The present invention relates to hydraulic rotary engines operating as a motor and relates further to hydraulic transmission utilizing such hydraulic rotary engines.

The principal object of the invention is to provide a hydraulic rotary engine which affords a perfect control of the speed of a driven shaft.

Another object of the invention is to provide a hydraulic rotary engine of the class described adapted to operate as a motor actuated by a pressure fluid which engine affords a perfect speed control of a driven shaft from a standstill and creeping speeds up to a given maximum value, either forwards or backwards.

Still another object of the invention is to provide a hydraulic rotary engine of the class described adapted to operate as a motor actuated by a pressure fluid in which engine the additional friction at the start of a driven shaft is eliminated and a quick speed control of said shaft is secured.

Still another object of the invention is to provide a hydraulic rotary engine of the class described, comprising two rotors both of which are actuated by a pressure fluid, a differential gear connecting said rotors with a common driven or driving shaft, respectively, and a device for varying the ratio of the speeds of the rotors.

These and further objects of the invention will be apparent according as the following description proceeds, reference being had to the accompanying drawings in which embodiments of the invention are illustrated by way of example.

In the drawings:

Figure 1 is a vertical sectional view of a hydraulic motor according to the invention;

Figure 2 is a sectional view on line III—III of Figure 1;

Figure 3 is a diagrammatical view of a hydraulic transmission according to the invention;

Figure 4 is a longitudinal sectional view of the hydraulic motor thereof;

Figure 5 is a cross-sectional view along the line V—V in Figure 4; and

Figure 6 is a diagrammatical view of the differential gear of the motor.

In the embodiment illustrated in Figures 1 and 2, 10 designates an external casing and 11 a cylindrical housing of a screw motor, said housing being provided with two end caps 12 rotatably mounted in ball bearings 13 in the external casing 10. The housing 11 is provided with axial intersecting bores for a central rotor 14 and two lateral rotors 15, each of said rotors in the illustrated embodiment being shaped as twin screws.

The central rotor 14 is rotatably supported by means of stud shafts 16 and 17 running in bearings in the end caps 12.

Fluid under pressure is supplied through an inlet 18 to the central chamber 19, whence the liquid passes to both sides through the axial bores in the housing 11 driving the twin screw sets 14, 15 and through openings 20 in the end caps 12 into the spaces 21 between the rotor housing 11 and the external casing 10, the fluid then escaping through the outlet 22.

Provided at one end of the screw motor is a differential gear comprising a rotatable drum 29 keyed to the driven shaft 30 and supported by a ball bearing 23 fixed to the housing 10 and by a bearing 24 forming the shaft end 241 of the rotor 14. Mounted on studs 25 in the drum 29 are two bevel planet wheels 27, and engaging said planet wheels are two bevel sun wheels 25 and 26, one 26, secured to the adjacent end cap 12 of the housing 11 and the other, 26, fixed to the rotor 14.

Provided at the opposite end of the screw motor is a mechanical braking device comprising two brake disks 31 and 32 slidably but non-rotatably mounted one, 31, on the stud 16 and the other, 32, on the end cap 12 of the housing 11. The disks are disposed in a space, which is divided into two chambers 35 and 36 by a partition 34. The partition 34 has brake surfaces on opposite sides adapted to operate with corresponding brake surfaces on the disks 31 and 32. The chamber 35 has an opening 31 and the chamber 36 an opening 38, said openings serving as inlet and outlet ports for the pressure fluid.

The apparatus described operates in the following manner:

On its passage through the hydraulic motor the fluid causes the rotors 11 and 14 and, consequently, the sun wheels 25 and 26 to rotate in opposite directions. If the sun wheels 25 and 26 rotate at equal speeds, the driven shaft 30 is at rest.

When fluid under pressure is supplied to one of the openings 37 or 38, the corresponding disk 31 or 32 is forced towards the partition 34 so as to produce a braking action on the corresponding rotor 14 or 11 and, consequently, to change the ratio between the absolute speeds of said rotors. This causes the driven shaft 30 to be rotated in the one or the other direction. If, for instance, pressure fluid is supplied through the opening 37, the disk 31 will be forced towards the partition 34 and the speed of the rotor 14 and, consequently, also that of the gear wheel 26 will be reduced.
Thus, the speed of the wheel 25 in the differential gear will exceed the speed of the wheel 26 causing the driven shaft 30 to be rotated in the same direction as the wheel 25. If, however, liquid is supplied through the opening 33, the disk 32 will be more or less retarded so that the speed of the rotor housing 14 and, consequently, also of the wheel 25 is thereby caused to rotate in the opposite direction. If one of the disks 31 or 32 is brought to a stand-still, the shaft 30 will have a speed equal to half the speed of the unimpeded rotor. This, it is possible to impart to the driven shaft 30 a speed varying from zero to a certain value in the one or the other direction depending upon the magnitude of the braking action applied on the respective rotor.

