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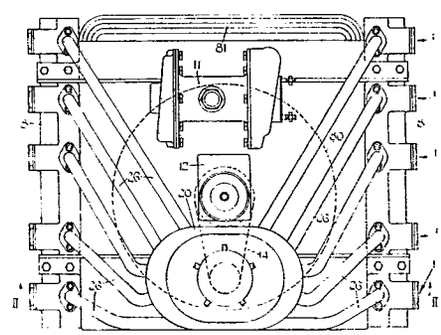
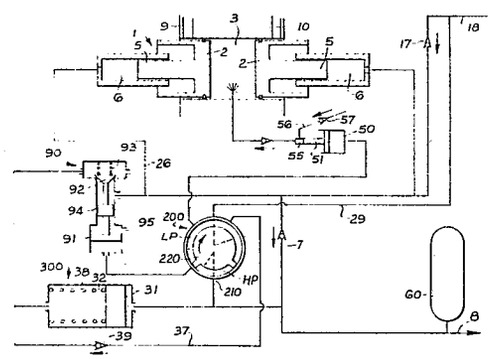
(54) Internal combustion engine arrangement.

(57) An internal combustion engine arrangement of the reciprocating piston type having a fluid pressure output is provided in which the or each piston of the engine such as opposed pistons (2) in a common cylinder (3) are connected to corresponding pistons (5) in cylinders (6) for receiving fluid from a source (18) of supply of the latter whereby on a power stroke of the engine pistons (2), the pistons (5) connected thereto are operated to expel fluid under pressure from their associated cylinders (6) for power output use. Driven valve means (200) and metering means (300) receive and direct only a necessary amount of said output fluid under pressure back to the cylinders (6) sufficient to effect fluid pressure operated return of the connected pistons (2, 5) for a compression return stroke of the engine pistons (2). Two or more cylinder units (1) each containing pistons (2, 5) and associated cylinders (3, 6) can be provided and supplied with fluid pressure for piston return from the driven valve means (200) also acting as a distributor.





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The object of this invention is to provide an internal combustion engine arrangement of the reciprocating piston type in which the power output is provided in the form of fluid under pressure such as pressurised hydraulic fluid. This and other practical advantages are apparent from the following disclosure.

According to this invention an internal combustion engine arrangement of the reciprocating piston type is characterised by the or each piston of the engine being connected to a corresponding piston of a cylinder for receiving fluid from a source of supply of the latter whereby on a power stroke of the engine piston, the piston connected thereto is operated to expel fluid under pressure from its associated cylinder for power output use, driven valve means and metering means being provided for receiving and directing only a necessary amount of said output fluid under pressure sufficient to effect fluid pressure operated return of the connected pistons for a compression stroke of the or each engine piston.

In practice the construction and arrangement is as follows, reference being had to the accompanying drawings in which:-

FIGURE 1 is an elevation of a multi-cylinder arrangement of the engine,

FIGURE 2 is a part sectional view taken on the line II-II of FIGURE 1,

FIGURE 3 is an axial plane section of the distributor valve unit,

FIGURES 4 & 5 are cross sectional views taken on the lines IV-IV and V-V of FIGURE 3.

FIGURE 6 is a diagram showing a modified arrangement of the hydraulic system of the engine, and

FIGURE 7 is a modified diagram similar to FIGURE 6 and including alternative valve means.

The engine may consist of one or more cylinder units 1 and in the example shown in FIGURE 1, five cylinder units 1 are employed, each of which advantageously consists of an opposed piston arrangement (see FIGURE 2) although a piston and cylinder head arrangement may be employed if desired.

Each engine piston 2 in its cylinder 3 is directly connected by a connecting rod 4 with a piston 5 of a hydraulic cylinder 6 which in turn communicates via a non-return valve 7 with a high pressure output manifold 8 for the supply of fluid under pressure for any required purpose such as the operation of one or more hydraulic motors and/or rams.

Each opposed piston cylinder unit 1 operates on a two-stroke cycle with preferably compression ignition in which fuel is injected at the appropriate time between the engine pistons 2 prior to their power stroke movement apart and operation of the hydraulic pistons 5 in expelling fluid from the hydraulic cylinders 6 to the output manifold 8. The engine cylinder 3

is shown finned at 13 for air cooling but may be liquid cooled and the inlet and exhaust manifolds are indicated at 9, 10 respectively. Exhaust gas output is arranged to operate a turbo-charger 11 (FIGURE 1) for admitting a forced air supply to the inlet manifold 9. Other suitable air charging means may be employed.

For equalized extent of operation and to ensure compression between the engine pistons 2 at a central position in the cylinder 3, i.e. at the point of fuel injection, each piston is shown connected at 35 to a corresponding rack 33 (FIGURE 2) meshing with a common pinion 34 so that relative movement of the pistons 3 is maintained in a positive manner.

Starting procedures of the engine are hereinafter referred to.

In order to obtain compression operation of the engine pistons 2, the operation of a distributor unit 20 (FIGURES 3 to 5) incorporating valve means is as follows:-

A supply of fluid at high or working pressure is taken from the output manifolds 8 (which are inter-connected) and admitted at 210 into the high pressure section HP of the chamber 21 of the distributor 20 containing a rotary valve member 22 (see FIGURE 5). The rotary valve member 22 is driven by a hydraulic motor 12 (FIGURE 1) via a toothed belt drive 14 and coupling 15 (FIGURE 3), the hydraulic motor 12 being continuously driven by a tapped off high pressure fluid supply from the output manifolds 8.

