Dec. 16, 1958 W. D. NOVAK 2,864,341

FLUID MOTOR

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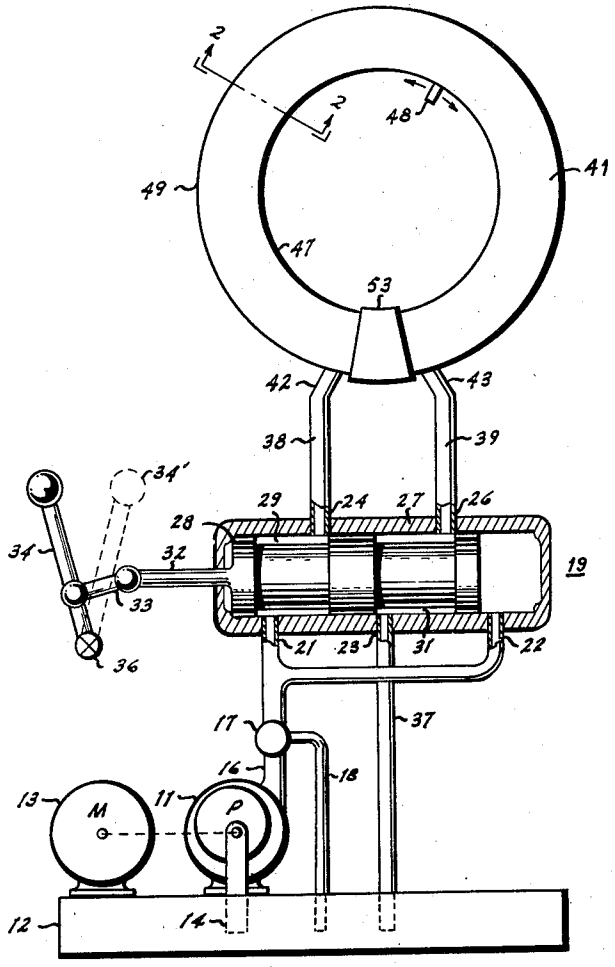


Fig. 1

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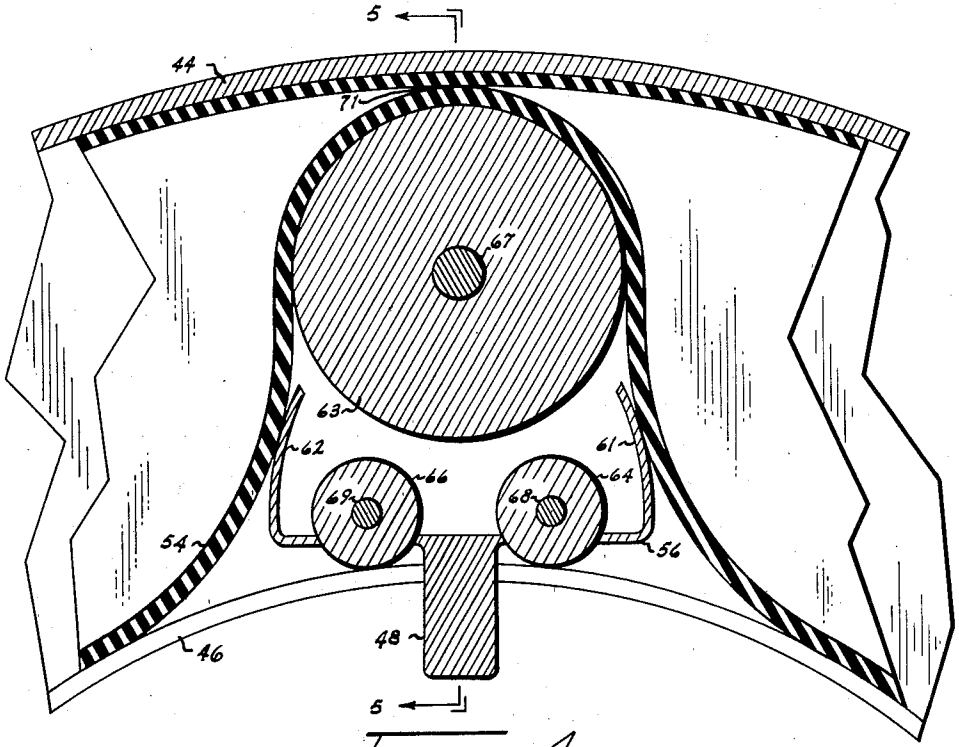


