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Kjellqvist

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[54] **HYDRAULIC ENGINE HAVING A FLAT SLIDE**

[75] Inventor: **Olof Gunnar Kjellqvist,** Ornskoldsvik, Sweden

[73] Assignee: **AB Hagglund & Soner,** Ornskoldsvik, Sweden

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **91/487**

[51] **Int. Cl.** **F01b 1/00,** F01b 3/00

[58] **Field of Search**....................... 91/484, 485, 486, 91/487, 492, 505

[56] **References Cited**

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Primary Examiner—William L. Freeh
Assistant Examiner—Gregory P. LaPointe
Attorney—Cushman, Darby & Cushman

[57] **ABSTRACT**

The present invention relates to a radial piston type hydraulic engine comprising a flat slide attached to the engine housing, said slide being provided with bores arranged to connect the pressure medium inlet passages and outlet passages of the engine in the engine housing with cylinder chambers of said engine. These chambers are located in a cylinder block which abuts the slide and is rotatable in relation thereto. Displaceable bushings are arranged in the engine housing and abut the slide and are subjected to the pressure prevailing in respective inlet and outlet passages to urge the slide towards the cylinder block with a force dependent on the pressure in said passages. The invention is mainly characterized in that passages are arranged between respective inlet and outlet bores in the slide in order to supply pressure medium from the space between the slide and the cylinder block to pressure chambers located in the engine housing. The pressure in the pressure chambers is arranged to act on displaceable balancing means which bear against the slide so that said balancing means, under the influence of the pressure in the chambers, urge the slide against the cylinder block with a force which varies in dependence on the pressure variations in the space between the slide and the cylinder block in the region of the discharge orifices of the passages while the engine is running.

