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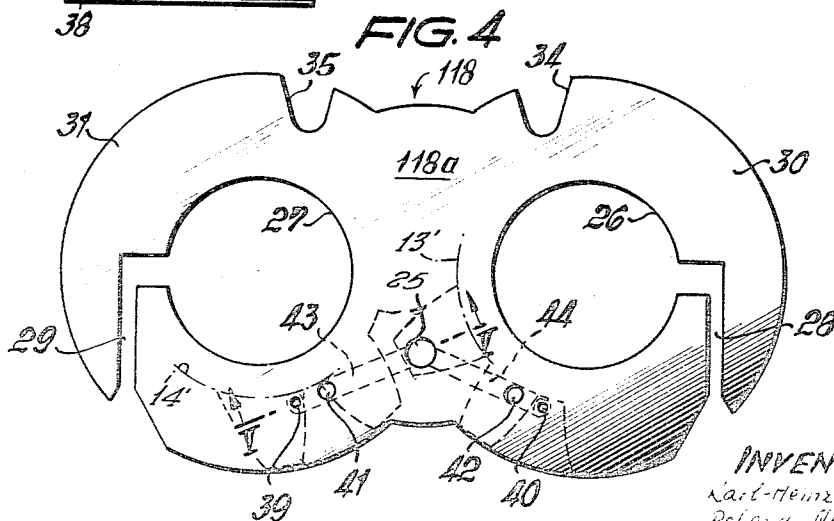
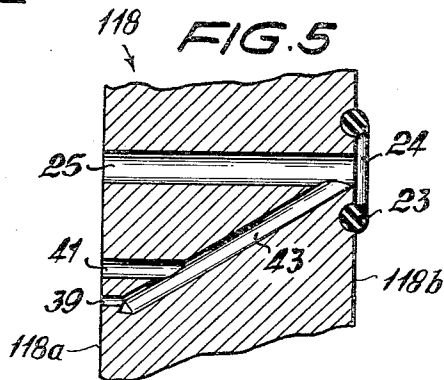
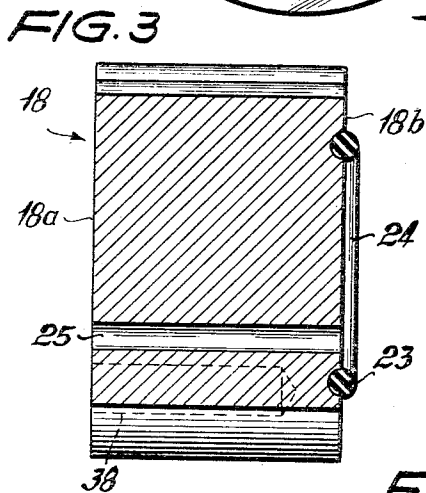
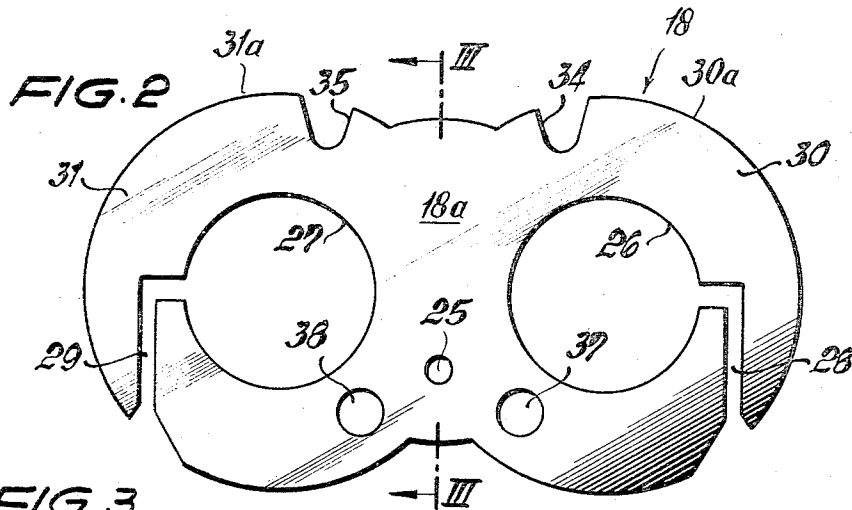
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HYDRAULIC APPARATUS

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HYDRAULIC APPARATUS

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The present invention relates to hydraulic apparatus in general, and more particularly to a rotary hydraulic apparatus which may be utilized as a pump or motor and wherein the meshing teeth of two revolving gears separate a suction chamber from a pressure chamber.

