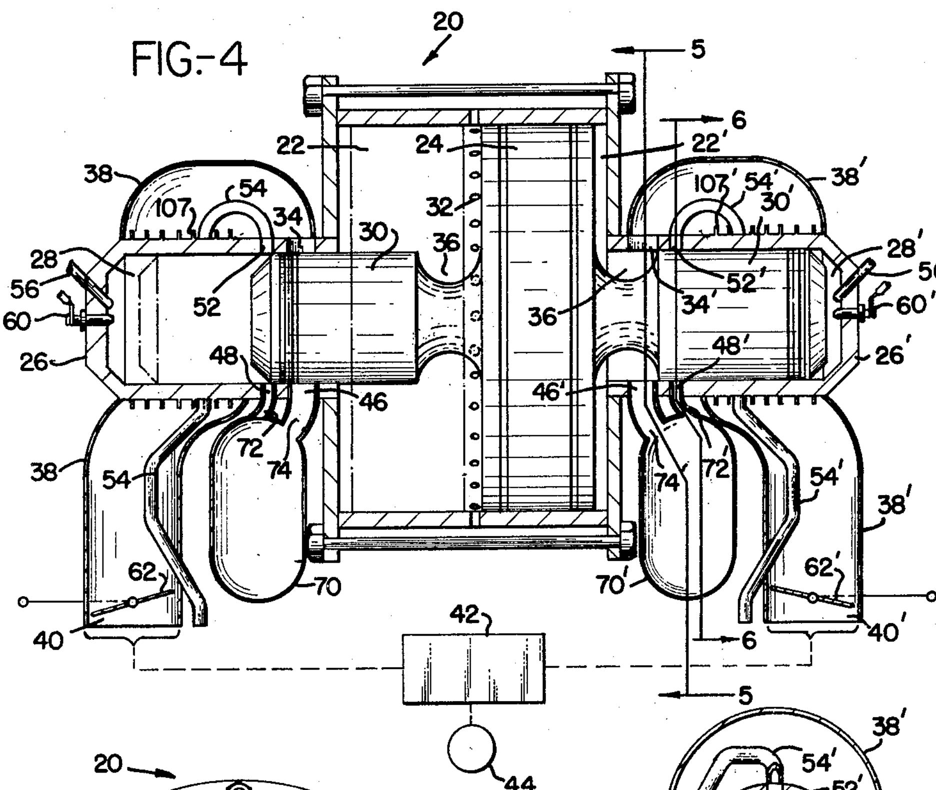
FIG.-4



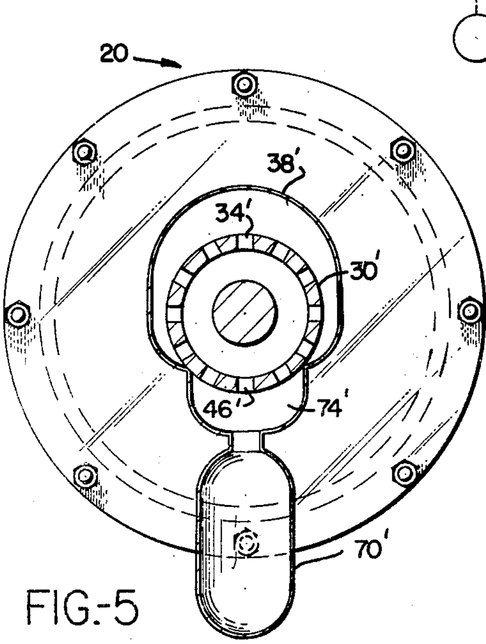


FIG.-5

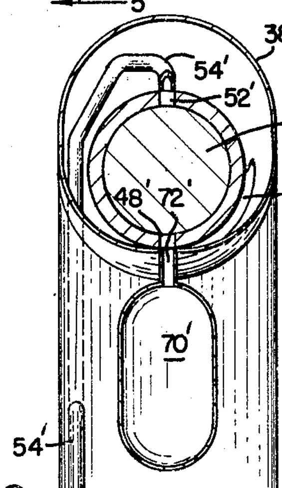


FIG.-6

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APPARATUS FOR COMPRESSING FLUIDS

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This invention relates to apparatus for compressing fluids such as air and the like.

