May 1, 1962 J. W. LUDWIG 3,031,845

HYDRAULIC SYSTEM

Filed Oct. 9, 1959 2 Sheets-Sheet 1

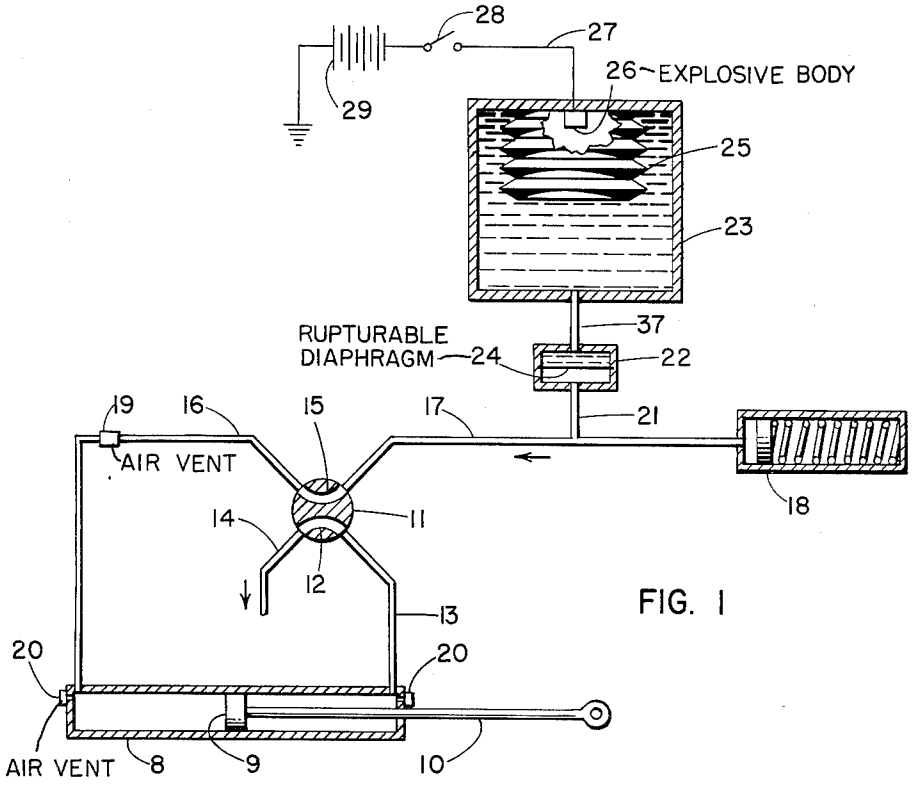



FIG. 1

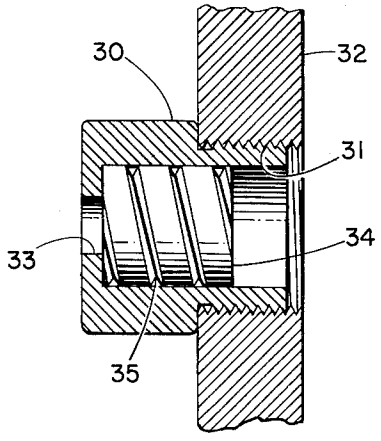



FIG. 2

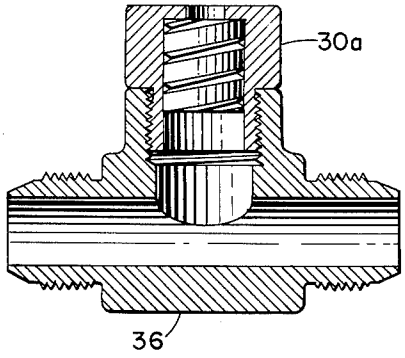



FIG. 3

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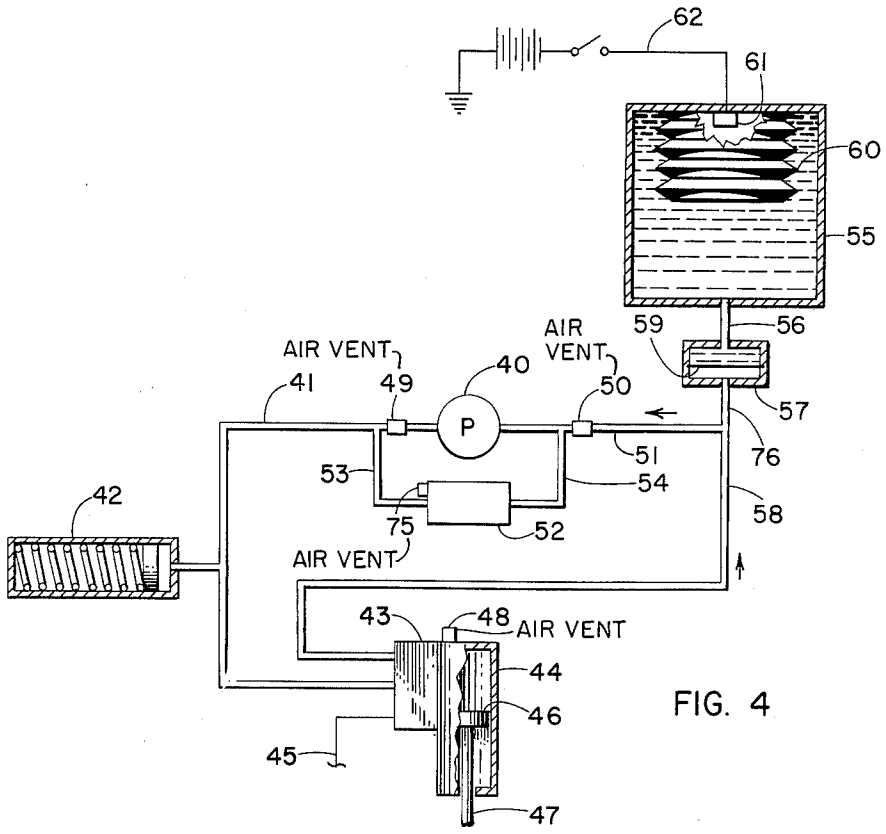



FIG. 4

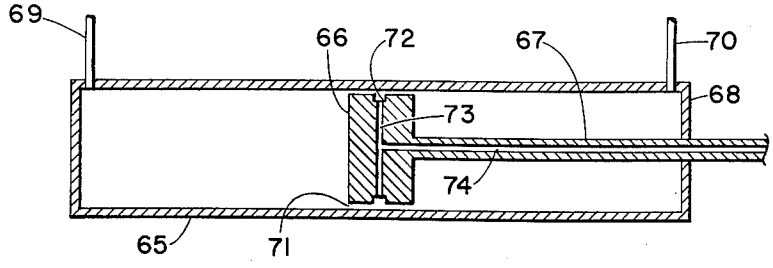



FIG. 5

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# HYDRAULIC SYSTEM

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6 Claims. (Cl. 60—51)

This invention relates to hydraulic powering systems and, more particularly, to means for supplying hydraulic fluid thereto immediately prior to use thereof.

Where a hydraulic system must be stored, ready for use, over long periods of time, as, for instance, in the case of a missile control system, certain annoying and serious problems arise. If the system is stored "wet" (that is, with hydraulic fluid filling its components), efficient sealing means must be employed in the system, such as packings, O-rings, and the like, to prevent leakage. Even with the best of such seals, system leakage of at least a few drops daily, ordinarily, is unavoidable, so that when the device containing the hydraulic system is to be stored, say for a number of years, this leakage is intolerable.

In addition, the system tends to be relatively shortlived when stored "wet"; for example, recurrent changes in temperature soon cause a "set" and aging of the packings and seals in the system. Consequently, when a hydraulically controlled device, such as a missile, has been stored over a long period, the control system is likely to be found to have lost most of its fluid by leakage and to have packings and seals which no longer are serviceable. On the other hand, "dry" storage of the hydraulic system demands that the system be filled with fluid prior to functioning thereof, as in launching and navigation of the missile, and conventional filling and bleeding techniques now employed for this purpose require the use of manpower and entail a serious loss of time.

Accordingly, an object of the present invention is to provide means to charge a hydraulic powering system with hydraulic fluid, for instance, preparatory to functioning of the hydraulically controlled device or apparatus.

Another object is to provide means for charging the hydraulic powering system with pressure transmitting fluid incident to or in coordination with the functioning or preparation for functioning of the hydraulically controlled device or apparatus.

Another object is to provide novel means for venting air or gases trapped in the hydraulic system, upon charging the system with hydraulic fluid, while preventing excessive escape of the hydraulic fluid therethrough.

Still another object is to provide a novel vent for the hydraulic system which is incorporated in the motor portion of the system.