6 Claims, 4 Drawing Figures

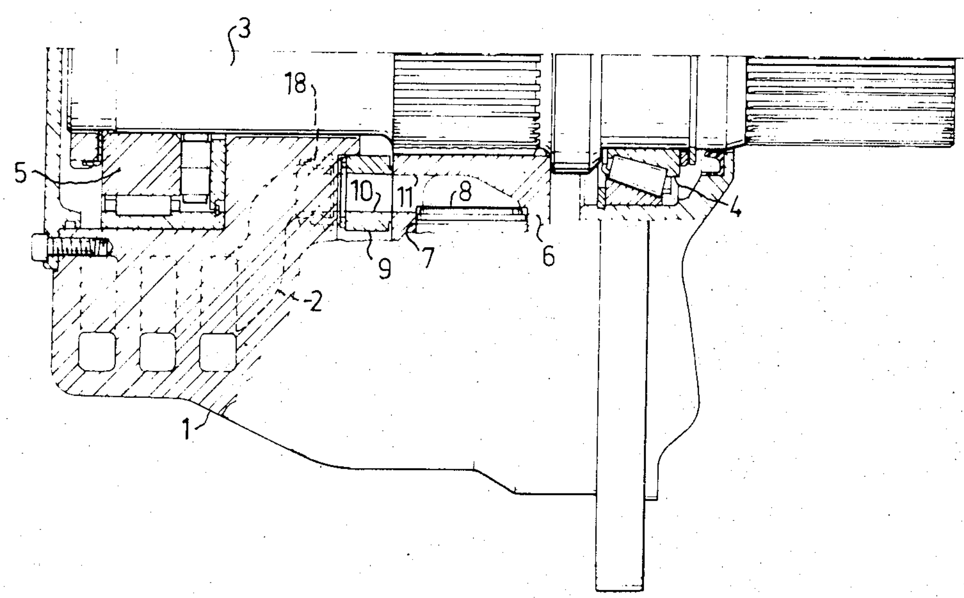

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FIG.1

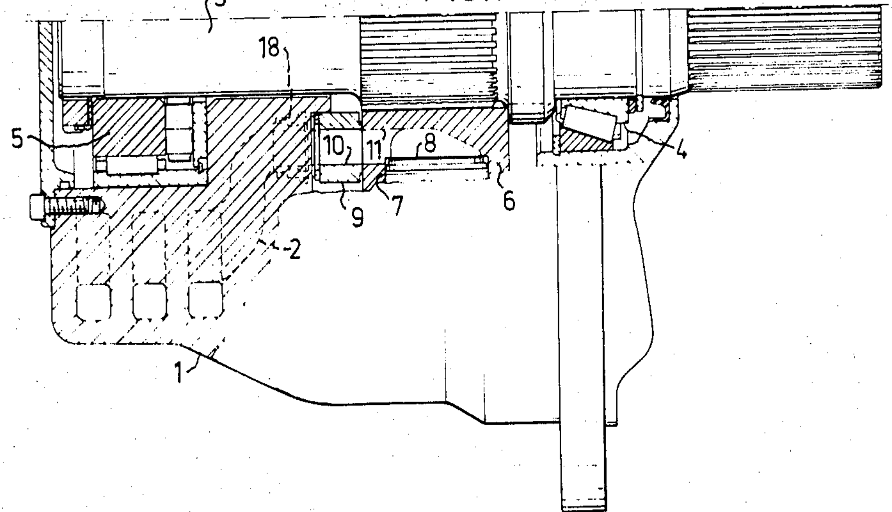


FIG. 2

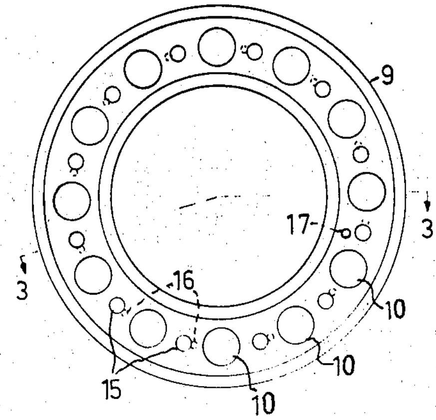


FIG. 3

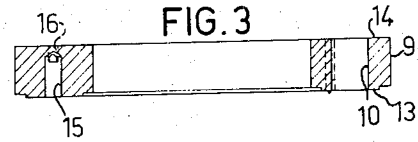
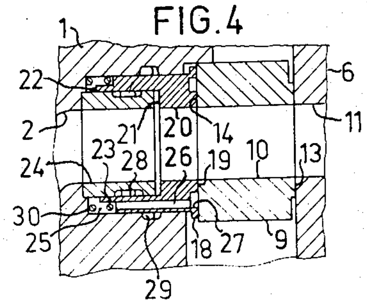


FIG. 4



HYDRAULIC ENGINE HAVING A FLAT SLIDE

The present invention relates to a hydraulic engine of the radial piston type, in which there is attached to the engine housing a flat slide provided with bores arranged to connect the pressure medium inlet passages and outlet passages of the engine in the engine housing with the cylinder chambers of said engine, said chambers being located in a cylinder block which abuts the slide and rotatable in relation thereto, and in which there are arranged in the engine housing displaceable bushings which abut the slide and which are subjected to the pressure prevailing in respective inlet and outlet passages to urge the slide towards the cylinder block with a force dependent on the pressure in said passages.

The purpose of the bushings is to urge the slide against the cylinder block while the engine is running in order to reduce the leakage between the two components. When the engine is running, the oil pressure is namely propagated to the space between the opposing surfaces of the slide and the cylinder blocks, between which surfaces a certain relative movement takes place. The pressure image occurring between the two surfaces seeks to separate the slide and the cylinder block from each other. Without the balancing force obtained by the bushings, an excessive play would occur between the slide and the cylinder block, which would result in an undesirably high leakage. The force exerted by the bushings of the slide, hereinafter referred to as the balance force, must at all times be greater than the force created by the oil pressure acting between the slide and the cylinder block, this latter force being hereinafter referred to as the rupture force, over a section of the slide, for example 30° with a slide having twelve bores. This is important, since the rupture force varies in accordance with a determined pattern upon relative rotation between the slide and the cylinder block. Thus, the balance force must be at least equal to the highest rupture force occurring within a section when an opening in the cylinder block which has previously been in communication with a high pressure bore in the slide is located between said bore and a following low pressure bore.

One disadvantage with this is that an over-balance force is obtained at the positions on the slide where full coverage is had between the bores in the slide and in the cylinder block, i.e. the balance force will be higher than the rupture force. The difference between these forces will thus be taken up as pure contact pressure between the slide and the cylinder block, which results in high frictional losses. For a known construction, these losses in talk reach to about 4 percent of the engine driving moment.

Attempts have been made to reduce these losses by making the slide resistant to bending forces and utilizing the mentioned over-balance forces of certain of the bushings in order to reduce the balance force to a magnitude smaller than that of the rupture force. It has been found, however, that when applying this technique large forces occur which tend to deform the slide, thereby resulting in leakage.

The object of the present invention is to provide a hydraulic engine of the type described in the introduction, with which the friction losses between the slide and the cylinder block can be maintained substantially at a far lower level than with the above described known constructions without impairing the sealing efficiency of the arrangement. This is achieved in accordance with the invention by arranging between respective inlet and outlet bores in the slide passages for supplying pressure medium from the space between the slide and the cylinder block to pressure chambers located in the engine housing, and that the pressure in the pressure chambers is arranged to act on displaceable balancing means which bear against the slide so that said balancing means under the influence of the pressure in the chambers urge the slide against the cylinder block with a force which varies in dependence on the pressure variations in the space between the slide and the cylinder block in the region of the discharge orifices of the passages while the engine is running. In this way, the balance force exerted by the bushings can be reduced to an extent such that the over-balance force in any position is a minimum, owing to the fact that the force exerted by the balancing means balances the rupture force at those positions on the slide where said force exceeds the balance force exerted by the bushings.