An object of this invention is to provide an apparatus in which fluid is compressed in a compression cylinder having a pair of adjacent compression chambers separated by a central fluid intake means.

Another object of this invention includes such a compressing cylinder construction in combination with power cylinder constructions attached to the ends of such cylinder construction.

Another object of this invention is to provide a compressing apparatus that is relatively simple and inexpensive to construct.

Another object is to provide a compressing apparatus having (*a*) high compression ratios in the power cylinders, (*b*) ability to burn a wide variety of fuels, (*c*) only one moving part with no side forces on such part, (*d*) ability to utilize a high percentage of the heat supplied, (*e*) the combination of high compression ratios, high utilization of heat supplied and low frictional losses to give high efficiency, and (*f*) having a high power to weight ratio for a piston engine.

Other objects are apparent from this description, the appended claimed subject matter, and/or the accompanying drawings in which:

FIGURE 1 is a diagrammatic longitudinal cross section of an apparatus embodying this invention.

FIGURE 2 is a transverse cross section taken along the line 2—2 of FIGURE 1.

FIGURE 3 is a view of a portion of FIGURE 1 showing certain parts in another position.

FIGURE 4 is a cross section similar to FIGURE 1, but showing another embodiment.

FIGURE 5 is a cross section along line 5—5 of FIGURE 4.

FIGURE 6 is a cross section along the line 6—6 of FIGURE 4.

In FIGURES 1–3, an air or fluid compressor cylinder 20 may be of any desired cross sectional shape, as illustrated in FIGURE 2. (The word "cylinder," as used herein, is intended to describe any cylindraceous construction whether the cross section is circular or of any equivalent shape capable of receiving a correspondingly cross sectioned piston). The cylinder 20 may be arranged so that it has end fluid compression chambers 22 and 22′. A compressor piston 24 is reciprocable alternately into and out of the compression chambers 22 and 22′.

The power cylinders 26 and 26′ are connected respectively to opposite ends of the compressor cylinder 20 and have power chambers 28 and 28′ which are connectable respectively to the compression chambers 22 and 22′, as will become apparent. Two power pistons 30 and 30′ are connected respectively to opposite ends of the compressor piston 24 and are reciprocable respectively into and out of the power chambers 28 and 28′.

Air or other fluid intake port means 32 may be provided between the compression chambers 22 and 22′ in the compressor cylinder 20. The compressor piston 24 reciprocates past the intake port means 32 as it reciprocates alternately into and out of the compression chambers 22 and 22′. The intake port means may be in the form of one or more generally radial ports circumferentially arranged around cylinder 20, which connect the

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interior of the cylinder 20 with a source of fluid to be compressed, such as air from the surrounding atmosphere. Suitable air or fluid cleaning or filtering means, not shown, may be provided for the air intake means 32, if desired. The term "air" is used herein for convenience and brevity broadly to describe air or any other suitable compressible fluid which may be introduced into the intake means 32.

Compressed air or other fluid discharge port means 34 and 34′ may be provided respectively in each of the power cylinders 26 and 26′ adjacent the respective ends of the compressor cylinder 20. These discharge port means may be in the form of one or more generally radial ports.

Compressed fluid passageway means 36 and 36′ may be provided in any of the pistons 24, 30 and 30′ respectively connecting the respective compression chambers 22 and 22′ with the respective discharge port means 34 and 34′ substantially at the terminations of the compression strokes of the compressor piston.

Means may be provided for conducting the compressed air or other fluid from the fluid discharge ports 34 and 34′ to a place of use. For example, respective hoods 38 and 38′ may be respectively connected to one or more discharge ports 34 and 34′ and may conduct the compressed fluid past the respective outlets 40 and 40′ to a place of use. Such place of use may be for example a compressed air tank, such as is diagrammatically illustrated at 42, in FIGURE 4 which may supply any desired compressed fluid using means, such as one or more compressed air or fluid motors 44, FIGURE 4, and the like.