On rotation of the valve member 22 (i.e. in a clockwise direction in FIGURE 5), fluid from the high pressure section HP is passed to a port A which communicates with one end of a bore 32 of metering means 30 containing a piston 31 (FIGURE 4) and moves the piston 31 axially to the right, which expels fluid from the bore 32 to the port B and from thence to the compression pressure section CP of the valve member 22. From this section CP and according to the rotation of the valve member 22 fluid under pressure is passed to an appropriate port 23 and from thence via a radial passageway 24 to an outlet connection 25 which is connected by a pipe 26 (FIGURES 1 and 2) via a non-return valve 16 to a corresponding hydraulic cylinder 6 for applying pressure to the piston 5 of the latter in order to return the associated engine piston 2 back for a compression stroke. Variation in such compression fluid pressure energy supply is hereinafter referred to.

After sufficient impetus has been imparted to the coupled pistons 2 and 5 for this purpose, the respective pipe 26 and port 23 is communicated with a low pressure section LP of the valve member 22, which section LP is in constant communication with a fluid supply reservoir (not shown) via a radial passageway 29 (FIGURE 3). This enables the non-return valve 16 to close in readiness for the next power stroke operation of the pistons 2 and 5.

In addition to fluid being admitted to the hydraulic cylinder 6 in this way from the compression pressure section CP of the valve member 22, fluid is also drawn into the hydraulic cylinder 6 from a fluid input manifold 18 via a non-return valve 17. Each fluid input manifold 18 is shown adjacent to, but separate from, an output manifold 8 and both input manifolds 18 communicate with the fluid supply reservoir.

The non-return valves 16 and 17 are shown conveniently embodied in the same assembly and in a relatively slidable manner, the assembly incorporating a single compression spring 19 loading both valves 16, 17.

As further rotation of the rotary valve member 22 takes place, the high pressure section HP is communicated with port B which acts on the piston 31 to move it in the opposite direction (i.e. to the left in FIGURE 4) which, in a similar manner, expels a quantity of fluid under pressure via the port A to the compression pressure section CP of the valve member 22 from where it passes to a further outlet connection 25 to the hydraulic cylinders 6 of another cylinder unit 1.

In the arrangements shown in FIGURES 3 to 5, the distributor 20 has three outlet connections 25 for use with three cylinder units 1 but can be developed in a similar manner for any practical number of cylinder units such as the five unit arrangement shown in FIGURE 1.

As will be evident from FIGURE 5 the recessing or pocketing of the rotary valve member 22 is arranged in a symmetrical manner for balanced operation.

An adjustable stop 36 is shown provided for the piston 31 whereby its extent of axial movement can be pre-set according to requirements, i.e. as determined by the amount of fluid pressure energy passed to a hydraulic cylinder 6 which is sufficient to effect required compression return movement of the associated engine piston 2. The stop 36 is shown in the form of a screw and is set for causing only a necessary amount of fluid pressure energy to be passed for compression purposes so that a minimum of such energy is taken from the fluid pressure output energy of the engine.

The stop 36 may be arranged for manual adjustment (i.e. as indicated in FIGURE 4) and/or it may be adjustable in response to the speed of rotation of the distributor 20 and/or output pressure and/or operation of fuel injection means to the engine cylinders 3 in obtaining a required metering action.

An innermost part 222 of the valve member 22 in the low pressure section LP has a port 228 co-operating with fixed ports 28 for effecting operation of a fuel injector unit 50. For this purpose fluid from the high pressure section HP of the distributor chamber 21 is supplied via a radial passageway 27 to the supply port 228 which is in turn, by the action of the innermost part 222 of the rotary valve member 22, communicated by a port 28 with means for actuating a corresponding plunger or piston 51 of the fuel injector unit 50 (FIGURE 3) for the supply of a required quantity of fuel to the injector of a cylinder 3 of the appropriate engine cylinder unit 1.

Referring to FIGURE 3 fluid is passed by an appropriate port 28 via a corresponding passageway 48 in a body 40 to a bore 42 which contains a piston 41 which in turn acts on the associated spring loaded plunger 51 of the injector unit 50, the number of injectors depending on the number of engine cylinder units 1 employed e.g. three in the case of the distributor unit 20 shown in FIGURES 3 to 5. As the valve member 22 rotates, fluid is able to exhaust from the passageway 48 and corresponding port 28 to the low pressure section or pocket LP of the valve member 22 and from thence to the reservoir via the radial passageway 29.

The extent of axial movement of each injector piston or plunger 51 can be limited or pre-set by axial adjustment of a spring loaded stop member 52 i.e. by means of a cam 53 acting on the outer end of a piston 54 connected to or

integral with the stop member 52. Thus by reducing the stroke of the plunger 51 the amount of fluid injected per stroke is reduced, the stroke of the actuating piston 41 being self-accommodating to the stroke of the plunger 51.

The body or block 40 carrying the injector unit 50 is angularly adjustable relative to the body of the distributor 20 for obtaining appropriate timing of fuel injection. Angular adjustment of the block 40 for such timing purposes may be automatically effected such as by controlled operation from the rack pinion 34 or by electronic means.

The output manifolds 8 are shown communicated with a vessel or an accumulator 60 for storing hydraulic fluid under pressure in not only catering for variation in demand for the fluid under pressure and thus maintaining proper operation of the engine, but also providing a supply of such fluid for starting purposes.

For initial starting a hydraulic pump or the hydraulic motor 12 operating as a pump may be driven by an electric motor to build up sufficient pressure in the output manifolds 8 for obtaining effective compression stroke operation of the engine pistons 2. For this purpose the engine pistons 2 should be first thrust apart e.g. by admission of air under pressure into each cylinder 3 between the pistons 2 therein. Resulting displacement of hydraulic fluid towards the output manifolds 8 may be temporarily accommodated in a reservoir arranged for communication with the manifolds 8 or directly with the hydraulic cylinders 6.