It is an important object of our invention to provide a rotary hydraulic pump or motor which produces a minimum of noise, even if it operates at very high pressures, and to bring about such reduction in noise with a minimum of expenditure in time or money and without adding to the bulkiness of the apparatus.

Another object of the invention is to provide a hydraulic pump or motor wherein appreciable reduction in noise may be brought about by suitable configuration and mounting of component parts which are invariably present in a hydraulic pump or motor and wherein such component parts, or portions thereof, perform at least one additional function.

A further object of the invention is to provide a hydraulic pump or motor wherein considerable reduction in noise may be achieved by proper configuration and mounting of bearings for the shafts of meshing gears which separate the inlet from the outlet and which actually compress the fluid.

An additional object of the invention is to provide a hydraulic pump or motor wherein a substantial reduction in noise may be brought about simultaneously with at least partial elimination of cavitation in the compartments between the teeth of meshing gears and wherein such elimination or partial elimination of cavitation is incidental to a reduction in noise.

Still another object of the invention is to provide a hydraulic pump or motor wherein a very substantial reduction in noise may be brought about despite the fact that the apparatus utilizes conventional spur gears, helical gears or similar toothed pressure generating elements and wherein at least some reduction in noise is incidental to proper sealing action along the end faces of meshing gears.

A concomitant object of our invention is to provide a hydraulic apparatus of the above outlined characteristics whose noise-eliminating or noise-reducing action can be selected and/or regulated in a very simple and time-saving manner so that, and assuming the user finds that the fully assembled apparatus produces excessive noise, such apparatus can be readily and rapidly modified to further reduce the noise.

A further object of the invention is to provide a hydraulic apparatus wherein the reduction in noise is incidental to proper sealing action along the suction and pressure chambers and wherein such reduction in noise is also incidental to at least partial elimination of cavitation in the compartments defined by the teeth of meshing gears.

Briefly stated, one feature of our invention resides in the provision of a hydraulic pump or motor which comprises a housing including two spaced end walls each having a surface facing and being parallel with and spaced from the surface of the other end wall, a pair of gears located between the end walls and having meshing teeth, gear-supporting shafts journaled in the end walls, a fluid-admitting inlet provided in the housing, and a fluid-evacuating outlet provided in the housing. The two gears

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define with the housing a suction chamber which communicates with the inlet and a pressure chamber which communicates with the outlet and is separated from the suction chamber by the intermeshing teeth of the two gears.

In accordance with our invention, the surface of at least one end wall is provided with at least one fluid-accommodating sound-absorbent recess having an open end located at least partially outside of the root circle of one of the gears and adjacent to the pressure chamber. Thus, the recess communicates with consecutive compartments between the teeth of the respective gear. It was found that the provision of one or more such recesses contributes greatly to a reduction in noise, and this surprising phenomenon is believed to be attributable to the fact that such recess or recesses serve as storage rooms for hydraulic fluid and compensate for high-frequency fluctuations in fluid pressure which prevails in the aforementioned compartments.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved hydraulic apparatus itself, however, both as to its construction and its mode of operation together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a hydraulic pump or motor provided with sound-absorbent recesses which are distributed and dimensioned in accordance with a first embodiment of our invention, a portion of the housing being broken away to reveal the pressure chamber and the end walls of the apparatus;

FIG. 2 is an enlarged end elevational view of one of the end walls substantially as seen in the direction of the arrow II in FIG. 1;

FIG. 3 is a transverse section through the end wall as seen in the direction of arrows from the line III—III of FIG. 2;

FIG. 4 is an end elevational view of an end wall which constitutes a modification of the end wall shown in FIG. 2;

FIG. 5 is a fragmentary section substantially as seen in the direction of arrows from the line V—V of FIG. 4;

FIG. 6 is an end elevational view of a third end wall;

FIG. 7 is a fragmentary section as seen in the direction of arrows from the line VII—VII of FIG. 6; and

FIG. 8 is another fragmentary section substantially as seen in the direction of arrows from the line VIII—VIII of FIG. 6.