Scavenging means may be provided for conducting compressed air or other fluid from fluid discharge port means 46 and 46′ adjacent each end of the compressor cylinder 20 respectively to scavenge port means 48′ and 48 in each power cylinder 26′ and 26 at the respective opposite end of the compressor cylinder. The fluid discharge port means 46 and 46′ may be the same as, or similar to, the port means 34 and 34′ heretofore described and may extend generally radially through the power cylinders 26 and 26′ adjacent the each respective end of the compressor cylinder 20. These ports 46 and 46′ may discharge respectively into conduits 50 and 50′ which conduct compressed scavenging air or other fluid respectively into scavenging or recharge ports 48′ and 48 at the respective opposite ends of the compressor cylinder 20. This scavenging or recharging air or fluid drives the exploded mixture in the respective power chambers 28 and 28′ out through the exhaust ports 52 and 52′ and into the exhaust pipes 54 and 54′ respectively, and recharges the respective chambers with relatively fresh air.

Starting means 56 for starting operation of said pistons and other parts of the apparatus may be provided. Further description of such starting means 56 is elsewhere provided.

The position of the ports illustrated in FIGURE 1 are shown substantially at the termination of the compression stroke of the piston 24 into the chamber 22′. The positions of some of the same ports are shown substantially at the termination of the compression stroke of the piston 24 into the chamber 22. FIGURE 3 shows the compressed air of other fluid in chamber 22 being discharged into port means 34 and 46 to provide compressed air or other fluid into the outlet 40 and in the scavenging passageway 50.

The power chambers 28 and 28′ may be provided with power producing means which may be a fuel which may be inserted, for example, through fuel tubes 56 and 56′ which may be placed on the cylinders 26 and 26′ as illustrated. The fuel tubes 56 and 56′ may be placed at any other desired place, such as in the conduits 50 and 50′ near or in the ports 48 and 48′.

The fuel may be solid or liquid, such as in the form of a powder or a spray.

The explosive mixtures in the power chambers 28 and 28′ may be ignited by any of the well-known igniting procedures. For example, the explosive mixtures may be ignited by spark splugs 60, 60′ or by glow plugs, or by the heat of compression, etc.

Valves 62 and 62′ may be provided in the compressed air or fluid passageways 38 and 38′ respectively. These valves may be actuated in conjunction with the actuation of the fuel control valves 64 and 64′ by any suitable linkage diagrammatically indicated by the dotted lines 66 which are emblematic of any type of linkage which is obvious. For example, when the portion actuating line 68 is moved upwardly manually, or automatically in response to any function, to cause the fuel valves 64 and 64′ to be throttled, then the valves 62 and 62′ are also correspondingly throttled, and vice versa. This causes a restriction in the outward flow of compressed air in the passages 38 and 38′, thereby increasing the pressure in these passages 38 and 38′. This insures that the recharge and purging passageways 50 and 50′ receive a full charge of air at part loads and also prevents a portion of the compressed air in compression chambers 22 and 22′ from discharging out of ports 34 and 34′. Therefore a portion of the energy in the form of pressure and temperature in the compressed air in the compression chambers 22 and 22′ is retained in such chambers. This retained energy assists the alternating power impulses in chambers 28 and 28′ in accelerating the piston assembly 24 and 30, 30′ to its opposite extreme position. Therefore, with the valves 62 and 62′ partially closed, less energy is required in the power chambers 28 and 28′ to cause the piston assembly 24, 30, 30′ to reciprocate with the proper amplitude of travel. Through the use of the valves 62 and 62′ the output of the apparatus can be closely controlled and the apparatus will run smoothly at reduced outputs.

In the embodiment of FIGURES 4–6, all of the elements are substantially the same in construction and operation. A small number of the elements are identified with the same reference numerals.

However, the ports 46 and 48, in FIGURES 4–6, are connected to a power cylinder recharge chamber 70 by passsageways 72 and 74. The ports 46′ and 48′ are connected to the recharge chamber 70′ by passageways 72′ and 74′.