A particularly good result is obtained if the passages in the slide are arranged to open out in between respective inlet and outlet bores on the side of the slide facing the cylinder block. It has namely been found that the pressure at this point varies in rhythm with the resultant of the rupture force. In this way, the force exerted by the balancing means will also vary in rhythm with the rupture force.

In accordance with a preferred embodiment of the invention, the bushings also form the balancing means, said balancing means having a first surface remote from the slide and being exposed to the pressure prevailing in the respective inlet and outlet passages in the engine housing, and a second surface exposed to the pressure in the pressure chambers. In this way, there is obtained a construction which requires relatively small space. The invention will now be described in more detail with reference to the accompanying drawing, further characteristic features of the invention being disclosed in connection therewith. In the drawing, FIG. 1 illustrates a side view, partly in section, of a portion of an engine constructed in accordance with the invention, FIGS. 2 and 3 illustrate respectively an end view and a cross section through a flat slide used with the engine of FIG. 1, and FIG. 4 is a cross sectional view through a portion of the slide with balancing means.

The radial piston type hydraulic engine illustrated in FIG. 1 comprises generally a stationary housing **1** provided with passages **2** for supplying and conducting away oil. A shaft **3** is mounted for rotation in the housing **1** in bearings **4** and **5**. Mounted for non-rotation on the shaft **3** is a cylinder block **6** in which radially disposed cylinders **7** with pistons **8** are located. Between the housing **1** and the cylinder block **6** is located an annular flat slide **9** arranged concentrically with the shaft **3** and having twice as many bores **10** as the number of cam peaks on the cam curve (not shown) of the engine. The bores **10** located in the slide **9** serve to connect the inlet and outlet passages **2** in the engine housing **1** with corresponding bores **11** in the cylinder block **6**, the bores **11** being in communication with respective cylinders **7**. The slide illustrated in FIG. 2 has twelve bores **10** and is intended for an eight cylinder engine whose cam curve has six cam peaks.

As will be seen from FIGS. 2 and 3, there are disposed between adjacent bores 10 in the slide, passages which open out in the two end surfaces 13 and 14 of the slide. The passages comprise a first bore 15 extending from the surface 13 of the slide 9, said surface 13 being intended to abut the cylinder block 6, and a second bore 16 which extends from the first bore 15 and which has a smaller diameter than the first bore 15 and is located adjacent thereto, the bore 15 opening out in between adjacent bores 10. The purpose of the bores 15 and 16 will be described hereinafter. Finally, there is located in the slide 9 a bore 17 intended to accomodate a driving pin connected with the engine housing 1 in order to prevent relative rotation between the housing and the slide.

As illustrated by dash lines in FIG. 1 and as clearly evident from FIG. 4, bushings, generally indicated at 18, are provided in the housing 1. In the illustrated embodiment having twelve bores 10 there are twelve bushings 18, i.e. one for each bore 10. The bushings 18 are arranged concentrically with respective bores 2 in the housing 1 and one end surface 19 of said bushings abuts the end surface 14 of the slide and has a bore 20 whose cross section corresponds to the cross section of the bores 2 and 10. The bushings 18 are provided with a radially inner step, so that a radially inner end surface 21 and a radially outer end surface 22 are formed. The inner cylindrical surface 23 located between the end surfaces 21 and 22 abuts a sleeve 24, on which the bushing is arranged for longitudinal movement. The outer cylindrical surface of the sleeve 24, the engine housing 1 and the radial inner end surface 22 of the bushing 18 together define pressure chambers 25 in the housing 1, which chambers communicate with the passages 15, 16 in the slide via a passage 26 in the bushing 18 and an annular groove 27 in the end surface 19 of the bushing abutting the slide line. Further, arranged between the bushing 18 and the sleeve 24 and the housing 1 are O-rings 28 and 29. A spring 30 is arranged in respective pressure chamber 25 and holds respective bushings in abutment with the slide with an initial force.

When the engine is running, each alternate one of the twelve passages 2 in the housing 1 is under high oil pressure and forms a supply passage to the cylinders 7, while the remaining six passages 2 form outlet passages and are exposed to the counterpressure prevailing on the low pressure side of the engine. The oil pressure is propagated to the space between the surface 13 of the slide and the cylinder block 6, between which surfaces a relative movement takes place, so that a rupture force of varying magnitude occurs, which attempts to separate the slide from the cylinder block.

