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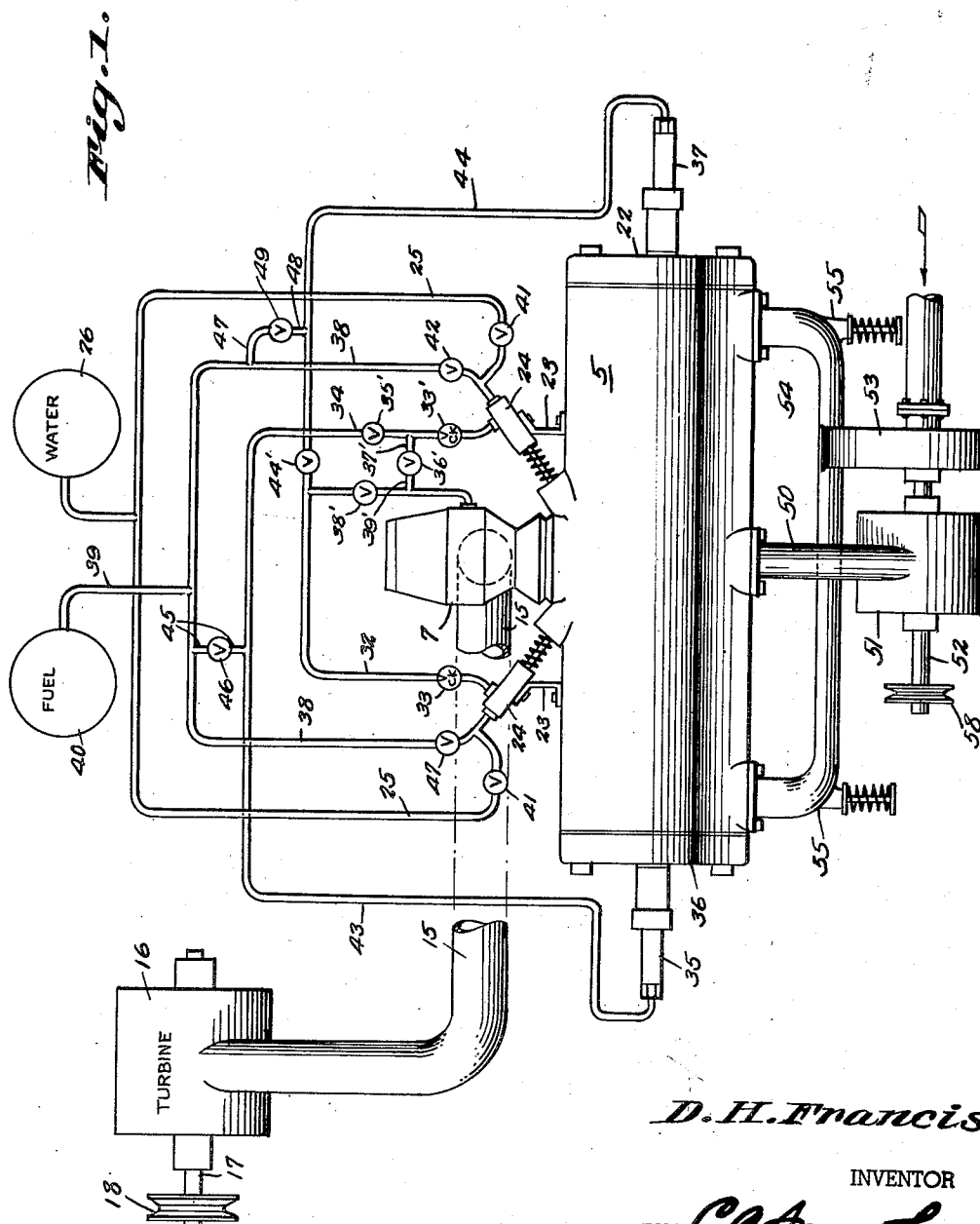
D. H. FRANCIS

2,693,076

FREE PISTON INTERNAL-COMBUSTION ENGINE

Filed May 18, 1951

3 Sheets-Sheet 1



D. H. Francis

INVENTOR

BY *Chas. H. Snow*
ATTORNEYS.