A generator or alternator 70 may be driven from the hydraulic motor 12 and also a fan or blower 80 for obtaining cooling of the cylinder units 1, the blower 80 operating in conjunction with an air cooling outlet indicated at 81.

Referring to the diagrammatic layout of FIGURE 6 in which corresponding reference numerals are employed, a modified arrangement is shown whereby the number of non-return valves is reduced per cylinder unit 1.

The hydraulic cylinders 6 are connected via a single non-return valve 7 to the fluid pressure output 8, the accumulator 60 communicating with the output 8.

The distributor valve 20 is generally of similar construction and operation to that already described with reference to FIGURES 4 to 5 and likewise the metering means 30.

A supply of fluid under pressure from the output 8 is admitted at 210 into the high pressure section of the distributor 20, output from the port A or B of the latter being directed to an appropriate end of the bore 32 of the metering means 30 and containing the piston 31. Hydraulic fluid returned by the action of the piston 31 to the distributor 20 is passed via the latter to the outlet 25 and from thence via pipework 26 containing a single non-return valve 16 in order to effect

return operation of the pistons 5 in the hydraulic cylinders 6 for compression stroke operation of the engine pistons 2. In addition to admission of fluid into the cylinders 6 in this way fluid is also drawn into the cylinders 6 from a fluid input 18 via a single non-return valve 17, the fluid input 18 communicating with a fluid supply reservoir. Communication of the low pressure section of the distributor valve 20 with the fluid input 18 is indicated at 29. Such fluid flow from the input 18 to the cylinders 6 may be assisted by a continuously operating pump incorporating a relief valve and driven for example by the same motor drive 12 to the distributor 20.

The plunger 51 of the fuel injector unit 50 may be operated by the distributor valve 20 in the manner already described or operation of the plunger 51 may be triggered by piston movement of the engine either by a piston actuated switch controlling a solenoid operating the plunger 51 or by a hydraulic switch similarly actuated in a fluid pressure supply arranged to effect operation of the plunger 51.

Fuel supply to a cylinder 55 containing the fuel injection plunger 51 is indicated at 56 and includes a non-return valve 57.

Referring to FIGURE 7 a development is shown incorporated in a further modified arrangement of FIGURE 6 for providing more direct hydraulic return operation of the pistons 5 in the cylinders 6 for compression stroke return of the engine pistons 2.

A generally similar but simplified distributor 200 having a driven rotary valve member 220 is arranged to supply fluid to a timing valve 90 and modified metering means 300.

In its pre-set condition a single acting metering piston 31 in the bore 32 of the metering means 300 is positioned at or near one end of the bore 32, viz: at the right hand end in the diagram and is continuously subject to fluid at working high pressure from the output 8. On high pressure fluid HP being passed from the distributor 200 to a piston 91 connected to the valve member 92 of the timing valve 90, the valve member 92 is lifted. As a result the action of the working high fluid pressure on the piston 31 is such as to move it rapidly to the left and thus expel fluid at high pressure from the bore 32 and past the lifted valve member 92 directly to the cylinders 6 via the pipework 26 or other suitable passage-way means. During this operation a by-pass 37 to the metering means 300 is maintained at low pressure LP from the distributor 200, i.e. up to the non-return valve 39 in order to ensure that high pressure fluid does not py-pass the metering means 300 at this stage.

On admission of fluid in this way to the cylinders 6 further fluid is drawn into the cylinders from the fluid input 18 via

the non-return valve 17 and pipework 26. Here again such fluid flow may be pump assisted.

After passage of the metered supply of high pressure fluid from the metering means 300 to the cylinders 6 continued operation of the distributor 200 communicates fluid supply to the piston 91 to the low pressure input 18 so that the valve member 92 is able to seat under the action of spring pressure at 93 and also under the action of high fluid pressure from the output 8 acting on an intermediate piston 94. The space between the pistons 91 and 94 is vented to atmosphere at 95.

Also immediately after such return operation of the pistons 5 in the cylinders 6 the distributor 200 operates to admit fluid at working pressure HP from the output 8 to both ends of the bore 32 of the metering means 300 via the by-pass pipe 37 in order to equalize pressure on the piston 31 and enable it to be returned to its initial position,(i.e. to the right hand end) in the bore 32 by the spring 38 ready for further operation on opening of the timing valve 90 again. During this operation the non-return valve 39 in the by-pass 37 prevents fluid expelled from the bore 32 on operative movement of the piston 31, being returned to the distributor 200. As before the extent of movement of the piston 31 should be adjustable by stop screw or other means.

It will be noted in this arrangement that the pipework 26 or similar passageway means serves not only to supply fluid under pressure to the cylinders 6 for compression return

movement of the pistons 5 and 2 but also to pass fluid from the cylinders 6 to the working fluid pressure output 8 on power stroke operation of the pistons 2 and 5.

Also in this arrangement a single distributor 200 can be employed for directing return of output fluid under pressure in turn to the cylinders 6 of each cylinder unit 1. However a metering unit 300 and timing valve 90 would be provided one to each cylinder unit 1.

Any suitable driven distributor valve 200 may be employed and may be electrically driven including electrical operation of its valve member or members.

