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HYDRAULICALLY OPERATED TOOL FOR OPERATING UNDER NONATMOSPHERIC PRESSURES

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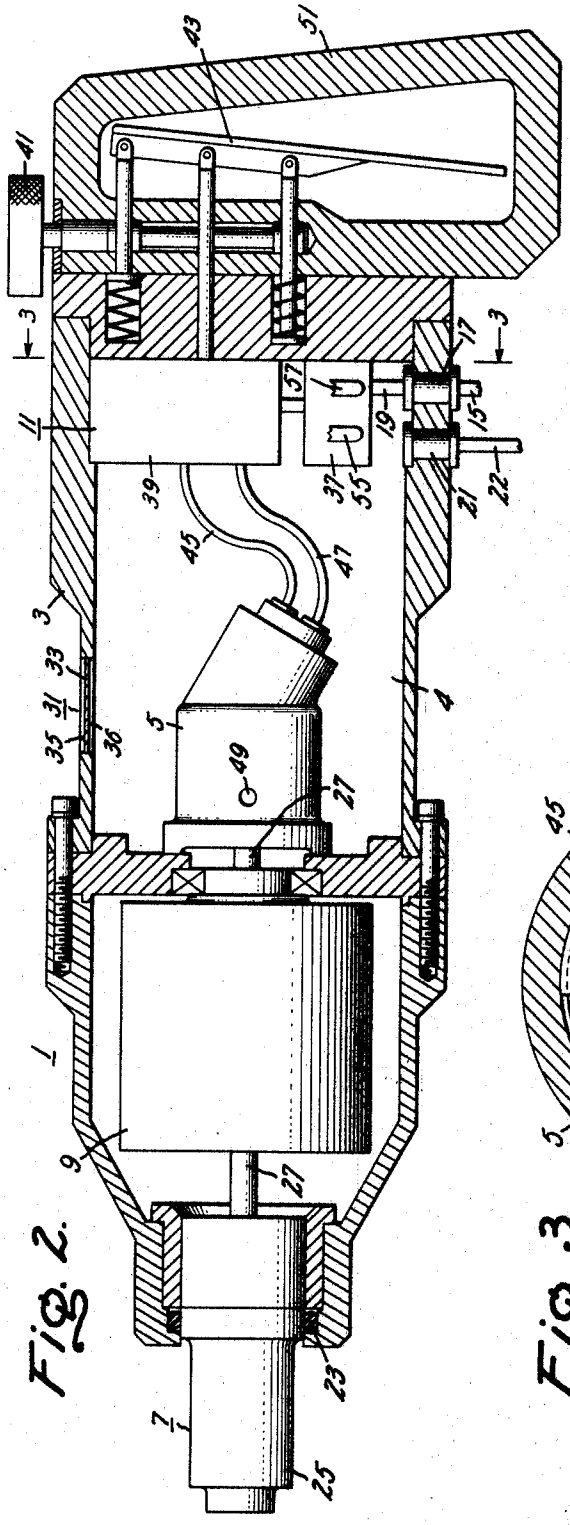


Fig. 2.

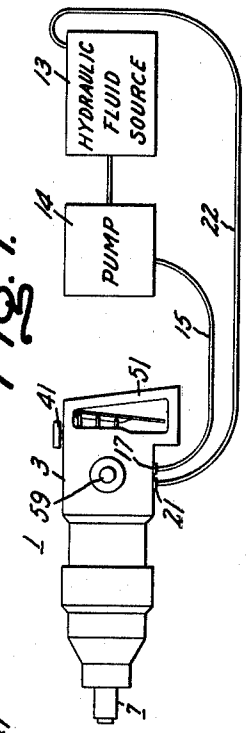


Fig. 1.

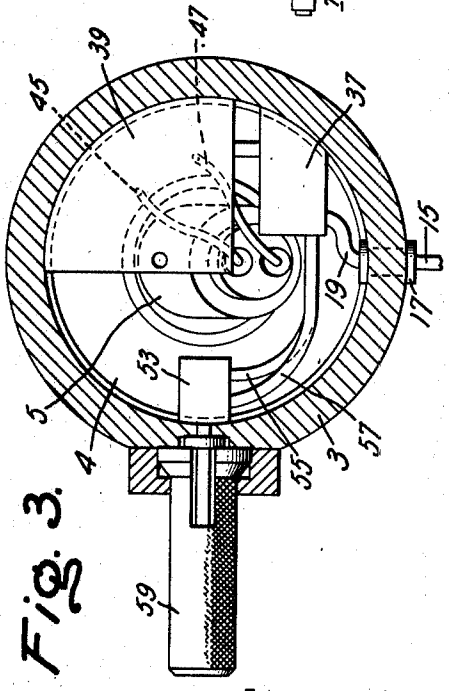


Fig. 3.