Referring first to FIG. 1, there is shown an apparatus which may be used as a hydraulic pump or motor and comprises a composite housing 10 including a cupped portion or shell 10a and a cover or lid 12. These two parts define between themselves an internal space 11 of 8-shaped cross section. The space 11 accommodates two flat plate-like end walls 17, 18 which constitute bearing members for the shafts 15, 16 of two meshing gears here shown as spur gears 13, 14. The end face of the shell 10a is provided with an annular groove which accommodates a sealing ring 12a. This ring is compressed by the adjoining face of the cover 12 which is connected to the shell by a series of bolts (not shown) passing through registering holes 10b, 12b. The gears 13, 14 are accommodated in that zone of the internal space 11 which extends between the inner surfaces 17a, 18a of the end walls 17, 18. Such teeth of the gears 13, 14 which are in mesh with each other separate the zone between the surfaces 17a, 18a into a pressure chamber 20 and a suction chamber which latter is not shown in FIG. 1. The shell 10a is provided with a fluid-evacuating outlet 19 which com-

municates with the pressure chamber 20 and with a fluid-admitting inlet (not shown) which communicates with the suction chamber.

FIG. 1 shows further that the outer surface 17b of the end wall 17 defines with the cover 12 a shallow reservoir 24 which is surrounded by an elastic sealing element 23 consisting of rubber or the like. This reservoir 24 communicates with the pressure chamber 20 through a bore 25 which extends between the surfaces 17a, 17b of the end wall 17. FIG. 3 shows that the other end wall 18 is formed with a similar bore 25 which allows compressed fluid to flow from the chamber 20 to a second reservoir 24 surrounded by a second elastic sealing element 23 which is recessed into the outer surface 18b and is compressed by the bottom wall of the shell 10a.

Referring now to FIG. 2, it will be seen that the end wall 18 resembles a spectacle frame and is formed with two relatively large circular openings 26, 27 for the corresponding end portions of the shafts 15, 16. These openings respectively communicate with L-shaped slots 28, 29 which provide the end wall 18 with two flexible tongues 30, 31. The tongues 30, 31 are connected with the main portion of the end wall 18 by two narrow webs which are respectively adjacent to cutouts 34, 35. Such construction lends flexibility to the tongues 30, 31 whose peripheral surfaces 30a, 31a are provided with reservoirs (not shown) analogous to the reservoirs 24 and allowing the fluid to press the tongues against the respective shafts.

The noise which develops when the hydraulic apparatus of FIG. 1 is in actual use is reduced due to the provision of two pairs of elongated recesses 37, 38, one pair for each of the end walls 17, 18. FIGS. 2 and 3 show that the recesses 37, 38 of the end wall 18 are mirror symmetrical with reference to each other and resemble blind bores of relatively large cross-sectional area whose open ends are located at the inner surface 18a. These recesses terminate short of the outer surface 18b and their open ends are located at least partially outside of the root circles of the gears 13, 14. Also, both open ends are closely adjacent to the pressure chamber 20. Since the diameters of the recesses 37, 38 are rather large and since the recesses extend a little less than all the way between the surfaces 18a, 18b, they can accommodate relatively large quantities of compressed leak fluid which bleeds between the surface 18a and the adjoining end faces of the gears 13, 14 but the bulk of which is received from the compartments or tooth spaces between the teeth of the gears 13 and 14. It was found that, by the simple expedient of providing such recesses in at least one of the end walls 17, 18, the noise is reduced to a surprising degree, especially if the apparatus of FIG. 1 is used as a pump, i.e., when the shaft 15 is driven by an electric motor or the like so that the gears 13, 14 draw fluid through the inlet and cause the outflow of compressed fluid through the outlet 19. We believe that such reduction in noise is due to the fact that the recesses 37, 38 serve to store compressed fluid and that such fluid compensates for high-frequency fluctuations in the pressure prevailing in the pressure chamber 20. The fluid which flows through the bores 25 and into the respective reservoirs 24 generates pressure between the outer surfaces 17b, 18b and the adjoining portions of the housing 10 so that the surfaces 17a, 18a bear against the end faces of the gears 13, 14 and prevent excessive leakage.