As will be appreciated from the foregoing and in each of the engine arrangements described only sufficient fluid is taken from the fluid pressure power output at 8 to provide an impetus for compression stroke operation of the engine pistons 2. Thereafter fluid at relatively low pressure from the input 18 is able to enter the fluid receiving cylinders 6 to ensure that they are substantially fully charged with fluid ready for power stroke expulsion therefrom for fluid pressure power output use. Thus only a minimum of fluid pressure energy is taken from the power output for effecting compression stroke operation of the engine so that efficient operation of the engine is maintained.

CLAIMS

1. An internal combustion engine arrangement of the reciprocating piston type characterised by the or each piston (2) of the engine being connected to a corresponding piston (5) of a cylinder (6) for receiving fluid from a source of supply of the latter whereby on a power stroke of the engine piston (2), the piston (5) connected thereto is operated to expel fluid under pressure from its associated cylinder (6) for power output use (at 8), driven valve means (20,200) and metering means (30,300) being provided for receiving and directing only a necessary amount of said output fluid under pressure back to the cylinder (6) and sufficient to effect fluid pressure operated return of the connected pistons (2,5) for a compression stroke of the or each engine piston (2).

2. An internal combustion engine arrangement according to claim 1 wherein at least one pair of engine pistons (2) are provided each connected to a corresponding piston (5) in respective cylinders (6) for receiving fluid, the engine pistons (2) having their heads opposed to one another in a common cylinder (3).

3. An internal combustion engine arrangement according to claim 1 or 2 wherein an engine piston (2) and cylinder (3) or a pair of opposed engine pistons (2) and common cylinder (3) and a corresponding piston or pistons (5) connected thereto of a said cylinder or cylinders (6) for receiving fluid constitute a unit (1) of two or more such units (1) of which output of fluid under pressure therefrom is received by at least one common output member or manifold (8).

4. An internal combustion engine arrangement according to claim 1, 2 or 3 wherein the driven valve means (20,200) includes a chamber (21) for receiving some of the output of fluid under pressure and contains at least one rotary valve member (22) arranged to be driven for directing fluid under pressure to the metering means (30,300) for return therefrom to a said fluid receiving cylinder or cylinders (6).

5. An internal combustion engine arrangement according to claim 1 wherein the metering means (30,300) comprises at least one piston (31) operating in a bore (32) for receiving a said necessary amount of said output fluid under pressure from the driven valve means (20,200), operation of said piston (31) expelling said necessary amount of output fluid under pressure from the bore (32) for return to the fluid receiving cylinder or cylinders (6) for effecting corresponding compression stroke operation of the pistons (2, 5).

6. An internal combustion engine arrangement according to claim 5 wherein the extent of operation of the piston (31) in the bore (32) is adjustable for varying the said necessary amount of output fluid under pressure received by the bore (32) and expelled therefrom for return to the fluid receiving cylinder or cylinders (6).

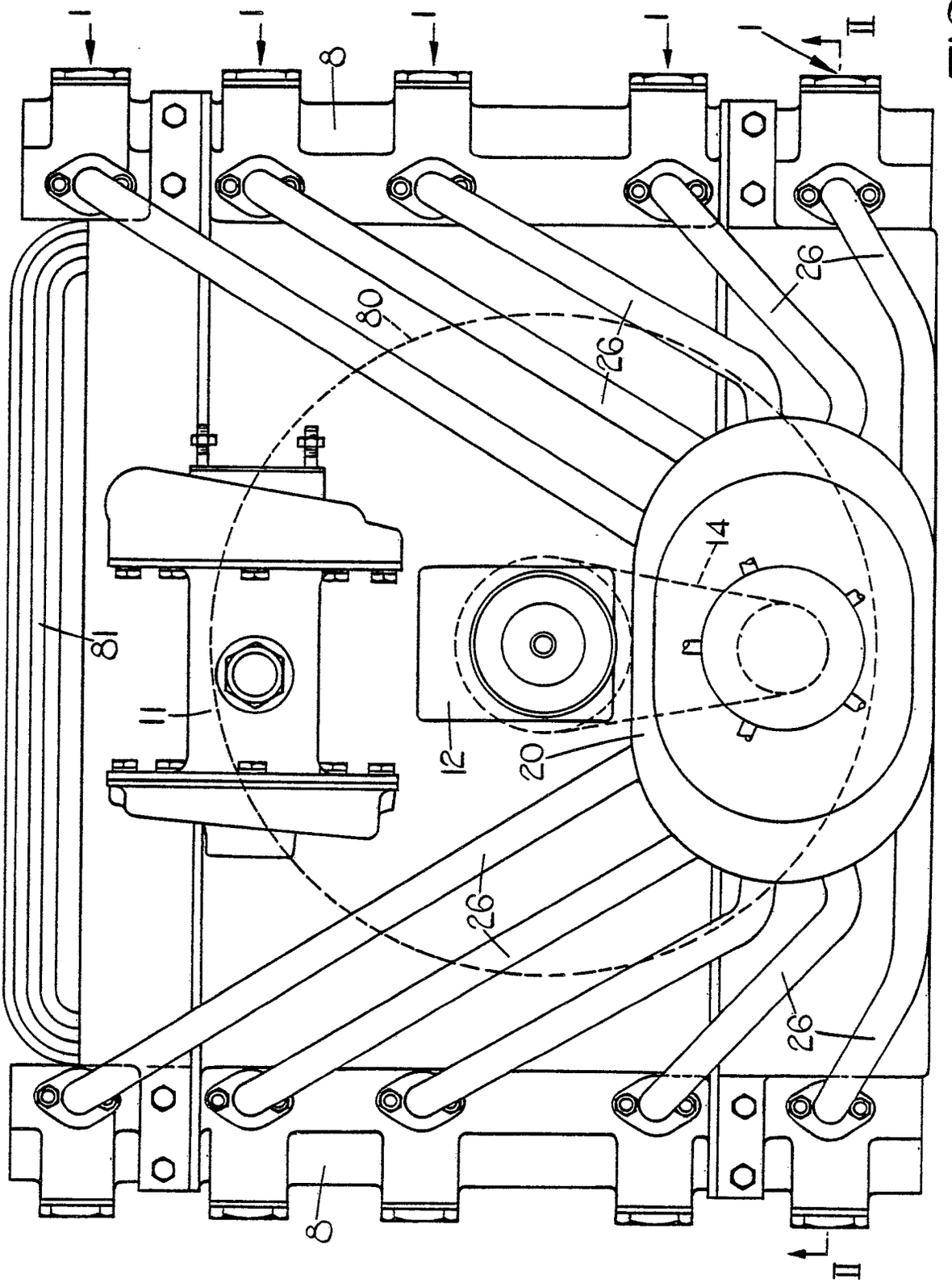
7. An internal combustion engine arrangement according to claims 1 and 3 wherein the driven valve means (20,200) is arranged to effect distribution of returned output fluid under pressure to a said fluid receiving cylinder or cylinders (6) of two or more units (1) of the engine.