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HYDRAULICALLY OPERATED TOOL FOR OPERATING UNDER NONATMOSPHERIC PRESSURES

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U.S. Cl. 173—163 4 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulically operated tool is provided comprising a case for housing a hydraulic motor, an output device, such as a wrench, means for coupling the hydraulic motor to the output device, and operating controls for the hydraulic motor. Hydraulic fluid which is supplied to operate the motor is further utilized for equalization of the internal case pressure with the ambient pressure so that the tool can be operated at great depths or high altitudes. In operation, the fluid, after leaving the motor, is first discharged into the case so that the case is filled. To effect pressure equalization, a diaphragm, positioned in the wall portion of the case, acts upon the case fluid to compress or expand the effective volume thereof in response to action thereupon by the ambient pressure.

This invention relates to power tools and, more particularly, to power tools which may be operated either manually or remotely at pressures other than atmospheric.

Submersible tools are well known and have been utilized for a number of various applications. Generally, when operating at rather shallow depths, the primary requirement of such a tool is merely that the case be watertight so that the interior thereof is not in any way damaged. However, when operating at great depths or high altitudes, the ambient pressure induces very high stresses in the cases and housings for such tools, and effective means must be provided to counteract the effect of such pressure. Prior art devices have generally utilized pressure vessels; that is, vessels effectively isolating the effect of the ambient pressure so that the internal case structure operates independent of and without regard to pressure differences. However, such pressure vessels are necessarily more expensive and more complex than their counterparts which are utilized at atmospheric pressure operation. Furthermore, even when such pressure vessels are utilized, there are often interengageable parts which must sometimes necessarily be removed or substituted so that one or more seals are required to keep the internal structure independent of the ambient pressure. Since a large differential pressure appears across each seal in such a system, generally high quality or specially designed seals are utilized with such devices to provide effective pressure isolation. These requirements of the prior art have generally resulted in rather large cumbersome tools which are rather expensive and rather difficult to manipulate when operated.

It is, therefore, an object of this invention to provide an improved, inexpensive submersible tool operable at pressures varying greatly from atmospheric pressure.

It is another object of this invention to provide a submersible tool which does not require a pressurized case.

It is a further object of this invention to provide a submersible vessel which can operate with ordinary seals.

In accordance with my invention in one form thereof, I provide a power tool comprising a rather simple case for housing a hydraulic motor, an output device, such as a wrench, coupling means for connecting the output of the motor with the output device, and suitable operating controls for the hydraulic motor. Hydraulic fluid applied to operate the motor is further utilized for equalization of the internal case pressure with the ambient pressure so that the tool can be operated at great depths or high altitudes. Pressure equalization occurs by allowing the fluid, after leaving the motor, to be first discharged into the case so that the case is filled. Pressure responsive means are positioned in a wall portion of the case and act upon the case fluid to compress or expand the effective volume thereof in response to the ambient pressure, and thereby, to effect pressure equalization.

The present invention may better be understood by reference to the following description when taken in connection with the accompanying drawings in which:

FIGURE 1 is an external view of the tool structure and the supply system therefor;

FIGURE 2 is a cross-sectional view of the hydraulically-powered tool of the present invention; and

FIGURE 3 is a cross-sectional view of the hydraulically-powered tool taken along the line 3—3 of FIGURE 2.

While my power tool may be operated under all ambient pressure conditions, ranging from ocean depths to outer space, the following description considers the operation of the tool when it is submerged in water.

In FIGURES 1 and 2, there is shown the hydraulically powered tool **1** of the present invention which comprises a case **3** including a large cavity **4** for housing a hydraulic motor **5**, an output device **7** such as a wrench, means **9** for coupling the output of the hydraulic motor **5** to the output device **7**, and suitable control means **11** for operating the hydraulic motor **5**. Also shown in FIGURE 1 is a supply source **13** of hydraulic fluid for operating hydraulic motor **5**. The source of hydraulic fluid is connected to a pump **14** so that a sufficient pressure differential may be created to operate hydraulic motor **5**. The outlet from pump **14** is connected by line **15** to a supply inlet **17** in the case wall. The fluid flows into case **3** and through a conduit arrangement **19** into hydraulic motor **5**. The fluid is then discharged from motor **5** into case cavity **4** and, finally, out a case drain outlet **21** and back through line **22** to the fluid supply source **13** so that continuous operation may be effected.

