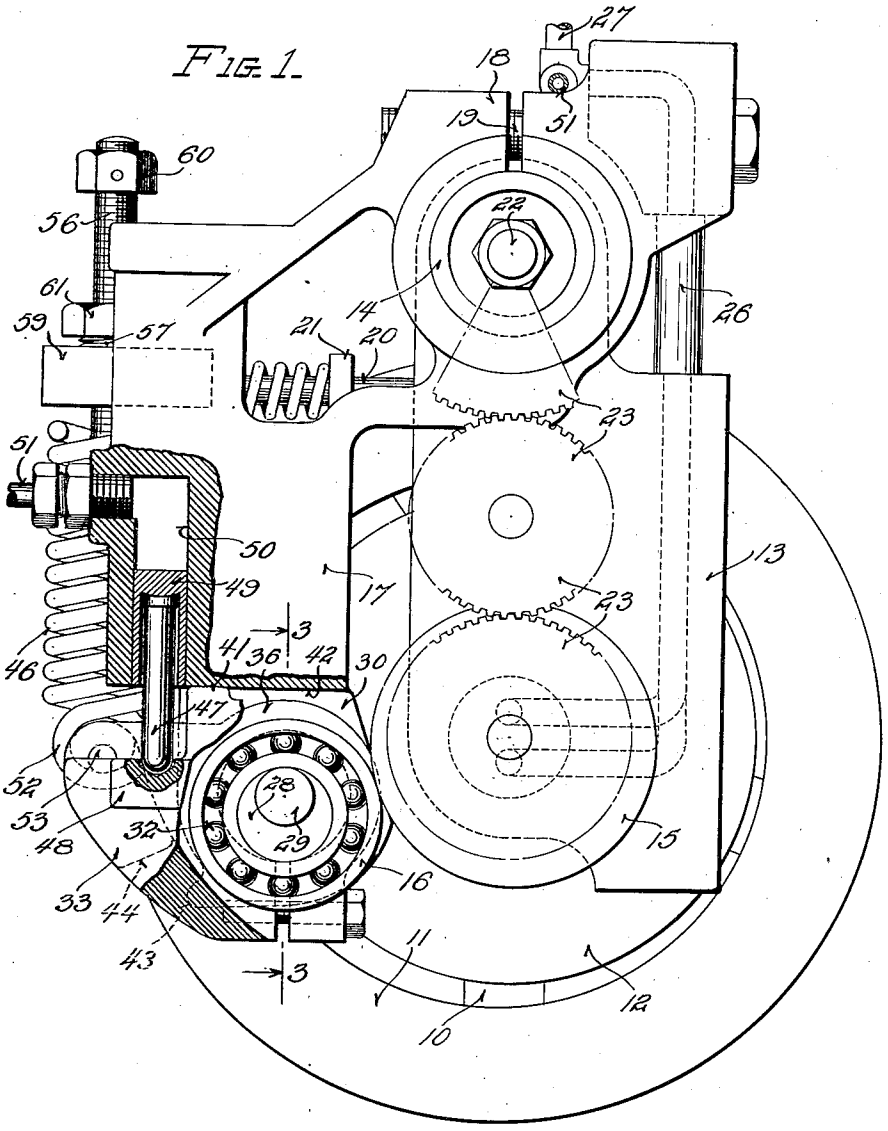
March 17, 1931. W. FERRIS 1,796,986

SLIP COMPENSATOR FOR HYDRAULIC DRIVES

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FIG. 1.



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FIG. 2.