8. An internal combustion engine arrangement according to claim 1 wherein the fluid receiving cylinder or cylinders (6) is or are arranged to be communicated with relatively low pressure fluid supply (18), i.e. after said return of output fluid under pressure to the cylinder or cylinders (6) for corresponding compression stroke operation of the pistons (2, 5).

9. An internal combustion engine arrangement according to claim 1 wherein a timing valve (90) is provided arranged to be operated for releasing fluid under pressure from the metering means (300) for passage therefrom to the fluid receiving cylinder or cylinders (6) in effecting compression stroke operation of the pistons (2, 5).

10. An internal combustion engine arrangement according to claim 9 wherein the timing valve (90) is arranged for fluid pressure operation by the driven valve means (200).

FIG.1.



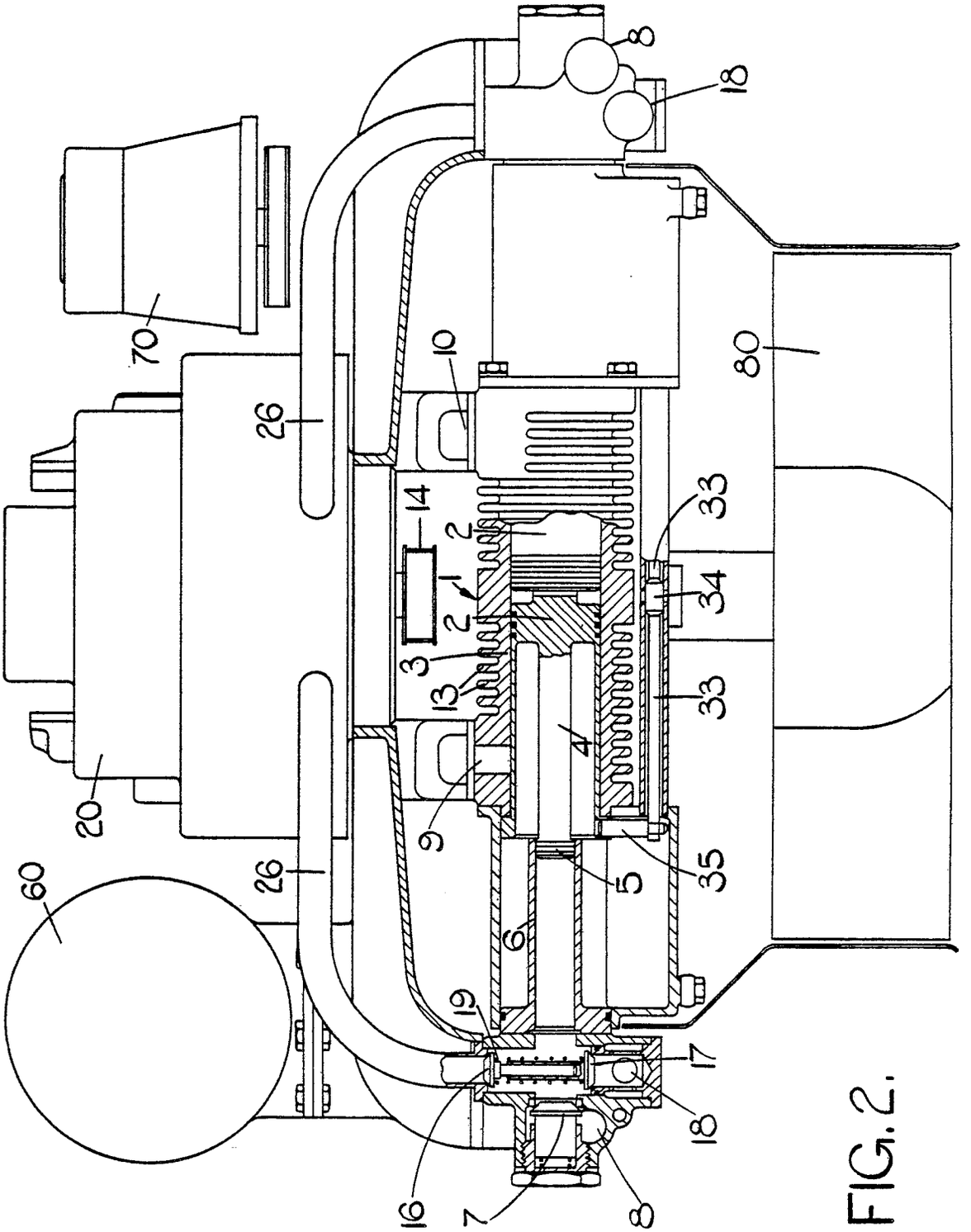


FIG. 2.