ATTORNEYS.

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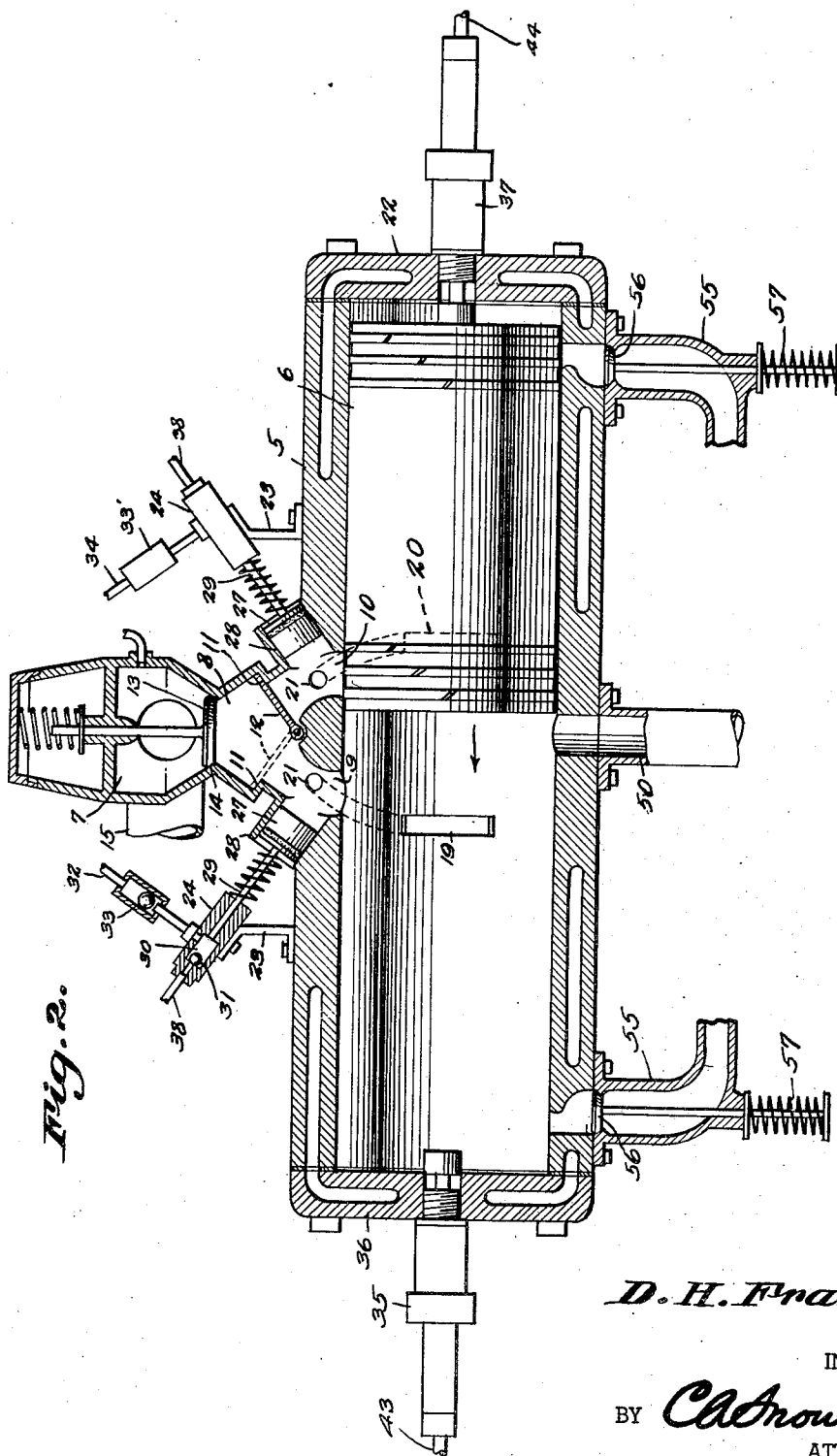
D. H. FRANCIS

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FREE PISTON INTERNAL-COMBUSTION ENGINE

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3 Sheets-Sheet 2



D. H. Francis

INVENTOR

BY *Chenoweth & Co.*
ATTORNEYS.