The embodiment of FIGURES 4–6 has the ports identified by numerals below 70 operating substantially the same as in FIGURES 1–3. However, in the positions of FIGURE 4, the port 48 is recharging the chamber 28 with compressed air received from recharge chamber 70 through passageway 72. Previously, when the piston 30 was in the left extreme position of piston 30 in FIGURE 3, the recharge chamber 70 of FIGURES 4–6 was filled with compressed air from the compression chamber 22 through passageway 74. The recharge chamber 70′ is now being filled with compressed air from chamber 22′ through passage 74′. This compressed air in recharge chamber 70′ will be ready for scavenging and recharging chamber 28′ when the piston 30′ moves to its extreme left position and uncovers port 48′.

It is thus to be seen that the recharging chambers 70 and 70′, of FIGURES 4–6, have replaced the conduits 50 and 50′ of FIGURES 1–3.

In the operation of the embodiments of FIGURES 1–3 and 4–6, when combustion takes place in power cylinder 28′, FIGURES 1 and 4, the piston assembly 24, 30 and 30′ is forced to the left position, corresponding to that shown in FIGURE 3. As the piston assembly 24, 30, 30′ moves leftwardly ports 34′, 46′ and 32 are closed and the air in compressor chamber 22 is compressed. Also a vacuum is produced in compressor chamber 22′. As the piston assembly moves further to the left ports 32, 34, 46, 52′ and 48′ are opened. Therefore compressed air from chamber 22 enters passageway 38 and recharge passageway 50 (if recharge chambers 70 and 70′ are used then recharge chambers 70 is pressurized). Outside air enters chamber 22′ through ports 32. The exhaust gases from power chamber 28′ exit out of port 52′ and thence through exhaust pipe 54′.

Recharge air for power chamber 28′ enters through ports 48′ from passageway 50 (or from recharge chamber 70′ if such chamber is used). Also as the piston assembly moves to the left, the air-fuel mixture in power chamber 28 is compressed. When combustion takes place in power chamber 28 the piston assembly 24, 30, 30′ is forced to the right. The same process takes place as when the piston assembly moved to the right except that the process is in "mirror image" or in symmetry.

The starting system 56 is used for either of the embodiments of FIGURES 1–3 and 4–6. When the starting control valve 1 is moved to the extreme left position show in FIGURE 1, the air passages connected through valve 1 are opened. Compressed air from the starting air flask 89 can then flow to shuttle valve 92. With the valve 92 in the extreme left position, as shown, starting air is then allowed to flow back through passage 93 into compressor chamber 22′. The high pressure starting air then forces the piston assembly 24, 30, 30′ to the left. When the piston assembly reaches its far left position, it uncovers ports 34 and 46 allowing compressed air in compressor chamber 22 to exhaust into passageways 38 and 50 and also uncovers the ports 32, allowing the starting air in chamber 22′ to exhaust out of ports 32. Since valve 62 is partially closed during starting, there is a pressure rise in the passageway 38 when the compressed air in chamber 22 is exhausted into passageway 38 through ports 34. This causes air to flow in passage 100 to the left side of valve 92 forcing it to the right. The air on the right side of valve 92 is exhausted via passage 100′ into passageway 38′ which at this time is not under pressure. Now high pressure starting air is directed to the compression chamber 22 through passage 102, forcing piston 24 to the right. The previous steps are repeated in mirror image as piston 24 moves to the right. Therefore a reciprocation of piston assembly 24, 30, 30′ and compression in power chambers 22 and 22′ are obtained.

The high compression starting air flask 89 is filled by compressed air from compression chamber 22′ whenever the pressure in line 93 rises sufficiently to open check valve 95 and to force air through pipe 97 into flask 89 during the regular power operation of the engine.

The plunger 1 of the starting control valve is biased rightwardly by compression spring 99 but plunger 1 can be moved leftwardly to start the engine by manually pressing the handle 98 to open the valve groove passageways 105. The plunger 1 is stopped in its rightward movement by a stationary ring 111.

