July 9, 1968 G. ORLOFF ET AL 3,391,538

HYDRAULIC INTENSIFIERS

Filed Jan. 25, 1967 4 Sheets-Sheet 1

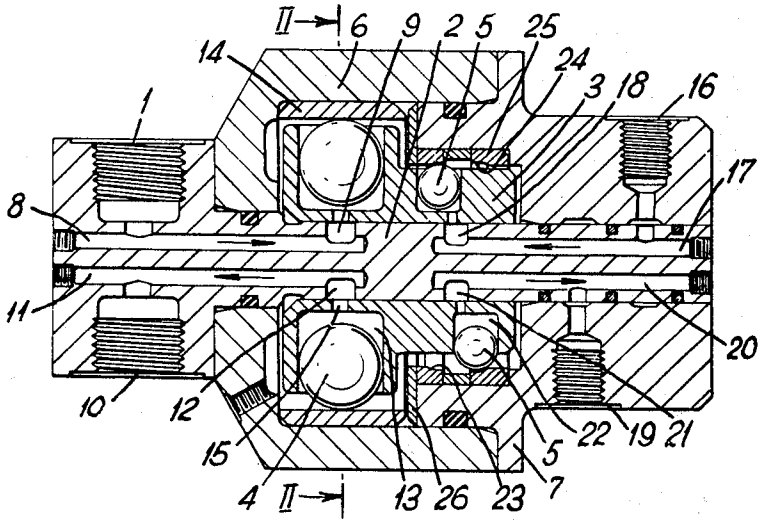


FIG. 1.

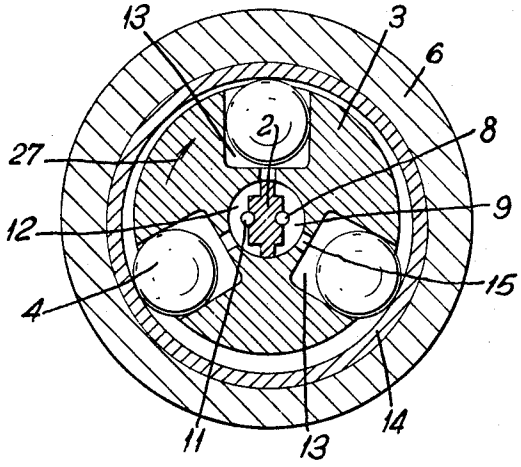


FIG. 2.

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HYDRAULIC INTENSIFIERS

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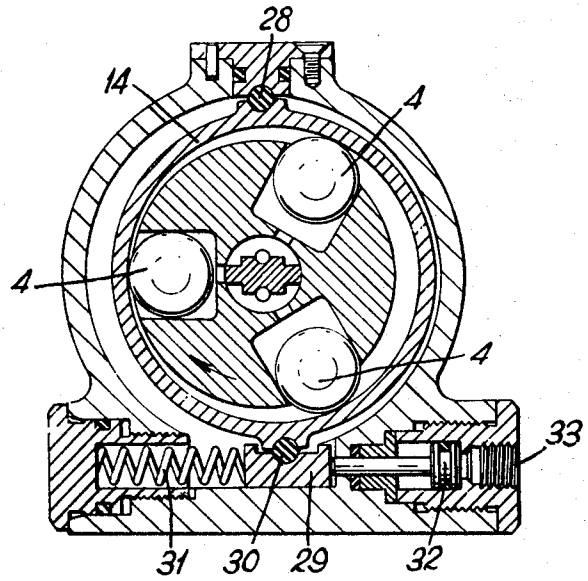


FIG. 3.

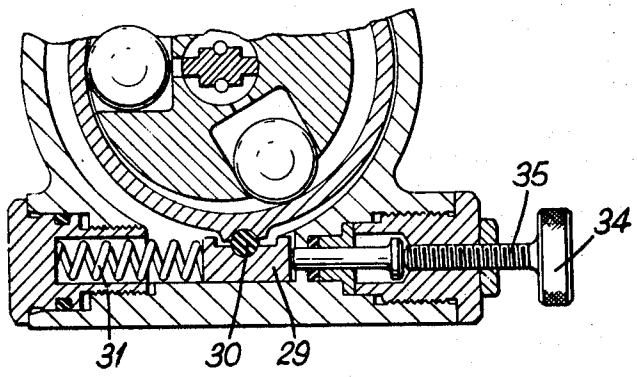


FIG. 4.