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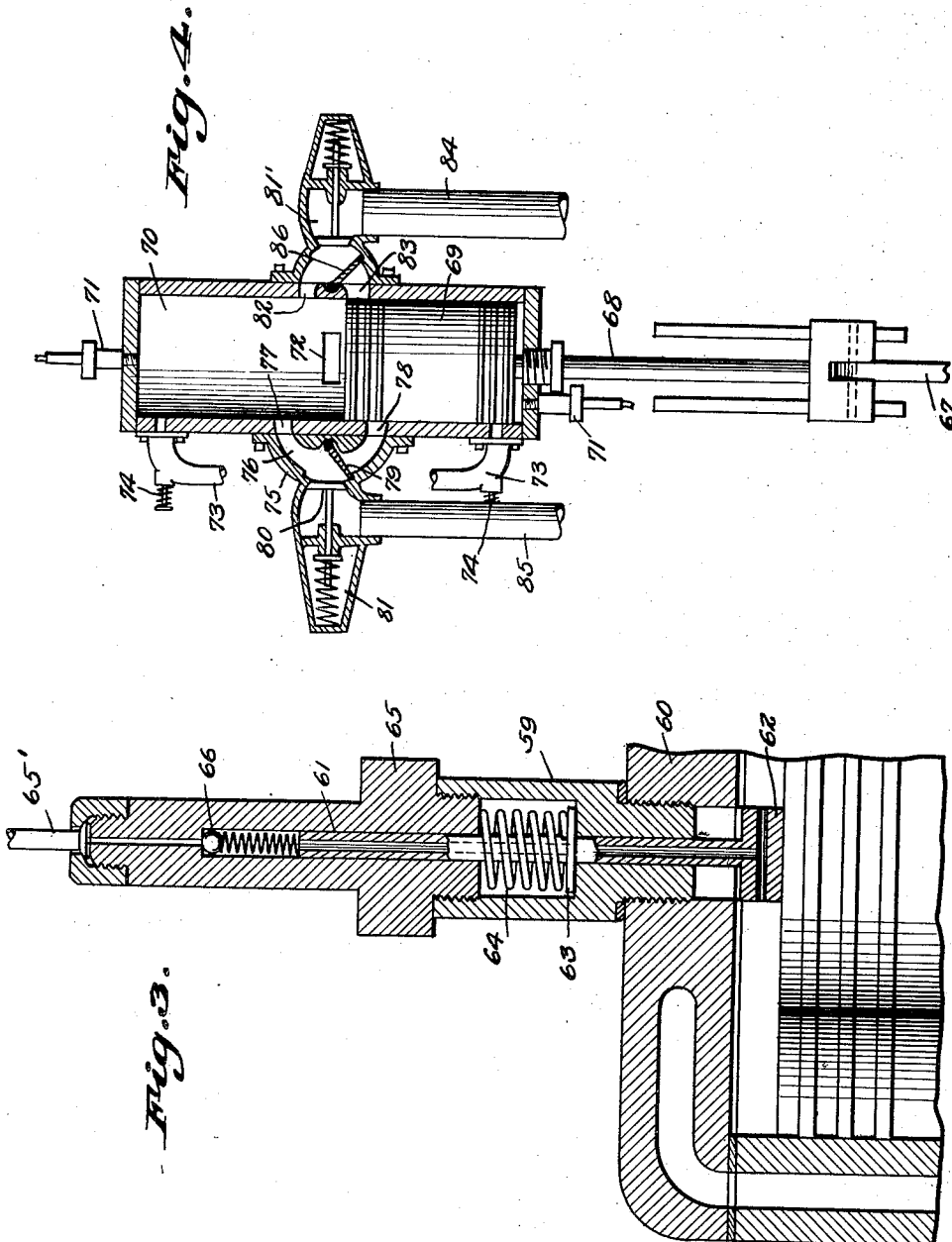
D. H. FRANCIS

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FREE PISTON INTERNAL-COMBUSTION ENGINE

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3 Sheets-Sheet 3



D. H. Francis

INVENTOR

BY *Chenoweth*
ATTORNEYS.