Other objects and advantages will be apparent from the specification and claims and from the accompanying drawing illustrating embodiments of the invention.

In accordance with the present invention, the hydraulic fluid for the hydraulic powering system is normally stored in a reservoir which is segregated from the system by a rupturable seal. An explosive is mounted within the reservoir, preferably within an expansible, sealing envelope, and means are provided for igniting the explosive when it is desired to render the hydraulic system operational. The explosively generated gases increase the fluid pressure in the reservoir and break the seal, thereby causing transfer of the hydraulic fluid to the hydraulic system. The explosive may generate the pressure required to operate the particular hydraulically

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controlled device or devices or instead may provide only a reservoir pressure sufficient to prime a hydraulic pump in the system. In either case, the explosive is regarded as supplying hydraulic fluid to the system under operational pressure. At various places in the system, air vents are provided, these either being individual devices or formed as by-passes around or through the working piston in a hydraulic motor embodied in the system. The vent orifices are so restricted as to rapidly vent air compressed in the system by the admission of hydraulic fluid thereto while substantially impeding the escape of hydraulic fluid therethrough.

In the drawing:

FIG. 1 is a schematic representation of the hydraulic powering system, as for control of a missile, including the invention;

FIG. 2 is a sectional view showing one form of air vent incorporated in the system;

FIG. 3 is a similar view of a slightly different type of air vent;

FIG. 4 is a schematic representation of a different type of hydraulic system incorporating the invention; and

FIG. 5 is a sectional view of a hydraulic motor incorporating a further modified air vent.

The hydraulic system of FIG. 1 includes a cylinder 8 with a piston 9 working therein and attached to a piston rod or stem 10 which carries control forces from the hydraulic system to the controlled unit. Control valve 11, actuated in any desired manner, has a first channel 12 connected through passage 13 with one end of motor cylinder 8 and with an exhaust passage 14 which, in the case of a missile wherein the control system need be operational for only a few minutes, may discharge outside the vehicle. The valve has a second channel 15 connected by piping 16 to the opposite end of motor cylinder 8 and by piping 17 to an accumulator cylinder 18. Incorporated in piping 16 is an air vent device 19, which may be of the type shown in FIG. 3. Attached to the opposite ends of motor cylinder 8 are air vent devices 20, which may be of the type shown in FIG. 2.

Branching from piping 17 is piping 21 which extends into one side of casing 22. From the other side of casing 22, piping 37 extends to reservoir 23. Traversing casing 22 and normally sealing the reservoir from the hydraulic system is a rupturable sealing diaphragm 24 made, for example, of a frangible material. A bellows 25, or other expansible sealing envelope, has its open upper extremity sealingly secured to the upper wall of reservoir 23, the remainder of the envelope being sealed. Mounted on the reservoir wall within envelope 25 is an explosive body 26 provided with suitable ignition means. Ignition wiring 27 extends from the explosive 26 through a control switch 28 to a source of electrical power, such as battery 29. The reservoir 23 normally contains the entire hydraulic supply for the system, and in this sense the piping 37 and the portion of the casing 22 above the diaphragm 24 serve as parts of the reservoir since they store a small quantity of the hydraulic fluid. In this sense, the piping 56 and casing 57 (FIG. 4) discussed in later paragraphs likewise serve as parts of the reservoir 55.

The vent device shown in FIG. 2 consists of a nipple 30 threadedly mounted in aperture 31 in wall 32 which, as stated, may be an end wall of cylinder 8. An aperture 33 in the opposite end of nipple 30 discharges to the atmosphere. Firmly lodged within the hollow interior of the nipple is a plug 34 having external spiral grooving 35 which forms, in effect, capillary vent passaging. This passaging which, alternatively, may be formed in the inner

wall of the nipple instead of in the plug, is designed as to cross sectional area and length to permit rapid venting of air from the system while substantially impeding the escape therethrough of hydraulic fluid, which is many times more viscous than air. Such impeded loss of hydraulic fluid will have no adverse effect upon the control system because it is so small as to be within acceptable rates of over-all fluid loss from the system. This especially is the case in a missile in which hydraulic operation is needed only in a short initial period of flight. In this connection, loss of fluid through the exhaust line 14, where the latter discharges overboard, of course will result eventually in depletion of the fluid supply of the system; but, before this occurs, the period of operation of the system will have ended and discharge of the fluid overboard will have rid the vehicle of the weight of the no longer needed hydraulic fluid.