As seen in FIGURES 1 and 2, case **3** comprises elements which are so interconnected as to present an integral body. However, seals, such as those designated **23**, must necessarily be provided at particular locations to insure the relative watertightness of the tool. Also, as seen in FIGURE 1, a socket **25** rather than a unitary output device, may be inserted in a forward aperture of tool case **3** so that it may be coupled with the output of the hydraulic motor shaft **27**. The tool of the present invention may comprise a relatively lightweight case **3** and utilize a conventional seal **23** due to a novel pressure equlaization arrangement which creates an internal case pressure equivalent to the ambient pressure when the tool is submerged so that the effective pressure across case **3** or across seal **23** is negligible.

A major feature of the present invention is the use of hydraulic motor **5** to drive output device **7** and a flow arrangement for the hydraulic fluid which is utilized not only to drive the motor, but to obtain the desired pressure equalization across the seals and the case. Pressure equalization is accomplished by causing the hydraulic fluid flowing into case **3**, after it has flowed through motor **5** to drive output shaft **27** thereof, to completely fill the internal volume or cavity **4** of case **3** before it drains back through case drain outlet **21** into return supply line **22**.

Of course, it would be expected that the fluid introduced in such an arrangement would normally be at approximately atmospheric pressure. Therefore, novel means **31** are provided to expand or contract the effective volume of the fluid within case cavity **4** in response

to the ambient pressure at any depth or height and, thereby, to lower or raise the effective internal case pressure in response to such fluid volume variation. The pressure equalization means **31** takes the form of pressure responsive diaphragm **33** which is positioned in a portion of the case wall, exposed on one side **35** thereof to the surrounding atmosphere and pressure thereof, and exposed on the other side **36** to the hydraulic fluid within case cavity **4** and the pressure generated thereby. Diaphragm **33**, being responsive to both the internal case pressure and the external ambient pressure, is caused to move until the volume of fluid within case cavity **4** is altered to such extent that the internal case pressure equals approximately the ambient pressure.

Since it is known that the hydraulic oil selected will compress as a function of its bulk modulus, it is necessary to select diaphragm **33** on a basis to cover the dimensional changes over the complete range of pressures expected and still remain within its functional tolerance. Diaphragm **33** need not be the simple configuration as shown. It might, for example, attain a cup shape for some applications.

Since the hydraulic fluid filling case cavity **4** is in a dynamic state and returns to supply source **13** through case drain outlet **21**, it can be seen that the supply fluid is always at the reference pressure. Thus, the hydraulic pump requirements remain essentially only those to account for the necessary hydraulic motor pressure drop and line friction which has some effect on the effective pressure. Obviously, the pump requirements will increase over long line lengths but can be minimized with proper choice of line sizes and flows over the depth range expected.

In addition to the pressure equalization means described above, there is provided a hydraulic control system **11** which controls the direction of motor operation and the operating speed of the hydraulic motor. Hydraulic control system **11** includes a pressure compensated flow control valve **37** and a transfer valve **39**. The flow control valve **37** is provided for regulating the fluid flow rate and, hence, the output speed of hydraulic motor **5**, through the system. Transfer valve **39** is provided to control the direction of fluid flow through motor **5** so that it is reversible. Manual control means **41** and **43** attached to a handle **51** are provided to control the operation of flow control valve **37** and transfer valve **39**, respectively. Both valves **37** and **39** and control means **41** and **43** are conventional and well known in the art and the particular structural configurations thereof are not part of the present invention.

As can be seen from FIGURE 1, fluid flows from supply source **13** through pump **14** and into case **3** via supply line **15** and case inlet **17**. The fluid, once in the case, flows in conduit arrangement **19** into pressure compensated flow control valve **37** for regulating the fluid flow rate to hydraulic motor **5**. After the hydraulic fluid has been discharged from flow control valve **37**, it flows into transfer valve **39** and one of two lines, designated **45** and **47**, determined by the position of manual control means **43**. In the normal off position, each line leading into hydraulic motor **5** is closed off. Depending upon which direction of rotation is desired for output shaft **27** of the hydraulic motor, manual control means **43** is operated, as seen FIGURE 3, to open one or the other of the lines **45** and **47** to the high pressure, at the same time opening the other to the drain side, so that the hydraulic fluid may be directed into and out of the hydraulic motor **5**.