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FREE PISTON INTERNAL-COMBUSTION ENGINE

Daniel H. Francis, Pueblo, Colo.

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1 Claim. (Cl. 60—13)

This invention relates to internal combustion engines of the high compression free piston type, the primary object of the invention being to provide an engine structure wherein the energy derived from the exhaust gases from conventional internal combustion engines, and which is usually wasted, may be harnessed and utilized for useful application without reducing the efficiency of the engine.

An important object of the invention is to provide means for trapping and controlling the exhaust gases in such a way that the combustion gases are effectively divided into a grouping, as high pressure, medium pressure and low pressure, for various uses.

Still another object of the invention is to provide a system of combustion control that will eliminate undesirable back pressure in various types of internal combustion engines, making a greater percentage of the energy of hydro-carbon fuels available for power.

With the foregoing and other objects in view which will appear as the description proceeds, the invention consists of certain novel details of construction and combinations of parts hereinafter more fully described and pointed out in the claim, it being understood that changes may be made in the construction and arrangement of parts without departing from the spirit of the invention as claimed.

Referring to the drawings:

Figure 1 is an elevational view illustrating a free piston type internal combustion engine, constructed in accordance with the invention.

Fig. 2 is a longitudinal sectional view through the cylinder and valves, controlling the passage of the exhaust gases from the cylinder.

Fig. 3 is an enlarged fragmental sectional view illustrating the principle of the invention as carried out in a vertical engine structure using a fuel injector.

Fig. 4 is a longitudinal sectional view through a vertical piston rod and cross head type engine with means for controlling the exhaust gases.

Referring to the drawings in detail, the reference character 5 indicates the cylinder of the engine in which the piston 6 operates, the piston 6 being of the type known as the free piston type, which moves to opposite ends of the cylinder 5, under the action of the exploding charges in the ends of the cylinder.

Disposed at a point intermediate the ends of the cylinder, is the valve housing 7 which is constructed to provide a high pressure chamber 8 that communicates with the engine cylinder 5, through the ports 9 and 10. Valve seats 11 are formed in the wall of the high pressure chamber 8, against which the flap valve 12 seats, closing the ports 9 and 10. The reference character 13 indicates the poppet valve that moves within the valve housing 7, and engages the valve seat 14 to control the passage of heat and pressure, to the turbine, through the pipe 15 that establishes communication between the valve housing 7 and the turbine, indicated by the reference character 16. The turbine 16 is provided with the usual shaft 17 which may be directly connected to electric generators, etc.

Pulley 18 is secured on shaft 17 so that power may be taken off from the turbine. The cylinder is also provided with openings 19 and 20 arranged slightly farther from the center of the cylinder, the openings 19 and 20 communicating with the ports 9 and 10, through the passageways 21. It follows that when the piston 6 is in the position as shown by Fig. 2 of the drawings, and is

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moved to the left, by reason of an explosion of gases between the head 22 of the cylinder and adjacent end of the piston, the piston will be forced toward cylinder head 36 and part of the exhaust gases and heat will pass through the opening and passageway 21, into the high pressure chamber 8, causing the flap valve 12 to swing from the dotted position shown by Fig. 2 of the drawing, to the full line position, whereupon the poppet valve 13 will be elevated allowing the high pressure products of combustion to pass port 10 with the least interference and on to the turbine 16 for operating it. Gas through the restricted passage 21 from port 20 will flip the flapper valve 12 more gently than the full jolt of gas from port 10 thus adding to the life of the wearing parts 12. After port 10 is fully open the piston uncovers port 50 through which low pressure gases may escape through a low pressure turbine 51 to the atmosphere as shown in Fig. 1 or if desired directly to the atmosphere, as shown in Fig. 2. If gases from port 50 pass to the low pressure turbine 21 the main purpose of the same may be to drive clean air through pipes 54 past valves 55 near the respective ends of the cylinder 5. Any surplus power may be taken off shaft 52 at pulley 58. It will be noted that at the time the high pressure gases from ports 20 and 10 are acting on flapper valve 12, high pressure chamber 8 and poppet valve 13, will also be acting on plunger piston 27 in piston cylinder 28 nearest cylinder head 22. This action on plunger 27 forces fuel to combustion chamber adjacent cylinder head 36 via pipe 43, more fully explained as follows:

Brackets 23 are mounted on the cylinder 5 and provide supports for the valves 24, valves 24 providing communication between fuel pipes 38 and the fuel tank 40 through which fuel is delivered to the valve 24. Fuel injector pump pistons 27 form part of the valve operating mechanism, and as shown, these pistons operate in cylinders 28, the pistons having valve rods 29 secured thereto, the valve rods 29 moving into the valve chambers 30 operating the ball valve 31 to cause the passage of fuel through valve housing 33' and past check valve 33. After passing ball check 33' fuel is directed through pipe 34 thence through pipe 43 to injector mechanism 35 as previously explained. Valves 35' and 36' will of course be moved to their open positions during the flow of fuel as described. It is evident that at the time fuel is delivered to injector mechanism 35 that piston head 6 is in close proximity of cylinder head 36 forming a combustion chamber where-in an explosion will drive piston 6 to the right or toward cylinder head 22. In this operation port 19 will first uncover permitting gas to pass through opening 21 to high pressure chamber 8, thus causing flapper valve 12 to flip into position shown by the solid lines in Fig. 2. This plunger piston 27 nearest cylinder head 36 will be actuated causing fuel to pass ball check 33' of valve housing 33 and into pipe 32 which leads to pipe 44, valve 41' being open, thence to injector 37 and thence to combustion chamber between cylinder head 22 and piston head 6, etc. During the operation valve 38' is closed.

The injectors referred to above Fig. 3 are of a special type and will be more thoroughly explained later in this description, as it is the intention that after the engine is warmed up and running smoothly that the valve 44' and valve 35' can be closed after valves 46 and 49 have been opened, thus permitting fuel to pass directly from the fuel tank 40 by way of pipes 39', 45 and 43 to injector 35 and by way of pipes 39, 47, 48 and 44 to the injector 47. When this is done the valves 42 and 47 may be closed cutting off fuel from the piston valves 24 and leaving them available to deliver small quantities of moisture to the high pressure chamber 7. To accomplish this water from tank 26 travels through pipes 25 past valves 41 into piston valves 24 thence past check valves 33' into pipes 32 and 34. From here it is directed through the pipes 37', valve 36' and pipe 39' into the high pressure chamber 7 where by reason of contacted heat it is converted into steam and will contribute additional power for driving the turbine 16.

It is within the scope of this invention that the moisture from pipes 32 and 34 will be conducted into cham-

ber 7 and into pipe 15 connected with chamber 7 and exhausted through pipe 15 as steam uncontaminated with the exhaust gases.

If in the engines described it is deemed desirable to exhaust the low pressure gases direct to the atmosphere power for driving the blower 53 for delivering clean air to the pipes 54 may be had from other sources, as for instance pulley 18.

It might be further stated that compressed air for starting, and other accessories of conventional nature are used in order to start the motor, but since these accessories play no part in the machine or engine other than to provide an operative starting structure, the construction of the accessories has been omitted in this showing.

In Fig. 3 of the drawings is shown the type of fuel injector used, which includes a body portion 59 that is threaded in a threaded opening of the cylinder head 60, the body 59 having a bore in which the hollow tube 61 is disposed, the tube 61 having a transversely disposed head 62 at the inner end thereof, there being provided a disc 63 secured to the tube, against which the coiled spring 64 engages, the spring 64 also abutting the inner end of the removable section 65 of the body of the injector. Connected with the outer end of the body portion of the injector is the pipe 65' through which fuel is admitted to the cylinder. Operating within the upper section of the injector body, is a spring pressed valve 66 that normally acts to prevent the exhaust gases from passing into the injector feed pipe 65'.