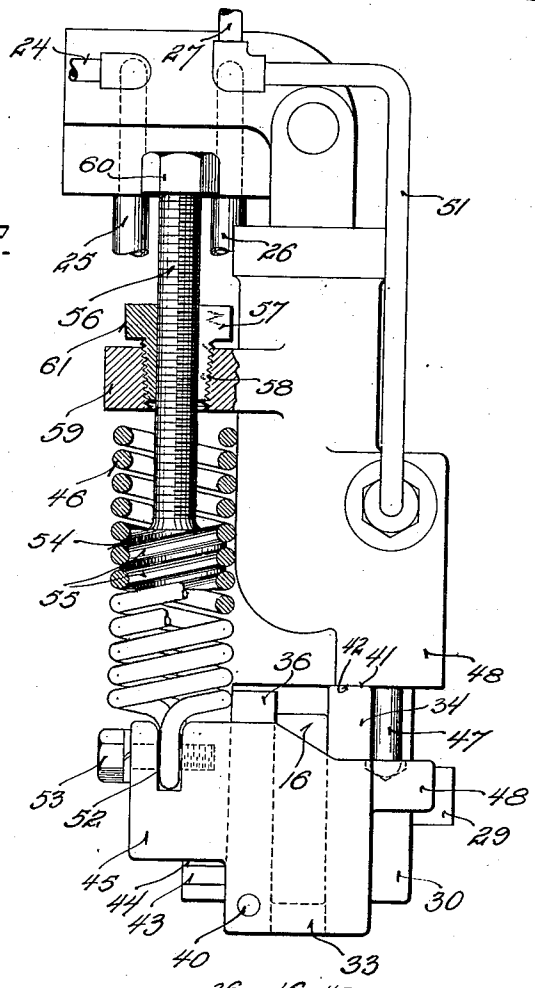
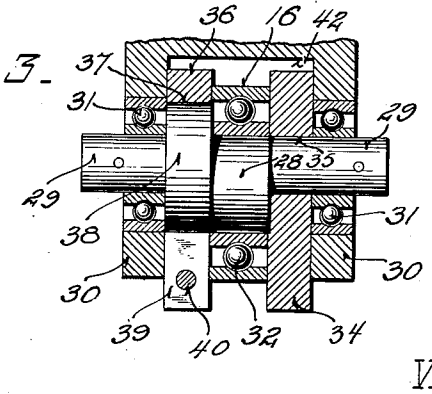


FIG. 3.



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UNITED STATES PATENT OFFICE

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SLIP COMPENSATOR FOR HYDRAULIC DRIVES

Application filed August 6, 1927. Serial No. 211,083.

This invention relates to pumps and more particularly to slip compensating mechanisms therefor.

In hydraulic transmissions, involving a variable displacement pump and hydraulic motor driven thereby, the phenomenon commonly known as slip, which results largely from leakage past the pump pintle and past the pump and motor pistons, produces a variable influence upon the speed of the motor. The effect of the slip is more apparent when pump displacement is relatively small and when the hydraulic pressures are relatively high.

The general aim of the present invention is to eliminate the effect of slip by automatically varying pump displacement in such manner as to make full compensation therefor under various conditions of operation. This I have accomplished by the use of mechanism designed to automatically vary pump displacement in accordance with variations in working pressures, this accomplishment being predicated upon my discovery that the degree of slip at any instant is actually substantially proportional to the hydraulic pressures involved.

A more specific object of the present invention is the provision in a variable displacement pump of mechanism automatically operable to vary pump displacement in accordance with variations in pump delivery pressures.

Another object is the provision of a slip compensator for the purpose mentioned which may be readily adjustable to adapt the same to the slip characteristics peculiar to the particular pump or hydraulic transmission to which it is applied.

Other objects and advantages will appear from the following description of an illustrative embodiment of the present invention.

In the drawings:—

Figure 1 is a conventional illustration of a variable displacement pump embodying a slip compensator constructed in accordance with the present invention.

Fig. 2 is a view in side elevation of the slip compensator as it would appear looking from left to right in Figure 1.

Fig. 3 is a detail sectional view taken substantially along the line 3—3 of Figure 1.

The variable displacement pump conventionally illustrated in Figure 1 is fully described in the copending application of John P. Ferris, Serial No. 199,925, filed June 20, 1927, which has matured into Patent No. 1,753,562 and to which reference is made for a complete understanding of the construction and operation thereof. It will suffice herein to state that this pump comprises a series of pistons 10 coacting with and between a circular driver 11 and a cylinder barrel 12, which are rotated at constant speed. The cylinder barrel 12 is supported upon a pendulum 13, rockably supported at its upper end upon a horizontally fixed hollow shaft 14, so that the cylinder barrel may be shifted laterally with respect to the driver to vary pump displacement. The pendulum 13 is adjusted and controlled in this instance by a cam 15, rotatably fixed thereon and coacting with a roller 16, supported by a fixed locating arm 17. The arm 17 is supported by a split bracket 18 clamped to the end of the shaft 14 by an appropriate screw 19. A spring loaded tension bolt 20, anchored in the pendulum 13 and projected loosely through a lug 21 on the arm 17, urges the pendulum 13 toward the left so as to maintain the cam 15 against the roller 16. The cam 15 is rotated and controlled from a rotary control stem 22 through an appropriate gear train 23. The pump receives liquid through communicating pipes 24 and 25, associated with the bracket 18, and discharges through similar pipes 26 and 27 at a rate depending upon the degree of eccentricity between the cylinder barrel 12 and driver 11.