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HYDRAULIC INTENSIFIERS

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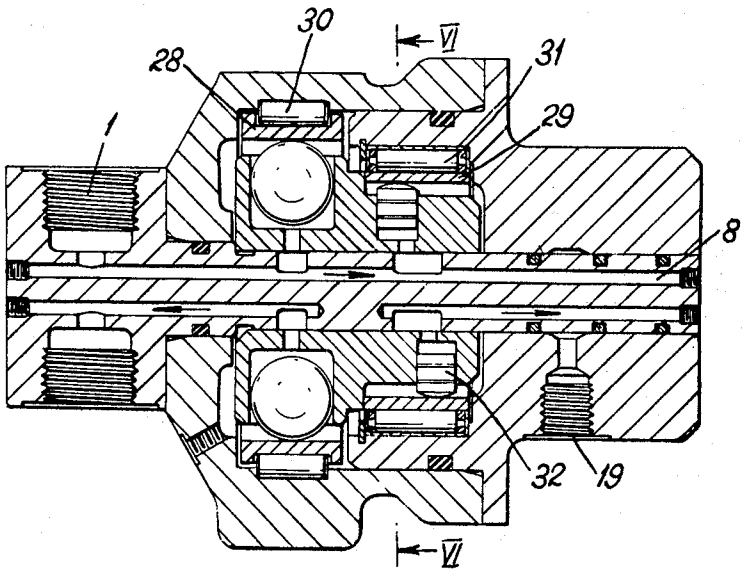


Fig 5

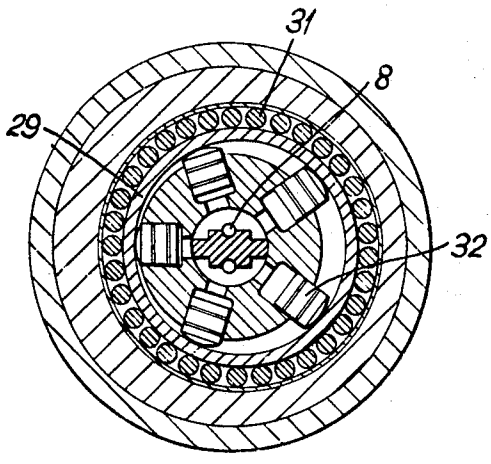


Fig 6.

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Filed Jan. 25, 1967 4 Sheets-Sheet 4

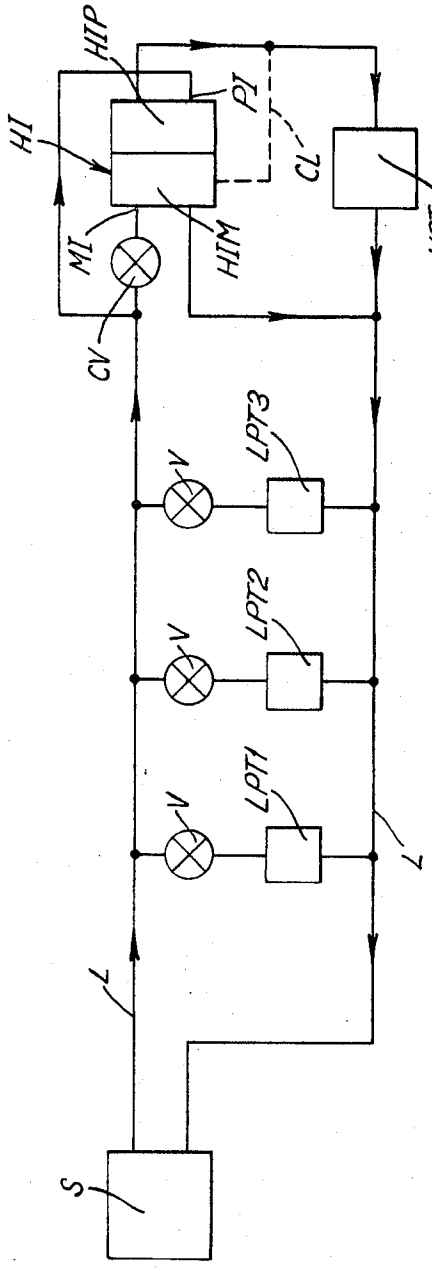


Fig. 7.

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United States Patent Office 3,391,538 Patented July 9, 1968

3,391,538

HYDRAULIC INTENSIFIERS

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Claims priority, application Great Britain, Feb. 3, 1966, 4,844/66
13 Claims. (Cl. 60—53)

ABSTRACT OF THE DISCLOSURE

A hydraulic intensifier has a pump rotor connected to and coaxial with a motor rotor, both rotors having radial cylinders containing free acting pistons which bear against eccentric cylindrical housings. The pump pistons are arranged in two planes transverse to the rotor axis, and the pump and motor may have a common fluid inlet so that high pressure fluid drives the motor and the pump emits fluid from the same source at an intensified pressure.