Fig. 4

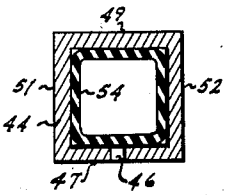


Fig. 2

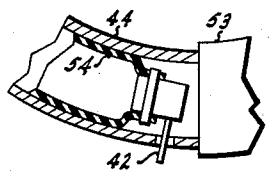


Fig. 3

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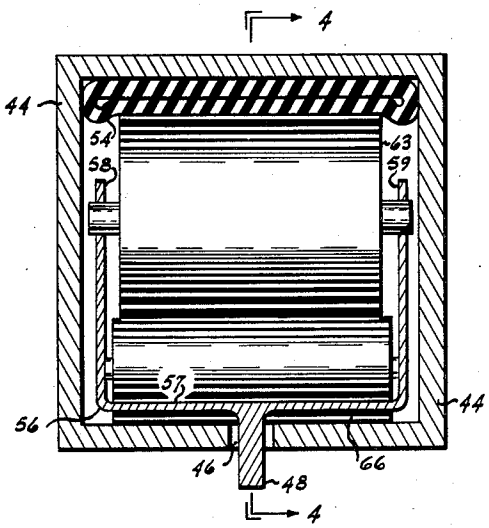


Fig. 5

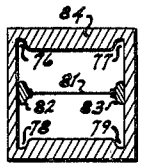


Fig. 7

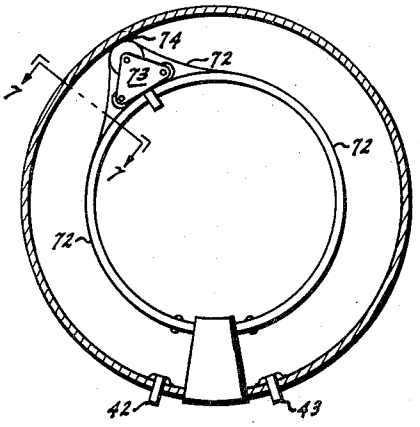


Fig. 6

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2,864,341
FLUID MOTOR

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Application April 4, 1957, Serial No. 650,787
4 Claims. (Cl. 121—48)

This invention relates to transducers wherein fluid power is converted to mechanical power and vice versa, and particularly to arrangements wherein hydraulic and pneumatic members are used to provide suitable motion.

Such devices are usually employed as components of a system for transmitting motion a short distance by means of fluid flowing in pipes. Such a system has several advantages over mechanical and electrical systems for transmitting power. For example, a fluid drive is frequently more compact, more easily applied, or provides a more flexible arrangement than either a mechanical or an electrical drive.

The present invention includes a fluid-to-mechanical transducer. However, in all embodiments the device is reversible in the sense that it may be either an actuator or a pump, converting fluid power to mechanical power or vice versa. The fluid employed may be either a liquid or gas.

The transducer is characterized by the use of a flexible member retained in a rigid tube which also contains a travelling member. When used as a motive means, the introduction of hydraulic or pneumatic pressure to one end of the tube causes the flexible member to be flexed against the traveller, forcing it along the tube. The traveller, through a connecting member, moves a mechanical load outside of the tube.

The reciprocating motion of the transducer may be in a straight line or in a curve. The curve may be circular or non-circular. If circular it may have limits of less than a complete circle or up to several complete rotations in the form of a helix. If non-circular, the motion may be in the form of an ellipse, a parabola, a sine curve, or any other form not having abrupt changes of direction.

The transducer of this invention is compact because it does not require the use of a piston rod. Compared with the single-acting fluid piston and rod, the instant transducer requires about one-half of the longitudinal space and compared with the double-acting device requires about one-third of the space.

Uses of the transducer of this invention when incorporated in a power transmission system are many. Among them is the precise positioning and rapid control of a lathe tool carriage or turret, control of any motions of a drill press or jig borer, and control of the lens, iris or other adjustments of an optical instrument.

The principal purpose of this invention is to provide a reciprocating transducer for the reciprocal interchange of fluid and mechanical power.

A specific purpose of the invention is the provision of a hydraulic reciprocating motive means characterized by a flexible hydraulic tube and further characterized by direct mechanical coupling to a reciprocated mechanical load without the intermediation of a rotating shaft.

A further understanding of this invention may be secured from the detailed description together with the drawings in which:

Figure 1 depicts an embodiment consisting of a hydraulic actuator containing an elastic tube, together with a hydraulic system including a pump for applying hydraulic power to the actuator.

Figure 2 is a cross section of Fig. 1 taken on the line 2—2.

Figure 3 is a longitudinal cross section of Fig. 1 through port 42.

Figure 4 is a longitudinal cross section through the travelling carriage employed in the actuator of Fig. 1, being a section of Fig. 5 taken on the line 4—4.

Figure 5 is a section of Fig. 4 taken on the line 5—5 but with the large roller shown in full.

Figure 6 is a longitudinal section of a transducer embodying this invention employing a thin sheet of metal or the like as the flexible member.