As above pointed out provision is made for automatically increasing pump displacement in accordance with increases in pump delivery pressures to thereby compensate for slip. This is accomplished in the pump shown by providing an adjustable mounting means for the roller 16 which responds automatically to variations in pressure within the delivery pipe 27 to shift the roller 16 with respect to the locating arm 17. In this instance the

roller 16 is mounted upon a circular head 28, carried by eccentric trunnions 29, rockably supported within spaced legs 30, depending from the locating arm 17. Anti-friction bearings 31 permit a free rocking action of the head and trunnions within the legs 30, and an anti-friction bearing 32 permits free rotation of the roller 16 upon the head.

The rotative position of the head and trunnions within the legs 30 is controlled by a yoke 33 removably secured thereto. One arm 34 of the yoke is perforated, as at 35, to snugly receive one of the trunnions, while the other arm 36 thereof is formed with an opening 37 to receive a circular head 38, formed as an integral part of the other trunnion and concentric therewith. Arm 36 is split, as indicated at 39, so that it may be firmly clamped to the head 38 by an appropriate screw 40. A lug 41, formed on the arm 34 and coacting with the lower face 42 of the locating arm 17, limits the upward movement of the yoke 33 (Figs. 1 and 2), and a lug 43, formed on one of the legs 30 and coacting with the lower face 44 on a projection 45 on the yoke, limits the downward movement of the yoke, so that the yoke 33, trunnions 29 and eccentric head 28 are rockable as a unit through a limited angle. The eccentric relation between the head 28 and trunnions 29 is such that, as the yoke 33 is swung downwardly from the upper extreme position shown in Figure 1, the roller 16 is actually shifted toward the right, and, acting against the cam 15, forces the pendulum 13 toward the right to thereby increase pump displacement.

A spring 46, preferably such as will be later described, serves to resiliently retain the yoke 33 in the upper position shown. A plunger 47, seated within a projection 48 on the yoke, responds to pressures within the pump delivery pipe 27 to force the yoke downwardly against the action of the spring 46. In this instance the upper end of the plunger 47 is seated within a hollow piston 49 closely fitted for reciprocation within a bore 50 formed in the locating arm 17. The upper end of the bore 50 communicates through a pipe 51 with the pump delivery pipe 27 so that the pressure within the bore 50 corresponds at all times with that in the delivery pipe.

The spring 46 is constructed and arranged so that under all conditions of operation the extent of movement of the yoke 33 from the upper position shown will be substantially proportional to the degree of pressure within the bore 50, and so as to permit a ready adjustment of the spring to thereby vary the ratio of pressure to the extent of movement and thus render the mechanism readily adaptable to the slip characteristics of the particular pump and hydraulic transmission to which the pump is applied. The spring shown is of double helical form and terminates in a loop 52, which is anchored within the projection 46 of the yoke 33 by appropriate means such as a screw 53. The spring is also engaged by an internal plug 54, formed with helical grooves 55 for snugly receiving the convolutions of the spring. The plug 54 is fixed to the lower end of a control stem 56, adjustably supported upon the locating arm 17. By rotation of the stem 56 and plug 54 the plug may be adjusted lengthwise of the spring to thereby vary the effective length and consequently the stiffness thereof. The stem 56 is in this instance threaded in a split tapered bushing 57, which is threaded within a tapered seat 58 formed in a lug 59 projecting from the arm 17. The stem 56 is provided with an appropriate operating head 60 and the bushing 57 with an operating head 61.