This invention concerns improvements relating to fluid intensifiers and discloses a rotary fluid motor and fluid pump assembled on the same shaft. The motor and pump are multicylindrical with free acting ball or cylindrical pistons. Both sets of pistons operate against eccentrically mounted rings and by varying the eccentricity of the motor ring the output pressure from the pump can be varied. The fluid inlets of the motor and the pump can be interconnected.

United States patent application Ser. No. 492,433, filed Oct. 4, 1965, now Patent No. 3,361,038, issued Jan. 2, 1968, relates to this application.

Fluid systems, whether hydraulic or pneumatic, are usually provided with an automatic device which prevents the pressure from exceeding a predetermined value. This device can take the form of a relief valve, an automatic cutout, or comprise a sensing mechanism, which can be built into a pump or compressor and which reduces its swept volume to zero when the predetermined value is reached. However, it may be required to raise the pressure in one part of the system to a value exceeding that determined by the off-loading device.

Such boosting of fluid pressure is commonly carried out by an intensifier which usually consists of a back-to-back rectilinear piston-cylinder device, this relying upon the ratio of the two piston areas for intensifying the normal system pressure to the value required in the local circuit. Commonly intensifiers are of the fixed displacement type in which the displacement volume in the high pressure side of the system is equal to or less than the displacement in the system itself. Sometimes several intensifiers are "ganged" in a similar manner to that used with beam engines during the last century and results in cumbersome and expensive hardware.

It is an object of the present invention to provide an improved form of intensifier to convert a high rate of flow at low pressure into a low rate of flow at high pressure, capable of being embodied in a miniature and economic converter which can be used, for example, for machine tools requiring high pressure operated auto-frettage chucks thus obviating an additional high pressure electrically driven pump and enabling low pressure control valves to be used in paralleled circuits.

According to the present invention there is provided a fluid intensifier in which a rotary fluid motor is couped to a rotary fluid pump; the motor comprising a motor rotor, a set of radially disposed motor cylinders contained therein, a free acting motor piston contained in each motor cylinder, an eccentrically disposed motor sleeve

surrounding said motor rotor, a fluid inlet and a fluid outlet; the pump comprising a pump rotor coaxial with and fixed to said motor rotor, a set of radially disposed pump cylinders contained therein, a free acting pump piston in each pump cylinder, an eccentrically disposed pump sleeve surrounding said pump rotor, a fluid inlet and a fluid outlet.

The use of such an intensifier in a fluid system requiring different operating pressures in different parts of the system is of particular advantage, as the intensifier can be placed in or close to that part of the system in which the higher pressure is required, thus reducing the total length of high-pressure hydraulic lines, without necessitating the provision of additional supplies (e.g. of electricity).

According to a further aspect of the invention, therefore, there is provided a fluid system comprising a source of hydraulic fluid at relatively low pressure, fluid lines connecting said source to one or more transducers operable by hydraulic fluid at said relatively low pressure, and at least one further transducer operable by hydraulic fluid at a higher pressure, in which a hydraulic intensifier as set forth above is associated with the further transducer, the motor of said intensifier being connected to said fluid lines and the pump of said intensifier being connected to the further transducer. In such a system, a control valve for the further transducer may be connected to the motor inlet, i.e. may operate at low pressure.

The motor and pump cylinders may be provided with a common fluid inlet.

Hydraulic intensifying apparatus according to the present invention will now be described by way of example with reference to the accompanying drawings, in which:

FIGURE 1 is a longitudinal section through an intensifier,

FIGURE 2 is a cross section on the line II—II of FIGURE 1,

FIGURE 3 is a variant on the embodiment shown in FIGURES 1 and 2,

FIGURE 4 is a further variant,

FIGURE 5 is the same view as FIGURE 1 of a still further embodiment,

FIGURE 6 is a cross section on the line VI—VI of FIGURE 5, and

FIGURE 7 is a diagram of a system embodying the invention.

In the following descriptive matter like numerals will refer to like parts. In FIGURES 1 and 2 there is shown a continuous flow intensifier in which the pump section operates on principles similar to those disclosed in United States patent application Ser. No. 492,433. Other principles such as those utilizing swash plates, etc., could be used but obviously an embodiment incorporating such would have a somewhat different configuration.