The end wall 17 is preferably provided with similar recesses 37, 38 the open ends of which are located at the surface 17a and are disposed at least partially outside of the root circles of the gears 13, 14 but close to the pressure chamber 20.

Referring now to FIGS. 4 and 5, there is shown a modified end wall 118 which may be utilized as a substitute for the end wall 17 or 18. The main difference between the end walls 18, 118 is that the latter is provided with two pairs of fluid-accommodating or storing noise-reducing recesses 39, 41 and 40, 42. The open ends of these

recesses are located at the inner surface 118a of the end wall 118 and each pair of recesses communicates with the bore 25 (and hence with the reservoir 24) through an inclined channel in the form of a blind bore 43, 44. Thus, the channel 43 connects the inner ends of the recesses 39, 41 with the bore 25, and the channel 44 connects the bore 25 with the inner ends of the recesses 40, 42. FIGS. 4 and 5 show that the axes of the recesses 39-42 are normal to the surface 118a respectively parallel to the flanks or to the flank line 20' (FIG. 1) of the gear teeth and that the distance between the larger-diameter recesses 41, 42 and the bore 25 is less than the distance between the bore 25 and the smaller-diameter recesses 39, 40, i.e., the open ends of the recesses 41, 42 of larger cross-sectional area are nearer to the pressure chamber 20. The open ends of the recesses 40, 42 are located at least partially outside of the root circle 13' of the gear 13, and the open ends of the recesses 39, 41 are located at least partly outside of the root circle 14' of the gear 14. Each of these recesses resembles a blind bore. It will also be seen from FIG. 4 that the space between adjacent gear teeth first communicates during rotation of the gears with the open ends of the recesses located at the surface 118a and only thereafter with the pressure chamber 20.

In the embodiment of FIGS. 4 and 5, fluid stored in the reservoir 24 and in the bore 25 of the end wall 118 also contributes to a reduction in noise because the bore 25 is in communication with the recesses 39-42. The housing of the pump or motor which utilizes end walls of the type shown in FIGS. 4 and 5 will have at least some flexibility and any pulsations developing in the compartments or spaces between the teeth of the gears 13, 14 are damped by fluid which is stored in the composite reservoir including the reservoir 24 proper, the bore 25, the channels 43, 44 and the recesses 39-42. Such pulsations will normally develop in the compartments between the teeth of the gears 13 and 14, especially at elevated pressures. The channels 43 and 44 further provide passages for communication of certain compartments between the teeth of the gear 13 with certain compartments between the teeth of the gear 14 so that the amplitude of pulsations in each set of such compartments is substantially the same. A very important advantage of the solution described in connection with FIGS. 4 and 5 is that the reservoir 24 at the outer surface 118b of the end wall 118 performs two functions, namely, it stores fluid which will cause the surface 118a to bear against the adjoining end faces of the gears 13, 14 and such fluid also serves to reduce noise because it can communicate with fluid contained in the recesses 39-42.

It is clear that the number of recesses in the end wall 118 may be more or less than four and that the other end wall may be of similar construction and configuration. The noise-reducing characteristics of the end walls may be varied by proper selection of the combined volume of the recesses and/or by proper dimensioning of channels which, in the embodiment of FIGS. 4 and 5, connect the bores with the reservoir 24.

FIGS. 6 to 8 illustrate an end wall 218 which constitutes a further modification of the previously described end walls. The inner surface 218a of this end wall is formed with two mutually inclined recesses 47, 48 which communicate with the bore 25 (see FIG. 8) and hence with the reservoir 24 at the outer surface 218b. The open end of the recess 48 is located at least in part outside of the root circle of the gear 13, and the open end of the recess 47 is located at least in part outside of the root circle of the gear 14. Both open ends are closely adjacent to the pressure chamber.