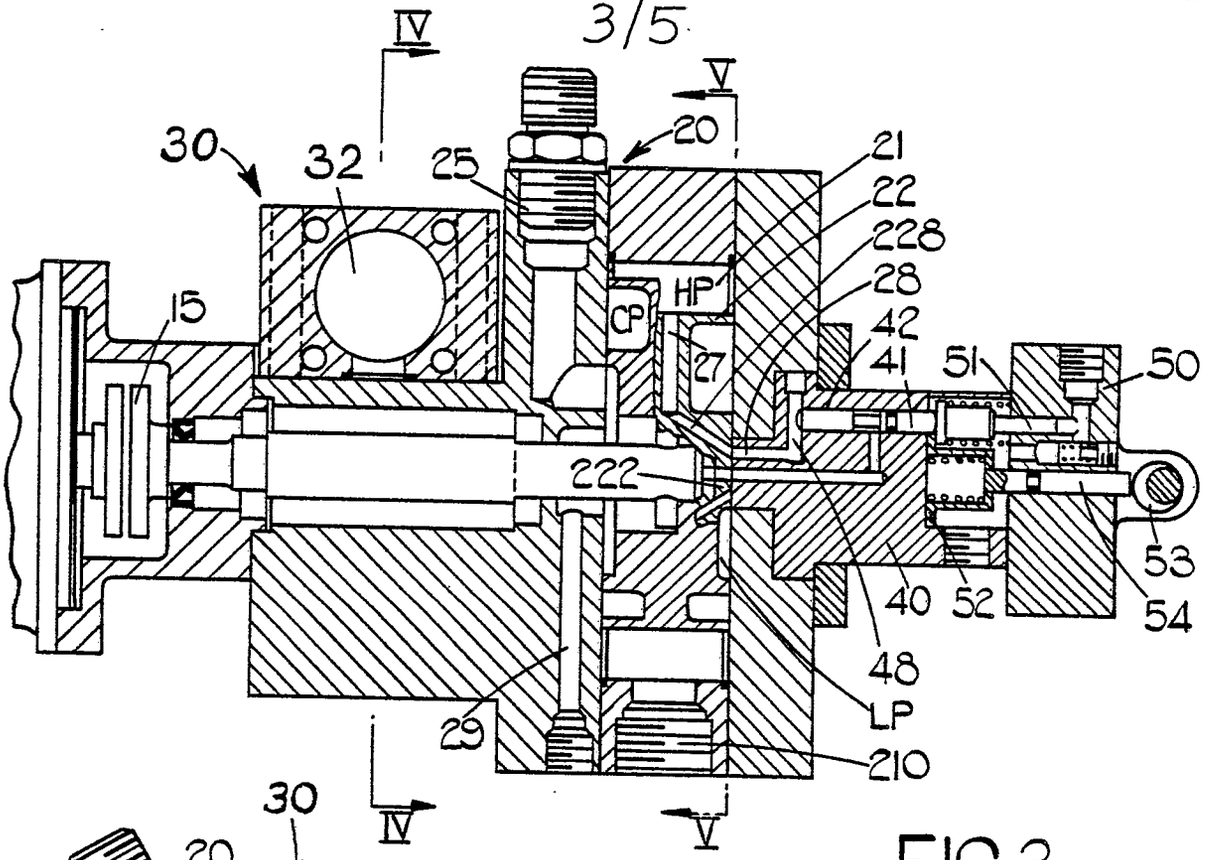


FIG.3.

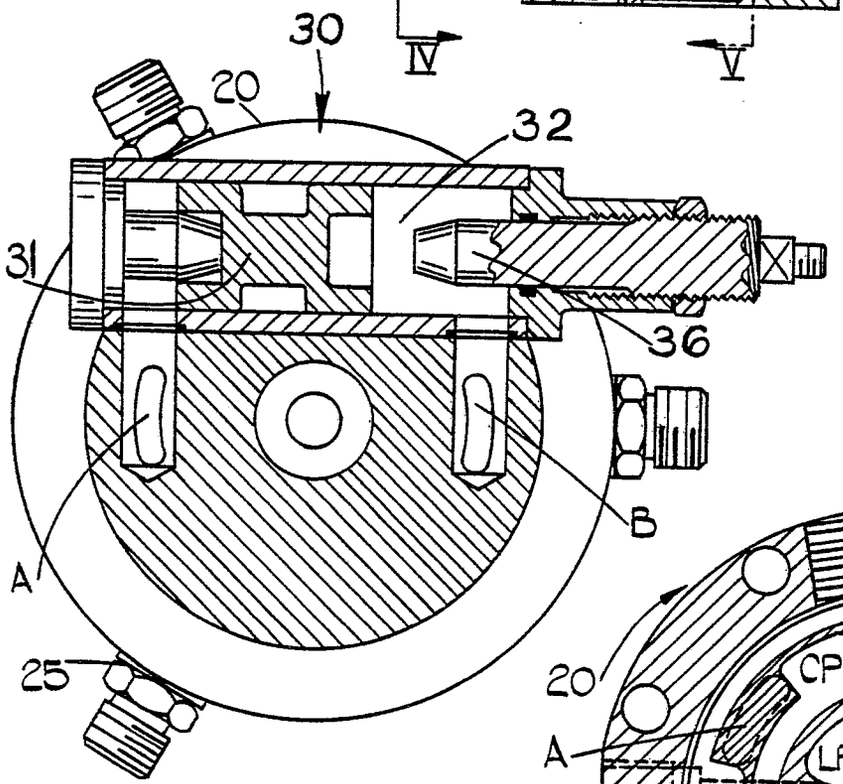


FIG.4.