It might be further stated that the threaded end of the body 59 of the injector is spaced a distance from the inner surface of the cylinder head 60, sufficient to allow the transversely disposed head 62 of the injector to move into the space under the action of the piston, the contact of the piston with the head 62 acting to cushion the movements of the piston, when in operation, also to cause fuel to be disbursed from the transverse opening in the head 62 of the hollow tube 61. The length of the stroke of tube 61 can be regulated by varying the thickness of disc 63, but owing to the restricted diameter of the transverse opening in head 62 additional ball checks in the structure are not deemed necessary, although contemplated.

In Fig. 4 of the drawings, the principle of the invention is carried out in reconstruction of an engine, wherein the piston is connected with the crank shaft 67, by the connecting rod 68 to supply energy for operating machinery (not shown).

In this type of engine, the piston, which is indicated by the reference character 69, operates within the cylinder 70 and is moved alternately from one end of the cylinder to the other, by the action of explosive charges exploded at the ends of the cylinder, as the fuel charge is compressed by the movements of the piston. The fuel enters through the injectors 71 disposed in the ends of the cylinder, and which are connected with pipes leading from sources of fuel supply (not shown).

The length of the piston 69 is such that when it reaches the limit of its movement in either direction, the port 72 will be open, the port 72 communicating with the atmosphere, or if desired, a low pressure turbine as already described in Fig. 2, turbine 51 and blower 53.

The reference character 75 indicates a high pressure manifold which has a curved passageway 76 that communicates with the interior of the cylinder 70, through the ports 77 and 78, the high pressure manifold 75 having the flap valve 79 mounted therein, which flap valve is adapted to swing within the manifold to limit the volume of space within the manifold subjected to high pressure gases after explosion, from the cylinder. The poppet valve 80 operates in the housing 81, forming a part of the manifold 75, and prevents back pressure directed to the cylinder, to retard the operation of the piston within the cylinder.

It will be noted that directly opposite to the manifold 75, is the manifold 81' which communicates with the cylinder, through ports 82 and 83. The openings 82 and 83 in the manifold 81' are arranged close together, as compared with the openings 77 and 78, so that medium pressure gases may pass from the cylinder 70 into the pipe 84, the pipe 84 being connected with a turbine (not shown) to be operated by the action of the high and low pressure gases, the high pressure gases passing to the turbine, through the pipe 85. The flap valve 86 is mount-

ed within the manifold 81' and controls the volume of the medium pressure gases trapped in the U-shaped portion of manifold 82 and 83. Clean air is forced into cylinder 70 through pipe 73 past valves 74, while the cylinder pressures are low and port 70 is uncovered. This high, medium and low pressure port arrangement is readily adapted to the free piston type engine shown in Figs. 1 and 2.

I have illustrated the engine in this invention as being of the high compression type wherein no ignition is required.

In the operation of the engine with the piston 6 in the position as shown by Fig. 2 of the drawings, a combustion chamber is provided between the cylinder head 22 and adjacent end of the piston. When a charge of fuel is ignited in this combustion chamber, with the piston 6 in the position shown by Fig. 2 of the drawings, combustion occurs, causing the piston 6 to move in the direction of the arrow, or to the opposite end of the cylinder.

In the present invention the ports 9 and 10 are so constructed that they provide a substantially Y-shaped passageway, which ports communicate with the cylinder at points slightly laterally of a perpendicular line to the horizontal axis of the cylinder, while the low pressure pipe 50' directly opposite thereto, communicates with the cylinder at the direct center point, or midway the length of the cylinder, the points of communication between the ports 9 and 10 being respectively slightly closer to the cylinder heads 36 and 22. Thus if an explosion has just taken place in the area between the cylinder head 36 and piston 6, the piston has been driven into the opposite end of the cylinder 5, as shown by Fig. 2. The exhaust gases will escape through the port 9 into the high pressure chamber 8 past poppet valve 13 into chamber 7, and as the piston advances towards the cylinder head 22, a remaining portion of gas which has not escaped through port 9, may escape through the pipe 50. In a similar manner, when piston 6 is driven from the end of the cylinder as shown by Fig. 2, into the opposite end of the cylinder, the exhaust gases incident to such an explosion, may first escape through the port 10 into the high pressure chamber 8, thence past poppet valve 13 into chamber 7, and subsequently as the piston advances towards the cylinder head 36, the remainder passes through pipe 50. It might be further stated that compression stops the piston 6 as it approaches head 36 or 22.