After the fluid has moved through motor **5** to operate motor output shaft **27**, it is discharged through a suitable outlet port **49** in the motor housing into case cavity **4**. By proper dimensioning of the motor outlet **49** and case drain outlet **21**, case cavity **4** is completely filled by the hydraulic fluid after it flows through motor **2**, and pressure equalization can be accomplished by the aforementioned diaphragm arrangement. The hydraulic fluid leaves case **3** through the drain line which also serves as the return line to the supply source of hydraulic fluid so that the system requires only a finite amount of fluid continuously circulating through the tool.

Since the internal case pressure is equal to the ambient pressure, it is important to ensure that, upon raising the tool to the surface, if it is submerged, no high pressures become trapped while at great ocean depths. Thus, the components and design must be such as to ensure this fact. In this case, the seals and cavities should be designed and oriented to allow the contained pressure to change as the ambient pressure changes when returning to the surface.

As was stated previously, the fluid flow rate is regulated by flow control valve **37** within case **3**. In a preferred form of the invention, output shaft **27** of hydraulic motor **5**, which rotates at the predetermined speed as determined by the pressure compensated flow control valve **37**, is connected to a suitable tool such as wrench **25** by coupling means **9** in the form of an inertia-clutch arrangement. The basic principle of such mechanism is well known; that is, the spinning of an inertia mass to a given speed and then directly clutching this mass to the output device, such as the wrench. The momentum of the mass is thereby converted into impact torque. The size of the mass and its speed, as well as the stopping time, determines the impact torque output of the wrench. The type of impact arrangement used in this invention employs a conventional cam operated clutch (not shown) to engage the rotating mass with the output shaft. In this type of arrangement, the mass is accelerated to the desired speed, at which time a cam forces the mass to engage the output shaft thereby causing the impact.

It takes only a small amount of torque to bring this inertia mass up to speed, because this can occur over either one revolution or several revolutions, but the very fast stopping time as it is clutched to the output shaft can produce large output torques. As was stated previously, the pressure compensated flow control valve **37**, which sets the oil flow to motor **5**, effectively controls the wrench impact torque. I also provide additional fine adjustment means to control the impact torque comprising a manually operated needle valve **53** positioned in a bypass across pressure compensated flow control valve **37** formed by conduits **55**, **57**. Valve **53** is adjusted by rotation of hand grip **59** in a conventional manner. The transfer valve **41** which controls the direction of oil flow to the motor serves to direct the output torque of wrench **25**.

I have thus described a hydraulically operated tool which may be used at widely different ambient pressures. The tool utilizes hydraulic fluid supplied to the hydraulic motor within the case for filling the case and accomplishing pressure equalization between the internal case pressure and the ambient external pressure. This is accomplished through a diaphragm in a wall portion of a case which varies the volume of an effective pressure of the hydraulic fluid within the case in response to the ambient pressure.

One of the advantages of my improved tool is that it requires no external support but can be carried by hand and manually operated. This is particularly attractive for outer space uses. Alternatively, for operating at great ocean depths the tool can be attached to a submerged vessel, such as a submarine, and operated by a manipulator attached to controls **41** and **43**. Under submerged conditions the tool appears substantially weightless and transfers only a low reaction torque to a diver holding it or to the maneuvering vessel. This feature also permits it to be used in an essentially zero *g* environment such as outer space.

While the invention has been described with specificity, it is the aim of the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A hydraulically operated tool for operating under a wide range of ambient pressure conditions comprising:

a case having a cavity therein and including an inlet and an outlet to said cavity;

a hydraulic motor within said case cavity, said motor including a rotatable shaft and a housing having an inlet and outlet communicating with said cavity;

an output device drivingly engageable by said rotatable shaft;

means for connecting said case inlet with a source of hydraulic fluid at a predetermined pressure;

means for connecting said case outlet to said hydraulic fluid source;

means connecting said case inlet with said motor housing inlet for delivery of hydraulic fluid thereto;

said motor housing outlet and said case outlet being so dimensioned that fluid leaving said motor housing outlet is discharged into and fills said cavity before draining through said case outlet; and

a pressure responsive means disposed in a wall portion of said case and exposed on one side thereof to the ambient pressure and exposed on the other side thereof to the hydraulic fluid within the case cavity for equalizing the pressure within said case, with the ambient pressure surrounding said case.

2. The hydraulically operated tool as recited in claim 1 wherein said pressure responsive means comprises a diaphragm.

3. The hydraulically operated tool as recited in claim 1 wherein said conduit means further includes fluid control means operable to control the direction of rotation of the rotatable shaft of said hydraulic motor.

4. The tool of claim 1 which includes a handle and controls for manual operation of the tool.

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JAMES A. LEPPINK, Primary Examiner

U.S. Cl. X.R.

175—6; 253—2