For the purpose of illustrating clearly how the rupture force varies over a section of the slide, i.e. 30°, it will be assumed that a bore 11 in the cylinder block 6 completely covers a high pressure bore 10 in the slide. The rupture force then has a value dependent on the input pressure. As the bore 11 is removed from full coverage by the bore 10 upon rotation of the cylinder block, the rupture force increases and reaches a maximum when the bore 11 is completely removed from the high pressure bore 10. Immediately thereafter, the bore 11 in the cylinder block 6 reaches the following low pressure bore 10 in the slide, whereupon the rupture force falls to a value dependent on the counter pressure on the low pressure side. It has been discovered experimentally that the variations in pressure best follow the variations in rupture force over a section of the slide at a point thereon located between two adjacent bores 10.

When the engine is running, the oil pressure in the bores 2 located in the engine housing acts on the radial inner end surfaces 21 of the bushings 18 in a manner such that the bushings, through their surfaces 19, press against the slide 9 with a force responsive to the pressure in the bores 2, further, the pressure between the slide and the cylinder block in the region between two bores 10 in the slide acts against the radial outer end surface 22 of the bushings 18 owing to the fact that this pressure is propagated to the pressure chambers 25 via the passages 15, 16 in the slide, the annular groove 27 in the bushings and the bore 26 therein. Thus, the bushings 18 are forced against the slide 9 with a constant force dependent on the pressure in the bores 2 and a variable force dependent on the pressure in the region where the passage 15 opens out. This means that when a bore 10 in the slide 9 is in full communication with a bore 11 in the cylinder block 6 the bushing 18 forces against the slide 9 with a lower force than when the bore 11 is located in between two bores 10 in the slide, since — in accordance with the above — the pressure in the region where the passage 15 opens out increases and therewith also the pressure in the pressure chamber 25.

In this way, it is possible to dimension the surfaces 21 and 22 of the bushings 18 in a manner such that the balance force exerted by the bushings at any movement is adjusted to the prevailing rupture force, thereby maintaining the over-balance force at a minimum.

Although the invention has been described and illustrated with respect to one embodiment thereof, it will be understood that the invention is not restricted thereto but may be modified within the inventive scope. Thus, although an embodiment has been shown in which the surfaces 21 and 22, exposed to a constant and a variable pressure, are arranged on one and the same bushing 18, an embodiment is conceivable in which solely the constant pressure acts on the bushing 18, while a separate balance means is arranged, said separate balance means being subjected to the variable pressure. If the engine space permits, this separate balance means may be placed in contact with the slide 9 in between two bores 10 located therein. In this way, a slightly more favourable construction is obtained with respect to the point of engagement of the balancing force. The respective resultant of the rupture force and the balancing force will then lie nearer to each other than with the aforedescribed embodiment. The distance between the balancing force and the rupture force with the alternative embodiment, however, is still only a fraction of what is the case when utilizing the over-balance force of adjacent bushings 18 as with the known constructions.

What is claimed is:

1. A radial piston type hydraulic engine, comprising a flat slide valve attached to the engine housing, said slide valve being provided with bores arranged to connect the pressure medium inlet passages and outlet passages of the engine in the engine housing with the cylinder chambers of said engine, said chambers being located in a cylinder block which abuts the slide valve and rotatable in relation thereto, and in which there are arranged in the engine housing displaceable bushings which abut the slide valve and having a surface remote

from the slide valve and exposed to the pressure prevailing in respective inlet and outlet passages to urge the slide valve towards the cylinder block with a force dependent on the pressure in said passages, characterized in that between respective inlet and outlet bores in the slide valve are arranged passages, for supplying pressure medium from the space between the slide valve and the cylinder block to pressure chambers located in the engine housing and that the pressure in these pressure chambers is arranged to act on displaceable balancing means having a second surface exposed to the pressure in the pressure chambers so that said balancing means under the influence of the pressure in the chambers urge the slide valve against the cylinder block with a force which varies in dependence on the pressure variations in the space between the slide valve and the cylinder block in the region of the discharge orifices of the passages while the engine is running.

2. Engine according to claim **1**, characterized in that the passages in the slide valve open out in between respective inlet and outlet bores on the side of the slide valve facing the cylinder block.

3. Engine according to claim **1** characterized in that

the balancing means are formed by the bushings.

4. Engine according to claim **3**, characterized in that the bushings are arranged concentrically with respective inlet and outlet passages, the first surface of the bushings being formed by a radial inner surface, and the second end surface being formed by a surface which is located radially externally of and axially spaced from said first surface and which forms a wall in respective pressure chamber remote from said slide valve and movable in a direction theretowards.

5. Engine according to claim **4**, characterized in that a portion of the inner cylindrical surface of the bushings located between the first and the second surfaces abut a sleeve separating the pressure chambers from respective inlet and outlet passages in the engine housing.

6. Engine according to any of claim **3**, characterized in that the end surface of the bushings bearing against the slide valve is provided with an annular groove from which extends at least one bore, said bore opening out into the pressure chamber.

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