The arrangement is such that, after withdrawing the bushing 57 from its seat 58, the plug 54, may be adjusted into any desired position lengthwise of the spring 46 by rotation of the stem and plug therein. Then, while the stem 56 is held under light tension, sufficient to retain the yoke 33 in its upper position without imposing any material initial tension in the spring, the bushing 57 is screwed downwardly along the stem until it is engaged in its seat 58 with sufficient force to collapse the same against the stem and thereby securely lock the stem in that position of adjustment. It will be understood of course that the threads between the bushing and its seat and between the bushing and the stem are of the same pitch so that the bushing may thus be screwed down into its seat without producing any relative movement between the stem and lug 59. Thus in all positions of adjustment the initial tension in the spring 46 is practically negligible so that the extent of downward movement of the yoke 33 will be directly proportional to the pressure within the bore 50. By varying the effective length of the spring in the manner above described the relation between the extent of movement of the yoke and the degree of pressure in the bore 50 may be varied to suit the characteristics of the pump. For a pump in which the average slip is relatively high the plug 54 is elevated to increase the effective length of the spring and thereby permit a greater depression of the yoke 33 under a given pressure in the bore 50, and for a pump in which the average slip is relatively low the plug 54 is lowered to decrease the effective length of the spring and thereby reduce the extent of depression of the yoke 33 under the given pressure in the bore 50. In each position of the plug 54 within the spring however the extent of movement of the yoke, and consequently the extent of adjustment of the roller 16 is proportional to the pressure within the bore 50, so that pump displacement is

automatically increased in accordance with increases in pump delivery pressures, which increase is substantially equal to and thus compensates for increases in slip corresponding to those increases in pump pressures.

Various changes may be made in the embodiment of the invention hereinabove specifically described without departing from or sacrificing the advantages of the invention as defined in the appended claims.

I claim:—

1. The combination with a variable displacement pump of a member movable to vary pump displacement, and mechanism coacting with said member to automatically increase pump displacement in accordance with increases in pump delivery pressures to thereby compensate for slip.

2. The combination with a variable displacement pump of means actuated by pump pressure for increasing pump displacement, and means for yieldably resisting said means to thereby maintain a predetermined relation between variations in pump pressure and the resulting variations in pump displacement.

3. The combination with a variable displacement pump of means actuated by pump pressure for increasing pump displacement, yieldable means coacting with said first named means for controlling the action thereof, and means for adjusting said yieldable means to vary the action of said first named means.

4. The combination with a variable displacement pump of means actuated by pump pressure for increasing pump displacement, means including a spring for yieldably resisting the action of said named means, and means for varying the effective capacity of said spring to vary the action of said first named means.

5. The combination with a variable displacement pump of means actuated by pump pressure for varying pump displacement, means including a coil spring for resisting the action of said means, and a member engaged with the convolutions of said spring and adjustable thereon to vary the effective length thereof to thereby vary the action of said first named means.

6. The combination of a variable displacement pump, a member movable to vary pump displacement, a stationary member, an element adjustably mounted on said stationary member and coacting with said movable member to control the position thereof, means actuated by pump pressure for adjusting said element to thereby increase pump displacement and resilient means for resisting and controlling the action of said first named means.

7. The combination of a variable displacement pump, a member movable to vary pump displacement, a stationary member, a roller on one of said members, a cam on the other of said members coacting with said roller to control the position of said movable member, means for adjusting said cam to regulate pump displacement, an adjustable support for said roller, and means actuated by pump pressure for adjusting said roller to vary pump displacement in response to variations in pump pressure.

8. The combination of a variable displacement pump, means including a cam and coacting roller for controlling pump displacement, means for adjusting said cam to regulate pump displacement, an adjustable support for said roller, and means for adjusting said support to vary pump displacement.

9. The combination of a variable displacement, pump, means including a cam and coacting roller for controlling pump displacement, means for adjusting said cam to vary pump displacement, and means responsive to pump pressure for adjusting said roller to vary pump displacement irrespective of the position of said cam.

10. The combination of a variable displacement pump, means including two coacting elements for controlling pump displacement, means for adjusting one of said elements to regulate pump displacement, and means actuated by pump pressure for adjusting the other of said elements to increase pump displacement with increases in pump pressure.

In witness whereof, I hereunto subscribe my name this 29th day of July, 1927.

WALTER FERRIS.