On account of the central rotor 14 and the rotary housing 11 being kept in continuous motion the additional friction at start is eliminated and a quick and perfect speed control of the driven shaft 30 is secured.

In order to remove the heat produced by the brakes, part of the pressure fluid may be allowed to pass from the respective inlet opening 37 or 38 through the space 39 between the disks and out through the other opening 36 or 37.

In the embodiment shown in Fig. 5, reference number 40 designates a pump driven by a motor 41 and circulating a fluid by means of a pressure conduit 42 and a return conduit 43 through a differential motor having an inlet 45 and an outlet 47, said differential motor being shown in detail in Figs. 4 and 5.

The differential motor which is shown in detail in Figs. 4 and 5 comprises a motor housing 50, a central body 51 and a differential gear casing 52. The motor housing 50 has an end cover 68 and two bores 53 and 54 each enclosing a screw set. The one screw set comprises a left-hand threaded power screw 55 meshing with two right-hand threaded side screws 56. The shaft 57 of the screw 55 is supported by a ball bearing 58 mounted in the body 51 and carries at its end a gear wheel 59. The other screw set comprises a left-hand threaded power screw 60 meshing with two right-hand threaded side screws 61. The shaft 62 of the screw 60 is supported by a ball bearing 63 and a drum 64 mounted on the body 51 and carries at its end a gear wheel 65 mounted loosely on the shaft 62 and meshing with the wheel 59 on shaft 57. The gear wheel 64 has an extended hub 65 which at its end is shaped to form a pinion 66. Near its end shaft 62 carries another pinion 67.

The inlet 45 (Fig. 3) opens into an inlet chamber 70 formed in the central body 51 and common to the two screw sets. At the other end of the screw sets are valve chambers 71 and 72 communicating with the outlet 47 (Fig. 3).

The differential gear comprises a drum 73 and a cover 74 fixed thereto, said drum and cover being supported by ball bearings 75 and 76, the one 75 secured to the gear casing 52 and the other 76 fixed to a shield 77 secured to the casing and supported by the central body 51. Rotatably journalled in the drum 73 are two planet gear wheels 80 and 81 and similarly journalled in the cover 74 are two planet gear wheels 82 and 83. As shown in Fig. 6, pinion 87 engages planet wheels 80 and 81 (but not 82 and 83) and pinion 66 engages planet wheels 82 and 83 (but not 80 and 81). The drum 73 is integral with the driven shaft 84.

The speed of the screws 55, 60 is controlled by a throttle valve having a valve body 89 controlling the outlet 52 and 59 from both valve chambers 71, 72 and secured to a stem 93 having a manoeuvring knob 94 (see Fig. 5).

When the fluid flows from the inlet 70 along the screw sets to the outlet valve chambers 71 and 72, the power screws 55 and 60 are rotated in the direction indicated by the arrows in Fig. 4, causing the pinions 66 and 67 to rotate in opposite directions. When the valve body 89 assumes its middle neutral position (see Fig. 5) the fluid is allowed to pass freely from both chambers 71 and 72, the power screws 55 and 60 then rotating at the same speed. In this case the drum 73 and the driven shaft 84 are at stand-still. When the valve stem 93 is moved for instance downwards in Fig. 5, the flow from chamber 72 is throttled causing the speed of screw 55 to be reduced. Assuming the quantity of liquid delivered by pump 46 per unit of time being constant, a greater portion of the total flow will then pass the screw set 60, 61 causing their speed to be increased to the same degree as that of the screw set 55, 56 is decreased. As a result shaft 84 will be rotated at a speed equal to half the difference between the speeds of the screws 55, 60. When the output 52 or chamber 72 is entirely shut, the screw 55 will be at stand-still and the screw 60 will rotate at twice its initial speed, shaft 84 rotating at half this speed and in the same direction as before. If the valve stem 93 is moved upwardly, the passage from chamber 71 is throttled causing the speed of the screw 60 to be reduced and that of screw 55 to be increased, with the result that the shaft 84 will rotate in opposite direction as before.