Since any useful work for a free piston type engine must be accomplished by harnessing the power of the exhaust gases, it is obvious that at the convergence of the Y-shaped ports 9 and 10, the poppet valve 13 is located and so designed as to permit the exhaust gases from cylinder 5 to pass therefrom, but will prevent return passage of these gases into the cylinder. Since the gases passing through the ports 9 and 10 are the first gases from each explosion, they are naturally higher pressure gases than subsequently pass through the port or pipe 50. It is obvious that gases having passed valve 13 and which move into chamber 7, cannot return to the cylinder. Thus the area 7 becomes a higher pressure area than port 50 and a high pressure can be maintained in area 7 without impairing the efficiency of the engine. A considerable volume of gas may be reservoir in the pipe 15 and its pressure may vary from low to high without stalling the engine. Any pressure remaining in the cylinder after port area 50 has opened, will act as interference to proper scavenging of the area, and clean air from the blower 53 is for the purpose of displacing any such spent gas.

By use of piston valve 27, flapper valve 12 and a poppet or other suitable check valve 13 and housing for same, a combination is brought about that makes it possible to utilize energy for useful application that otherwise wastes as exhaust, as in the conventional combustion engine.

It is understood that in the combination shown in Fig. 4 that the piston rod 68 may be continued on through piston 69 and on through the second cylinder head, as is common practice in horizontal double action internal combustion engine construction. It is also to be noted that the foregoing descriptive matter pertains to double action internal combustion engine types, both free piston and controlled piston types. However, it is within the scope of the invention to adapt the principle of controlled exhaust to the single action type of two cycle engines in common use today. The necessary modifications involved are as follows. Referring to Fig. 4, the

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piston head and stuffing box and injector 71 closing the end of the cylinder adjacent piston rod 68 and connecting rod 67 are discarded, as is piston rod 68 in which place is substituted a connecting rod and wrist pin (not shown) mounted in piston 69 in the conventional manner and connected to a crank shaft (not shown). In this arrangement one combustion chamber 70 would exist with its single air pipe 73 and valve 74 and adjacent cylinder head and injector. The air pipe 73 and valve 74 adjacent the discarded piston rod 58 are also discarded. All other parts, as high pressure housing 75 with its valve 80, its passage 76 and port 77, are left intact, as shown, with the exception that the port 78 need not be provided. The medium pressure housing with its port 82 and valve 81' is left intact, as are the pipes 84 and 85 of both housings. The port 83 may, however, be closed and in this or such particular case, the flapper valves 79 and 86 have no special function and may be discarded. Port 72 continues and serves to release low pressure gases. It so serves in all type engines.

It is also within the scope of the invention to provide and adapt spark plugs or hot ball ignition, if such ignition be desired.

Having thus described my invention, what is claimed is:

A free piston internal combustion engine, comprising

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an engine cylinder, a free piston operating within the cylinder, a fuel injector mounted in each end of the cylinder, valve controlled means for delivering air to the ends of said cylinder for mixture with the fuel entering the ends of said cylinder, a valve housing mounted intermediate the ends of the cylinder, passageways providing communication between said housing and cylinder, fuel injector pump pistons disposed at oblique angles with respect to the cylinder, operating at opposite sides of said housing at the base thereof, a flap valve operating between said fuel injector pump pistons alternately controlling the passage of exhaust gases from said passageways into said housing, and a poppet valve in said housing controlling the passage of exhaust gases from the housing, and a turbine, a pipe establishing communication between the turbine and housing operated by products of combustion from the engine.

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