The bleed in FIG. 3 is generally similar to that in FIG. 2 except that nipple 30*a* is mounted in one arm of the T-passage of a fitting whose two remaining arms are adapted for incorporation in a hydraulic line, for example in tubing 16.

In operation, the system is stored with reservoir 23 filled with a proper supply of hydraulic fluid, sealing diaphragm 24 being in position and imperofrate and control switch 28 being open. When it is desired to charge the system and/or place its fluid under pressure to render it operational, switch 28 will be closed, igniting explosive charge 26. The generated gases will cause expansion of envelope 25, thus sharply increasing the pressure within reservoir 23 and breaking sealing diaphragm 24. The hydraulic fluid thus placed under pressure then enters tubing 21 and 17 and accumulator 18, charging the latter. From tubing 17, the fluid passes through channel 15 of valve 11 and tubing 16 to the left end of hydraulic motor cylinder 8. This causes rightward propelling of piston 9 and the discharge of air from the right and left ends of the cylinder through vents 20 and through tubing 13, valve channel 12, and exhaust tubing 14. Should valve 11 be turned to reverse the control action, fluid from tubing 17 would flow through valve channel 12 and tubing 13 to the right end of cylinder 8 causing leftward propulsion of piston 9. Air remaining in the left hand end of the cylinder 8 will be released through the associated vent 20 and hydraulic fluid exhausted through tubing 16, valve channel 15, and exhaust tubing 14. The small loss of hydraulic fluid through vents 19 and 20 will be made up from accumulator 18 so that the system will remain under operating pressure for a substantial period of time.

The hydraulic system in FIG. 4 includes a pressure pump 40 connected by outlet tubing 41 to accumulator 42 and control valve device 43 preferably attached to the side of hydraulic motor cylinder 44. The control valve may be of the solenoid actuated type and is provided with a control wire 45. Working in cylinder 44 is a piston 46 having piston rod 47 for carrying hydraulic forces to the controlled unit. A slight clearance is provided between the piston and cylinder and also between the piston rod and the cylinder end wall for the escape of air from the cylinder 44, which in the example is a component of a hydraulic motor of the single-acting type. Alternatively or additionally, a separate air vent device is shown at 48, which device may be of the general type shown in FIG. 2. Other air vents are shown at 49 in tubing 41 and at 50 in tubing 51 connected to the inlet side of pump 40. A by-pass, pressure limiting device is shown at 52 connected around the pump by piping 53 and 54 and may utilize an air vent device 75 of the type shown in FIG. 2. While a single-acting hydraulic motor is shown in FIG. 4, it will be recognized that, where required, this may be replaced by a double-acting motor such as shown in FIG. 1 or FIG. 5.

A reservoir 55 is connected by piping 56, casing 57, and piping 76 to pump inlet line 51 and pressure return line 58 from control valve 43. A preferably frangible diaphragm 59 normally cuts off communication between the reservoir and the hydraulic system. Within the reservoir is a bellows 60 with its open upper extremity secured to the top wall of the reservoir as in FIG. 1. Similarly, an explosive charge 61 is mounted within the bellows and provided with suitable ignition wiring 62, also as in FIG. 1.

In operation of the form of the invention shown in FIG. 4, ignition of charge 61 causes expansion of bellows 60 to cause placing the hydraulic fluid in the reservoir under pressure and fracturing of sealing diaphragm 59. Hydraulic fluid is supplied under pressure through piping 51 to the inlet of pump 40, whence it is further placed under pressure and supplied through outlet piping 41 to accumulator 42 and control valve 43. In one condition of the control valving, hydraulic fluid will enter the upper portion of cylinder 44 and drive piston 46 and rod 47 downwardly. In the other condition of the control valving, piston 46 may move upwardly under an external force and the fluid from the pressure chamber in cylinder 44 may be exhausted through piping 58. Air is released through vent 48. In this form, explosive 61 provides merely enough pressure to prime pump 40 and maintain the hydraulic fluid in the control system in liquid condition.

FIG. 5 shows the hydraulic motor portion of a hydraulic system including cylinder 65 and piston 66 working therein and provided with piston rod 67 extending through end wall 68 of the cylinder. Suitable packing, of course, will be provided between the piston rod and cylinder end wall. Hydraulic fluid connections are shown at 69 and 70. A slight clearance is provided between the piston and cylinder wall as at 71, and the piston is provided with an annular groove 72 and with a transverse bore 73 which connects groove 72 with a duct 74 extending lengthwise of piston rod 67 to the outside of the cylinder. Passages 71, 72, 73, 74 are sufficiently restricted to impede substantially the escape of hydraulic fluid therethrough while permitting rapid escape of air.