When it is desired to add heat to the air being pumped, passageways 38 and 38′ may be constructed to allow the compressed air to pass over the power cylinders 26, 26′ as shown in FIGURES 1 and 4. The power cylinders 26 and 26′ are thereby cooled and heat is added to the compressed air, increasing its energy content. The exhaust pipes 54 and 54′ also are passed through the passageways 38 and 38′ so that as much heat of the exhaust gases of the power cylinders as possible is added to the compressed air in passageways 38 and 38′. When it is desired to keep the compressed air as cool as possible, the compressed air passageways 38 and 38′ may be constructed so that the compressed air will not pass over the power cylinders 26, 26′, and the exhaust pipes 54 and 54′ will not be led through the compressed air passageways 38, 38′. In that case the power cylinders will be cooled in another manner, such as by utilizing the energy of the exhaust gases in connection with a jet pump to draw fresh air over the power cylinders to cool them.

The power cylinders 26 and 26' may be provided with fins 107, if desired.

It is thus to be seen that a new, useful and unobvious apparatus for compressing fluids has been provided.

While the form of the invention now preferred has been disclosed as required by statute, other forms may be used, all coming within the scope of the claimed subject matter which follows.

What is claimed is:

1. In combination: a fluid compressor cylinder having opposite and fluid compression chambers; a compressor piston alternately reciprocable into and out of said compression chambers; two power cylinders connected respectively to opposite ends of said compressor cylinder and having power chambers therein connectable to said compression chambers; two power pistons connected respectively to opposite ends of said compressor piston and reciprocable respectively into and out of said power chambers; fluid intake port means between said compression chambers in said compressor cylinder past which said compressor piston reciprocates alternately into and out of said compression chambers; compressed fluid discharge port means in each of said power cylinders adjacent respective ends of said compressor cylinder; compressed fluid passageway means in said pistons respectively connecting said respective compression chambers with said respective compressed fluid discharge port means substantially at the respective terminations of the compression strokes of said compressor piston.

2. A combination according to claim 1 in which scavenging and recharging means are provided for conducting compressed fluid from said fluid discharge port means adjacent each end of said compressor cylinder respectively to scavenge and recharge port means in each power cylinder at the respective opposite end of said compressor cylinder.

3. A combination according to claim 1 in which means are provided for conducting compressed fluid from said fluid discharge ports to a place of use.

4. A combination according to claim 1 in which starting means are provided for starting operation of said pistons.

5. A combination according to claim 1 in which fuel controlling valves are provided to control the injection of fuel into said compression chambers.

6. A combination according to claim 1 in which throttling means are provided for said compressed fluid discharge means.

7. A combination according to claim 1 in which fuel controlling valves are provided to control the injection of fuel into said compression chambers and in which throttling means are provided for said compressed fluid discharge means, and in which said valve controlling means and said throttling means are actuated proportionately to throttle said fuel and said compressed fluid discharge means.

8. A combination according to claim 1 in which means are provided to heat the compressed fluid by heat generated in said power cylinders.

9. A combination according to claim 1 in which scavenging and recharging fluid chambers are connected to compressed fluid discharge ports in said power cylinders and to scavenging and recharging ports in said power cylinders.

10. In combination: a fluid compressor cylinder having end fluid compression chambers; a compressor piston alternately reciprocable into and out of said compression chambers in said cylinder; fluid intake means in said compressor cylinder past which said piston reciprocates; and means operated by said compressor piston to discharge compressed fluid from said compression chambers substantially at the opposite terminations of reciprocation of said piston, and in which said last-named means includes smaller pistons connected to opposite ends of said compressor piston; smaller cylinders at opposite ends of said compressor cylinder into which said smaller pistons reciprocate; discharge ports in said smaller cylinders; and grooves in said smaller pistons adjacent said compressor piston connecting said compression chambers to said discharge ports at the terminations of the reciprocations of said pistons, and in which said smaller pistons are power pistons and in which said smaller cylinders are power cylinders.

11. A combination according to claim 10 in which at least one of said discharge ports in one power cylinder is connected to the power cylinder at the opposite end to purge said last-named power cylinder.

12. A combination according to claim 11 in which an exhaust port is provided in said last-named cylinder through which said last-named cylinder is exhausted.

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