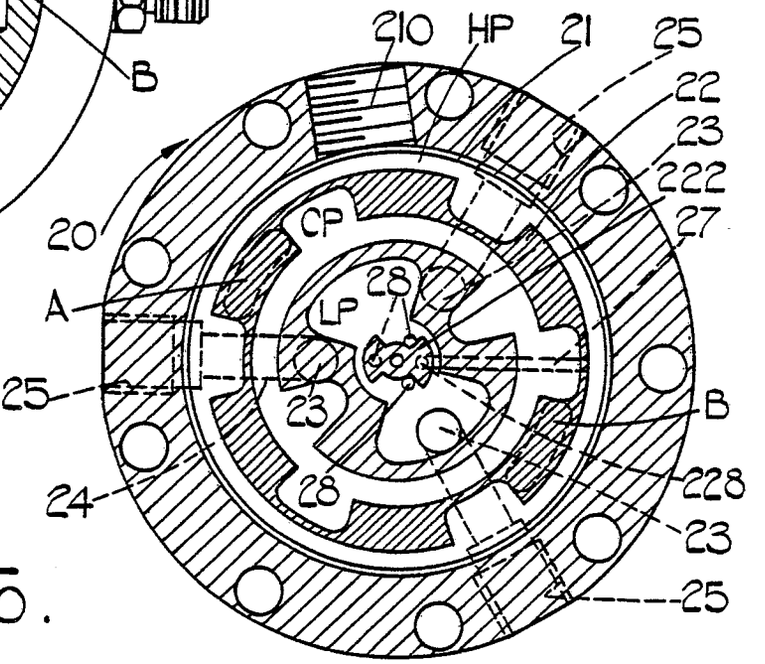


FIG.5.