FIGS. 6 and 7 show that the inner surface 218a of the end wall 218 is provided with an elongated fluid flow throttling groove 49 of triangular cross-sectional outline whose cross-sectional area increases in directions away from the open ends of the recesses 47, 48, i.e., the maxi-

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mum cross-sectional area of this groove is preferably located midway between the open ends of the two recesses. The groove 49 extends along the pressure chamber 20 (not shown in FIGS. 6-8) so that it allows compressed fluid to flow between the open ends of the recesses 47, 48.

The reservoir 24 of FIG. 8 performs the same dual function as the reservoir 24 of FIG. 5, and the groove 49 allows some compressed fluid to flow between the pressure chamber 20 and the nearest compartments between the teeth of the gears 13 and 14, namely, to the compartments which approach the pressure chamber. Such limited flow of pressure fluid between the chamber 20 and the compartments between adjoining teeth on the gears 13, 14 has been found to result in a very effective reduction or in complete elimination of cavitation in the compartments. In other words, the fluid medium flowing between the compartments defined by the teeth of the gears 13, 14 and the pressure chamber 20 will allow for proper regulation of pressures prevailing in the compartments.

The structure shown in FIGS. 1-3, 4-5 or 6-8 has been found to be very satisfactory in pumps or motors which operate at a very high pressure. Invariably, the noise is reduced to an acceptable level, and such reduction in noise is brought about in an extremely simple way.

The noise which develops when a rotary hydraulic pump or motor with meshing gears is in actual use is due to rise and drop in pressure prevailing in the compartments or tooth spaces between the teeth of such gears. The open ends of the recesses 37-42 and 47-48 are preferably immediately adjacent to the zones where the teeth of the gears 13, 14 enter the pressure chamber 20. The arrangement shown in FIGS. 4 and 5 has been found to be particularly effective whereas the arrangement of FIGS. 1 to 3 constitutes the simplest solution because it can be embodied in existing hydraulic apparatus, i.e., all that is needed is to drill blind bores into the inner surface 17a and/or 18a.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. In a hydraulic gear pump, in combination, a housing including two end walls each having a surface spaced from and facing the surface of the other end wall; and a pair of rotary gears located between said surfaces and having meshing teeth, said gears defining with said housing a suction chamber and a pressure chamber separated

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from each other by said meshing teeth, at least one of said end walls being provided with at least two elongated recesses, one for each gear, said recesses having open ends in said surface located at least partially outside of the root circle of the respective gear, said recesses communicate at portions spaced from said open ends thereof with said pressure chamber to be filled with fluid under pressure and said open ends being spaced from said pressure chamber to such an extent that the space between adjacent gear teeth first communicates with the open end of the respective recess and only thereafter communicates directly with said pressure chamber, said recesses extending toward said surface in such a manner that pressure fluid passing from said recesses into a space between adjacent teeth of the respective gear will flow substantially parallel to the flanks of said teeth.

2. In a hydraulic gear pump as defined in claim 1, wherein the axis of each elongated recess is substantially parallel to the flanks of said teeth.

3. In a hydraulic gear pump as defined in claim 2, wherein at least one of said end walls is axially movable, said one end wall having an inner surface abutting against end faces of said gears and an outer surface defining with adjoining portions of said housing a fluid-containing reservoir communicating with said pressure chamber through a bore through said one end wall, said recesses communicating with said reservoir.

4. In a hydraulic gear pump as defined in claim 3, wherein two recesses are provided for each gear, both recesses communicating with the space between adjacent teeth of the respective gear shortly before said space opens directly into the pressure chamber, the open end at said inner surface of one of said two recesses being closer to said pressure chamber than the open end of the other recess and said one open end having a larger cross section than the other.

5. In a hydraulic gear pump as defined in claim 3, and including a throttling groove in said inner surface extending through said pressure chamber and connecting said open ends of said recesses.

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