Figure 7 is a cross section of Fig. 6 taken on the line 7—7 with the addition of beading to prevent leakage of fluid.

Referring now to Fig. 1, a hydraulic pump 11 is mounted on a sump or tank 12 partly filled with hydraulic fluid. The pump 11 is rotated by an electric motor 13 causing it to draw hydraulic fluid from the sump 12 through its intake pipe 14 and to discharge it through pipe 16. A conventional pressure release valve 17 releases the discharge fluid when its pressure rises above a selected value through a release pipe 18 into the sump 12, thus maintaining the pressure at a specific constant level. A conventional valve 19 of the type known as "four-way" is provided with two ports 21 and 22 for the hydraulic fluid under pressure and one port 23 discharging to the sump 12. The valve 19 is also provided with two ports 24 and 26 which are connected to a load in a manner hereinafter to be described. The valve 19 consists of a casing 27 enclosing a cylindrical piston 28 provided with two annular grooves 29 and 31. The piston 28 is slideable longitudinally within casing 27 through the medium of a stem 32, connecting link 33 and hand lever 34 pivoted at a bearing 36.

In the operation of four-way valve 19 in the position shown, hydraulic fluid under pressure passes from the intake port 21 through annular passage 29 and out through the port 24. The hydraulic fluid, after performing work, returns at lower pressure to port 26, passes through annular passage 31, leaves by way of port 23 and is discharged at low pressure through pipe 37 to the sump 12. When the manual lever 34 is moved to its other extreme position indicated by the dotted outline 34', the piston 28 is moved to its extreme right position, connecting load pipe 39 to the pressure port 22 of the hydraulic system and connecting pipe 24 for discharge to the sump. Thus the valve reverses the intake and exhaust functions of the load pipes 38 and 39 connected to ports 24 and 26.

When lever 34 is positioned midway of its two extreme positions both the intake and exhaust ports are closed and no hydraulic pressure is applied to either port 24 or 26. At other positions the valve exerts proportional control, the hydraulic power applied to the load being a function of the valve position.

The pipes 38 and 39 are connected to a hydraulic load consisting of a reciprocating hydraulic motive means or actuator 41 which constitutes an embodiment of the invention. The actuator 41 is in the form of an annular ring having two ports 42 and 43 to which pipes 38 and 39 are connected. The cross section of the actuator 41 is square as depicted in Fig. 2. The outer shell 44 of the actuator 41 is made of an unyielding material such as metal and is provided with a slot 46 in its inner cylindrical surface 47. A pin 48, Fig. 1, projects through this slot. This pin 48 is provided to couple the generator to the device which the actuator is required to move. Alternatively the slot 46, Fig. 2, may be in the outer surface 49, Figs. 1 and 2, of the annular ring or conceivably in one of the other two surfaces 51 or 52, Fig. 2.

The outer shell 44, consisting of a metal pipe of square cross section, is bent in the form of a circular ring and is hollow throughout its circumference except for the section 53, Fig. 1, which interposes an internal barrier interrupting the passage within the shell. Within shell 44 there is a flexible and elastic tube 54 made of a material

such as rubber. When not distended this tube may have a square, circular, or any other cross section but when disturbed it must be capable of filling the shell **44**, except perhaps at the corners, as depicted in Fig. 2.

The tube **54** extends throughout the hollow part of shell **44**, the two closed ends of the tube **54** abutting the wide partition formed by section **53**, Fig. 1. Two fittings are inserted in tube **54** at or near its closed ends, these fittings incorporating ports **42** and **43**, a cross section of one form of construction being depicted in Fig. 3.

The pin **48**, Fig. 1, is secured to a carriage or traveller which is interposed between the shell **44** and the tube **54**, and which substantially closes the passage within tube **54** at that point by pinching the tube closed. The carriage includes a frame **56**, Figs. 4 and 5, having a floor **57**, two end plates **58** and **59**, and two guide plates **61** and **62**. A large roller **63** and two smaller rollers **64** and **66** are journalled by means of axles **67**, **68** and **69** in the end plates **58** and **59**. The pin **48** is secured to the frame floor **57** and protrudes through the slot **46** in the shell **44**.