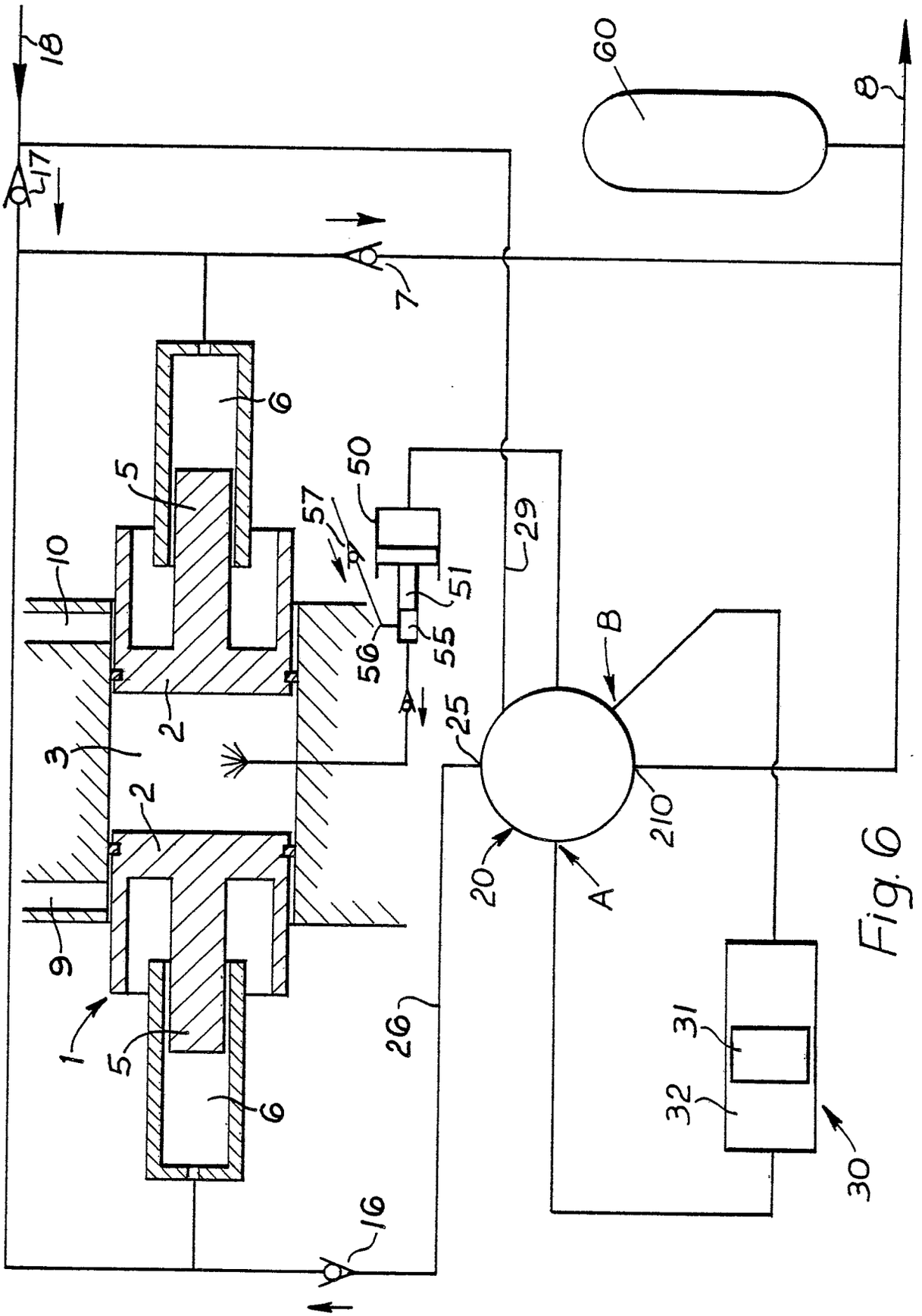

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Fig. 6

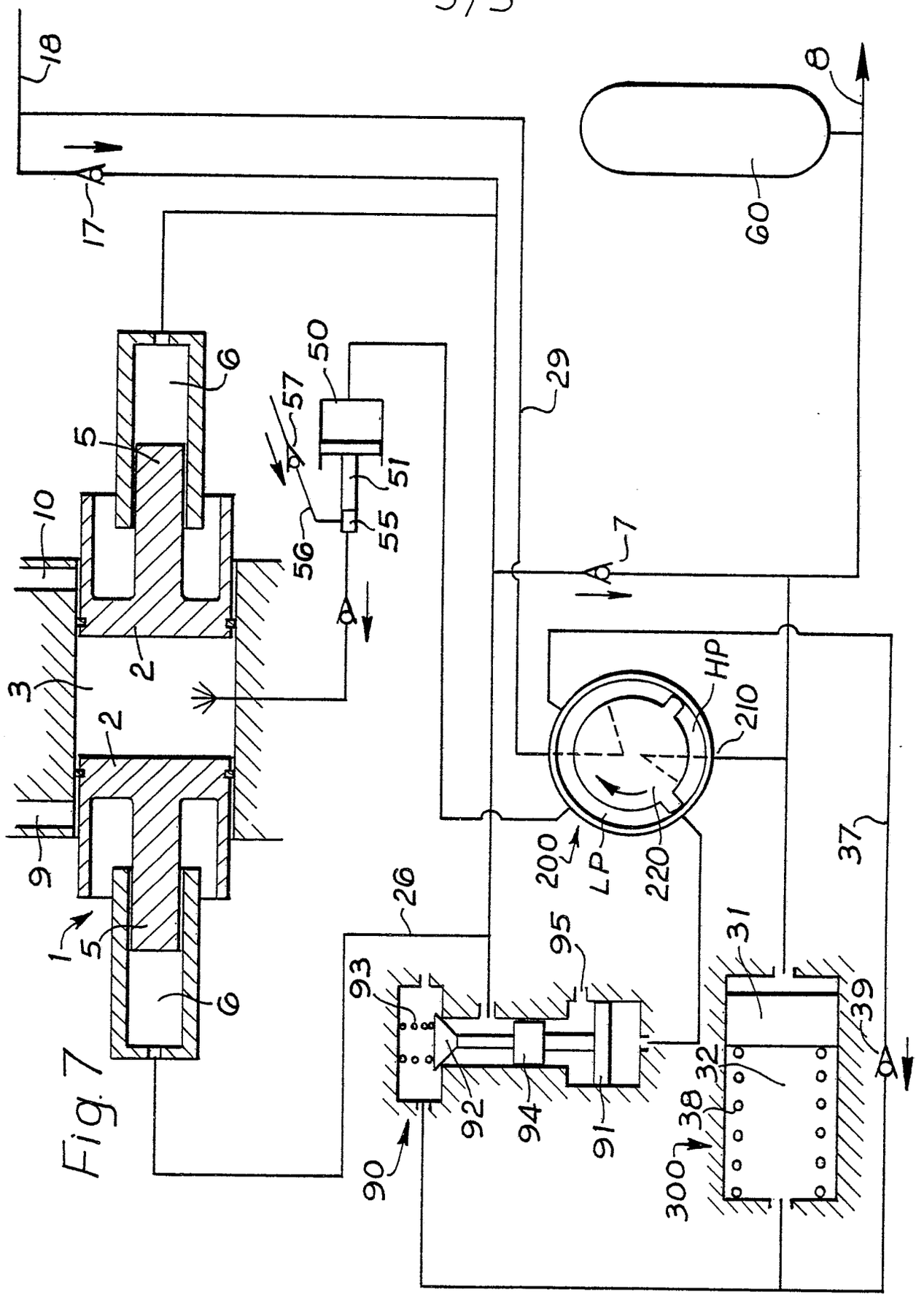
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Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

0057300
Application number

EP 81 30 0343.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - C - 909 402 (G. MICHEL) * claim 1; page 1, lines 11 to 20; page 2, lines 38 to 75; fig. *	1-3
	US - A - 2 541 464 (R.H. DAVIES) * claims 1 to 3; column 1, lines 1 to 60; column 2, lines 28 to 62; column 3, lines 1 to 49; fig. *	1,4-6
	US - A - 3 024 591 (A.J. EHRAT et al.) * claims 1 to 3; column 1, lines 25 to 36 and 62 to 72; column 2, lines 1, 2; fig. *	1,2, 8
	US - A - 2 978 986 (F.B. CARDER et al.) * column 1, lines 15 to 40 and 44 to 70; fig. 1, 3, 4, 5 *	1,2
	US - A - 2 849 995 (F.M. LEWIS) * whole document *	1-4

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CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

F 02 B 71/00

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

F 01 B 7/00
F 01 B 11/00
F 02 B 71/00
F 04 B 17/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
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E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	11-09-1981	CANNICI

EPO Form 1503.1 06.78

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	US - A - 2 583 115 (W.A. MORAIN) * whole document * --		
A	US - A - 3 119 230 (H. KOSOFF) * whole document * ----		TECHNICAL FIELDS SEARCHED (Int. Cl.³)