Low pressure fluid is admitted to a connector **1** which is part of a pintle **2**. Coaxial with the pintle is a rotor **3** in which are housed spherical motor pistons **4** and two offset rows of pump spherical pistons **5**. Also attached to the pintle **2** are two body members **6** and **7**. An inlet port **8** joins the connector **1** to a inlet segment **9** which extends somewhat less than 180° around the pintle **2**. It should be noted that in FIGURE 2 the pintle section **2** is shown as if it had been rotated through 90° from the position shown in FIGURE 1. Fluid is returned to tank through a low pressure connector **10** via a port **11**, which opens out into a second segment **12**. The motor pistons **4**, which in this case are balls, operate within radially disposed cylinders **13** and bear against a cylindrical surface or sleeve **14**. Each cylinder is provided with an opening **15** which is communicatable with the segments **9** and **12**.

The pump parts are housed within the body member **7**. An inlet connector **16** admits fluid via a port **17** to a

segment 18. Fluid under intensified pressure is pumped from the apparatus from outlet connector 19 which communicates via a port 20 with a complementary segment 21. The spherical pistons 5 operate within cylinders 22 and bear against working surfaces 23 and 24 of an eccentrically mounted surface or sleeve 25, the working surfaces 23 and 24 being disposed for angular contact with the pistons 5 which, as disclosed in the aforementioned patent application Ser. No. 492,433, are arranged in two spaced planes normal to the axis of the pintle 2 and of the rotor 3. The pump and motor sections are separated by a packing complex 26.

When the connectors 1 and 10 are connected respectively to fluid of the system's pressure and to tank the pistons 4 are forced along their respective cylinders 13 so that the rotor 3 starts to rotate in the direction of arrow 27 in FIGURE 2. If the connector 16 is now put into communication with a fluid at low pressure either of the same system or of any other system rotation of the rotor 3 causes the pistons 5 moving within their cylinders 21 to pump this fluid to an increased pressure and to deliver it through the connector 19.

In FIGURE 3, which represents a section on the same line as that of FIGURE 2 but with the pintle in its position as shown in FIGURE 1, a modified embodiment is shown in which governing of the displacement of the motor portion of the apparatus has been included. The sleeve 14 is arranged to be of variable eccentricity, being pivotable about a pivot pin 28. The pivoting means is a block 29 which is connected to the sleeve 14 by a further pin 30. A spring 31 under compression which tends to move the block 29 to the right, as seen when viewing FIGURE 3, is partially counteracted by a leftward acting force from a piston 32 which communicates via a connector 33 with an external fluid pressure which may be the intensified fluid from the connector 19 suitably reduced through a reducing valve which is not shown. The resultant force is arranged to be rightward acting and this is balanced by a clockwise acting torque reaction from the pistons 4. Thus the speed of the motor portion and, therefore, the output pressure from the pump portion of the intensifier can be regulated by the control shown in FIGURE 3.

A simpler type of control is shown in FIGURE 4 where the resultant force from the spring 31 is regulated by a hand adjusting knob 34 at the end of a screw 35.

The arrangement shown in FIGURES 3 and 4 can be modified to utilize displacement servocontrol transfers, which may be manual or automatic, hydromechanical or electrohydraulic, and in the case of the FIGURE 3 embodiment, can be made such as to follow a predetermined programme.

In FIGURES 5 and 6 further modifications are shown. It is evident that if the same fluid is used in both the motor and pump portions of the intensifier the ports 8 and 17 of FIGURE 1 can be joined. This has been done in FIGURE 5 so that fluid at system pressure is admitted through the connector 1 and via the port 8 both to the motor portion and to the low pressure side of the pump portion.

A number of detailed constructions are possible. The one chosen in FIGURES 5 and 6 uses a straightforward ball piston eccentric motor and a radial eccentric piston pump running on cylindrical tracks 28 and 29 respectively. These tracks are themselves rotatable being separated from the body members 6 and 7 by needle bearings 30 and 31 respectively.

It is also to be noted that the pump pistons in this embodiment are no longer balls but cylindrical pistons 32. It is considered that this arrangement enables higher output pressures to be obtained since leakage between piston and cylinder walls is less than in the case of spherical pistons.

FIGURE 7 illustrates, in diagrammatic form, a hydraulic system embodying the invention. The system comprises a source S of hydraulic fluid at relatively low pressure; the source S may take any convenient form, e.g. an electric motor coupled to a pump, and may include any desired control devices for stabilising its output pressure to a desired degree. Fluid lines L provide flow and return paths, as indicated by arrows, between the source S and three hydraulic transducers operable at said relatively low pressure and identified by references LPT1, LPT2, LPT3.