The apparatus described is simple in operation and affords perfect speed control of shaft 84 from stand-still and creeping speeds, forwards or backwards, up to a given maximum value.

The gear wheels 55, 60 may be of different diameters, for instance having those in Fig. 5, 1:2 and the diameter of the pinion 66 may be made twice as great as that of pinion 67. Thereby it will be possible to reduce the diameters of the planet gear wheels and, thus, that of the drum 73. Or six planet gear wheels may be used in which the drive shaft 65 and 67 engage each three of these six wheels. This slightly more complicated design is preferred for larger output giving considerably smaller dimensions.

The screw set 55, 56 may be threaded in a direction opposite to that of the screw set 60, 61. If in this case the gear ratio of the wheels 59, 64 is different from 1:1 the shaft 84 will always rotate in the same direction irrespective of whether the outlet 71 or the outlet 72 is throttled, but when throttling one of said outlets the driving torque of the shaft 84 will be different from that obtained when throttling the other outlet.

In the following claims the expression differential gear is used to indicate any device in which two rotary movements serve to produce a third rotary movement proportional to the difference between or the sum of the first-mentioned rotary movements.

What I claim is:

1. A hydraulic rotary engine, comprising two rotatable members each adapted to be actuated by a pressure fluid, a differential gear comprising a rotary drum having a shaft, two sun wheels and a plurality of planet wheels rotatably mounted on said drum, means for connecting each of said rotatable members with one of said sun wheels,
and means for controlling the flow of fluid through at least one of said rotatable members.

2. A hydraulic rotary engine, comprising two rotatable members each adapted to be actuated by a pressure fluid, a differential gear comprising a rotary drum having a shaft, two sun wheels and a plurality of planet wheels rotatably mounted on said drum, means for connecting each of said rotatable members with one of said sun wheels, and means for braking the speed of at least one of said rotatable members.

3. A hydraulic rotary engine, comprising two rotatable members each adapted to be actuated by a pressure fluid, a differential gear comprising a rotary drum having a shaft, two sun wheels and a plurality of planet wheels rotatably mounted on said drum, means for connecting each of said rotatable members with one of said sun wheels, means for braking the speed of at least one of said rotatable members, and hydraulically operated means for controlling said braking means.

4. A hydraulic rotary engine, comprising a plurality of intermeshing rotary screws, a rotatable housing for said screws, said screws and housing being adapted to rotate in opposite directions actuated by a pressure fluid, a shaft, a differential gear connecting said screws and housing with said shaft, and means for varying the ratio of the speeds of said screws and housing.

5. A hydraulic rotary engine, comprising two sets of intermeshing rotary screws, a fixed housing for said screws, said sets of screws being adapted to be actuated by a pressure fluid, a shaft, a differential gear connecting said sets of screws with said shaft, and means for varying the ratio of the speeds of said sets of screws.

6. A hydraulic rotary engine, comprising two rotatable members each adapted to be actuated by a pressure fluid, a differential gear comprising a rotary drum having a shaft, two sun wheels and a plurality of planet wheels rotatably mounted on said drum, means for connecting each of said rotatable members with one of said sun wheels, and means for varying the ratio of the speeds of the rotors thereby varying the speed of the shaft.

7. A hydraulic transmission, comprising a power driven pump adapted to deliver liquid, two rotatable members adapted to be actuated by said liquid, a shaft, a differential gear connecting said rotatable members with said shaft, and means for varying the ratio of the quantities of liquid leaving the rotatable members thereby varying the speed of said shaft.

8. A hydraulic transmission, comprising a power driven pump adapted to deliver liquid, two rotors adapted to be actuated by said liquid, inlet and outlet for the liquid to and from said rotors, a shaft, a differential gear connecting said rotors with said shaft, and means for varying the quantity of liquid flowing through each of the rotors thereby varying the speed and the direction of rotation of the shaft.

9. A hydraulic transmission, comprising a power driven pump adapted to deliver liquid, two sets of intermeshing screws adapted to be actuated by said liquid, an inlet for liquid to the sets of screws, separate outlets for liquid from said sets of screws, a shaft, a differential gear connecting said sets of screws with said shaft, and means for throttling said outlets for varying the speed and the direction of rotation of the shaft.

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