The hydraulic system will be provided with suitable packings and seals, as is customary. Moreover, the system may be varied as required for the particular intended use. In some cases, it may be possible to eliminate the expansible envelope which segregates the explosive-generated gases and the hydraulic fluid within the reservoir. The air vents, of course, will be calibrated in proportion to the relative viscosities of air to be vented and the hydraulic fluid and, also, to the period of time during which the hydraulic system must remain operational. In the case of a missile whose guidance system will be operational only during a very short period, the loss during operation of a few drops or even considerably more hydraulic fluid is of no importance and may be advantageous. In other cases, it may be advisable further to restrict or to completely prevent the loss of hydraulic fluid through the air vents.

It will be noted that each of the hydraulic motors shown in FIGS. 4 and 5 constitutes an expansible and contractible chamber having a piston which forms a movable wall of the chamber and whose position, hence the volume of the chamber, is influenced by pressures within the chamber. The clearance between the piston and cylinder wall in each of the FIGS. 4 and 5 provides a gap between the piston and cylinder, which gap is a restricted orifice which by-passes the movable wall or piston. This gap allows air to pass the piston but it too narrow to allow more than a slight flow of hydraulic fluid past the piston.

While only one embodiment of the invention has been described herein and shown in the accompanying drawing together with certain modifications thereto, it will be apparent that various further modifications are possible in the arrangement and construction of the components of the hydraulic powering system without departing from the scope of the invention.

I claim:

1. A hydraulic powering arrangement adapted for ex-

tended, leak-free storage and rapid activation, said arrangement comprising, in combination:

a hydraulic powering system initially empty of hydraulic fluid;
a reservoir containing a supply of hydraulic fluid;
outlet means in connecting relation between the reservoir and the system;
sealing means preventing the transfer of fluid from the reservoir into the system;
venting means for discharge of air from the system, said venting means being connected to the system and the atmosphere;
and means to unseal the sealing means and discharge hydraulic fluid into the system from the reservoir, whereby the system is filled with the hydraulic fluid concurrently with expulsion of air from the system through the venting means by entrance of the hydraulic fluid into the system.

2. The arrangement set forth in claim 1 wherein the hydraulic fluid is substantially more viscous than air and said venting means includes at least one orifice restricted so as to substantially impede the escape of hydraulic fluid therethrough while permitting rapid passage therethrough of air placed under pressure by the entry of hydraulic fluid into the system.

3. A hydraulic powering arrangement adapted for extended, leak-free storage and rapid activation, said arrangement comprising, in combination:

a reservoir;
hydraulic fluid stored in the reservoir;
a contractible, pressure-influenced chamber having a movable wall and initially empty of hydraulic fluid;
outlet means in connecting relation between the reservoir and the chamber;
rupturable sealing means closing the outlet means and preventing transfer of hydraulic fluid from the reservoir to the chamber;
means to increase fluid pressure in the reservoir and rupture the sealing means for charging the chamber with hydraulic fluid through the outlet means;
and means for venting gases from the chamber while substantially impeding the escape therethrough of hydraulic fluid, said venting means comprising at least one restricted passage connected to the chamber and atmosphere and bypassing said movable wall.

4. The system claimed in claim 3, the chamber comprising a fluid motor having a cylinder and a piston working therein and the venting means including a passage in said motor bypassing said piston, the restricted orifice lying in controlling relation to fluid flow through the passage.

5. The system claimed in claim 4, the motor including an operating stem attached to the piston and the passage extending through the piston and stem to a location outside said cylinder.

6. In a hydraulic powering arrangement of the type wherein a hydraulic reservoir has an outlet means and is associated with means for raising pressure in the reservoir to a given level for forcing the hydraulic fluid therefrom, the combination with the reservoir of the elements comprising:

a hydraulic powering system initially empty of hydraulic fluid and connected to the reservoir by the outlet means;
sealing means preventing the discharge of fluid from the reservoir into the system and interposed between the hydraulic fluid and the system, the sealing means being rupturable by a fluid pressure less than the given pressure provided by the means for raising pressure in the reservoir;
and venting means for discharge of air from the system upon compression of the air by entry of hydraulic fluid into the system, the venting means being connected between the system and the atmosphere.


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