The low-pressure transducers LPT1, LPT2, LPT3 may be of any form appropriate to the needs of the system, e.g. where the system is applied to a machine tool these transducers may include hydraulic motors coupled to lead screws and/or hydraulic rams for operating drive clutches. Each transducer may be connected to lines L via a control valve V.

A further transducer HPT is included in the system; this further transducer is however not suitable for operation by the relatively low pressure fluid supplied by source S, but requires a higher pressure supply. Accordingly, the transducer HPT is not directly connected to the fluid lines L but is connected to a hydraulic intensifier HI which may be of any of the forms hereinbefore described with reference to FIGURES 1–6. Said intensifier comprises a motor HIM and a pump HIP, and may if desired be arranged for control of the motor (by variation of the eccentricity of the motor sleeve) as described with reference to FIGURE 3, hence may include a control line CL connecting the pump output to the motor. The motor HIM is connected to the lines L, a valve CV being interposed for control of the transducer HPT. It will be seen that one of the lines L, carrying the flow from source S as indicated by arrows, and constituting the pressure side of the relatively low pressure supply, is connected both to the motor inlet MI and to the pump inlet PI, the connection to the motor inlet being via the control valve CV. Output from the pump is delivered to the transducer HPT and the latter also has a connection to the return path provided by the other of lines L. The control valve CV, although it need only be a low-pressure valve, serves to control the high-pressure transducer HPT.

The intensifier HI may conveniently be of the form described with reference to FIGURE 3, as indicated by dashed line CL denoting a control line by which fluid delivered by the pump HIP is made available to the motor for control of the eccentricity of its sleeve.

It will be appreciated that the use of the hydraulic intensifier HI enables a system such as that represented in FIGURE 7 to be produced with the minimum of complication due to the requirement of two different operating pressures. The high-pressure connection between the intensifier HI and transducer HPT may be made short by mounting these two elements of the system close together.

What we claim as our invention and desire to secure by Letters Patent is:

1. A fluid intensifier in which a rotary fluid motor is coupled to a rotary fluid pump; the motor comprising a motor rotor, a set of radially disposed motor cylinders contained therein, a free acting motor piston contained in each motor cylinder, an eccentrically disposed motor sleeve surrounding said motor rotor and operatively engaging each motor piston, a fluid inlet and a fluid outlet; the pump comprising a pump rotor coaxial with and fixed to said motor rotor, a set of radially disposed pump cylinders contained therein, a free acting pump piston in each pump cylinder, an eccentrically disposed pump sleeve surrounding said pump rotor and operatively engaging each pump piston, a fluid inlet and a fluid outlet.

2. A fluid intensifier as claimed in claim 1, wherein said pump cylinders are disposed in at least two different planes, said planes being transverse to the axis of said pump rotor.

3. A fluid intensifier as claimed in claim 2, wherein said pump sleeve is provided with at least two working surfaces, one to the cylinders of each plane.

4. A fluid intensifier as claimed in claim 1 further comprising means for varying the eccentricity of said motor sleeve.

5. A fluid intensifier as claimed in claim 4, wherein said means for varying the eccentricity of said motor sleeve permits said motor sleeve to be pivoted about an axis eccentric both to said motor rotor axis and to its own axis.

6. A fluid intensifier as claimed in claim 4, wherein said means for varying the eccentricity of said motor sleeve is manually operable.

7. A fluid intensifier as claimed in claim 4, further comprising means for operating said means for varying the eccentricity of said motor sleeve in response to the output fluid pressure from said pump.

8. A fluid intensifier as claimed in claim 1, wherein said pistons are spherical.

9. A fluid intensifier as claimed in claim 1, wherein said pistons are cylindrical.

10. A fluid intensifier as claimed in claim 1 including a body wherein said motor and pump sleeves are rotatably carried by roller bearings.

11. A fluid intensifier as claimed in claim 1 wherein said motor and pump fluid inlets are connected.

12. A fluid system comprising a source of hydraulic fluid at relatively low pressure, fluid lines connecting said source to at least one transducer operable by hydraulic fluid at said relatively low pressure, and at least one further transducer operable by hydraulic fluid at a higher pressure, in which a hydraulic intensifier as claimed in claim 1 is associated with the further transducer, the motor of said intensifier being connected to said fluid lines and the pump of said intensifier being connected to the further transducer.

13. A system as claimed in claim 12, including a control valve connected to said motor inlet.

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