In the operation of the hydraulic actuator, pump **11**, Fig. 1, applies hydraulic pressure through valve **19**, with lever **34** in the position shown, and through pipe **38** and port **42** to one end of elastic tube **54**, Figs. 3, 4 and 5. This pressure expands tube **54** to fill shell **44** and to force the tube **54** against the traveller and particularly against its large roller **63**. The guide plates **61** and **62** prevent the elastic tube **54** from being forced between large roller **63** and one of the small rollers as well as providing additional surface against which the tube may bear in driving the traveller forward. At the same time the other end of the flexible tube **54** is relieved of pressure because its port **43** is open through valve **19** to the sump **12**, which is at low pressure and may even be open to the atmosphere. The fluid pressure applied to roller **63** cannot go past it to the other side because at point **71**, Fig. 4, the elastic tube is collapsed with its walls pressed together and against one flat side of shell **44** by the roller **63**. The tube under pressure therefore causes the traveller to move through the shell, roller **63** rolling along tube **54**. The force with which the tube presses against the traveller is equal to the hydrostatic pressure multiplied by the effective shell internal cross section. The motion of the traveller is rapid, and if permitted by its load continues until it reaches the end of the tube **54** or until the pressure is cut off by the four-way valve **19**.

The hydraulic system which is described and which is illustrated in Fig. 1 is elementary. Obviously the transducer **41** may be employed in many other systems, such as those with proportional control and systems employing negative feedback and positioning the traveller precisely at an intermediate position determined by an applied input signal. Other types of control valves may be employed which are operated mechanically, electrically, hydraulically or pneumatically. The entire operation of the transducer **41** may be pneumatic, applying gas or vapor pressure to it instead of hydraulic fluid pressure.

A second embodiment may employ hydraulic operation but is particularly adapted to pneumatic operation. This embodiment employs, as does the first embodiment, a square cross section shell. However, it contains no elastic tube and the two ports provide access directly to the internal space of the shell at its ends. In place of the elastic tube its function is discharged by a thin metal sheet, as wide as one wall of the shell, and extending from end to end within it, as shown by sheet **72**, Fig. 6. This metal sheet should be strong and flexible, being made, for example, of stainless steel five thousandths of an inch in thickness. The clearance between each edge of the sheet and the side wall should be not more than a few thousandths of an inch. The traveller **73** may be of the design shown in Fig. 4 and should press the sheet **72** against the wall of the shell at point **74**.

When pneumatic pressure is applied through port **42** or **43**, the amount of air leaking past the sheet can be made negligible and the traveller will be moved with great force,

If this embodiment is to be hydraulically operated it may be advisable to reduce or eliminate the clearances between the edges of the sheet and the shell by beading the edges with strips of nylon or other suitable material. Fig. 7 shows a cross section of a shell provided with recesses **76**, **77**, **78** and **79** at the corners and containing such a sheet **81** shown in an intermediate position. Nylon beads **82** and **83** are affixed to the entire lengths of the edges of strip **81** and serve as packing shoes, taking up the clearance between the edges of strip **81** and shell **84** and fitting into recesses **76**, **77**, **78** and **79**.

The embodiments of Figs. 1 and 6 depict a reciprocating fluid actuator circularly curved in an arc of about 350°. It is obvious that the principles of this actuator may be applied to a great many other forms. The simplest of such forms is that of a straight tube and the traveller and its pin, moving in a straight line, can be employed to move or position the drill of a drill press, one of the rectilinear motions of a machine tool table, and for many other purposes. The reciprocating fluid actuator can also be curved into a circular helix, and by suitable connections to the pin can thus control motion through more than a full circle. The curved actuator need not be circular, but can be curved sinusoidally, parabolically, spirally, or as otherwise required.

Both of the described embodiments are reversible and can be used as pumps to transduce mechanical force to fluid force.

What is claimed is:

1. A hydraulic motive means comprising, a rectangular metal tube having a longitudinal slot in one side, a travelling carriage in said tube, said carriage having a pair of rollers bearing on one wall of said tube and a third roller adjacent to the opposite wall thereof, mechanical coupling means secured to said carriage and extending through the slot in said metal tube to the exterior thereof, a rubber tube within said metal tube, said rubber tube lying between said third roller and said opposite wall and constricted therebetween, said rubber tube extending throughout the length of said metal tube, and means on each end of said rubber tube for applying hydraulic power thereto.

2. A hydraulic motive means in accordance with claim 1 in which said rectangular metal tube is curved.

3. A hydraulic motive means in accordance with claim 1 in which said rectangular metal tube is circularly curved in the form of a portion of a circular ring.

4. A hydraulic motive means comprising, a rectangular metal tube having a slot in one side, a traveling carriage in said tube, said carriage having a pair of rollers bearing on one wall of said tube and a third roller positioned adjacent the opposite wall thereof, a guide plate formed at each end of said carriage extending transversely of said tube in advance of a respective one of said pair of rollers, a mechanical coupling means secured to said carriage and extending through the slot in said metal tube to the exterior thereof, a rubber tube within said metal tube, said rubber tube lying between said third roller and said opposite wall and constricted therebetween, said rubber tube extending throughout the length of said metal tube, and means at each end of said rubber tube for applying hydraulic power thereto.

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