Dec. 30, 1958 C. O. J. MONTELIUS 2,866,415

HYDRAULIC TRANSFORMERS

Filed July 13, 1954 5 Sheets-Sheet 1

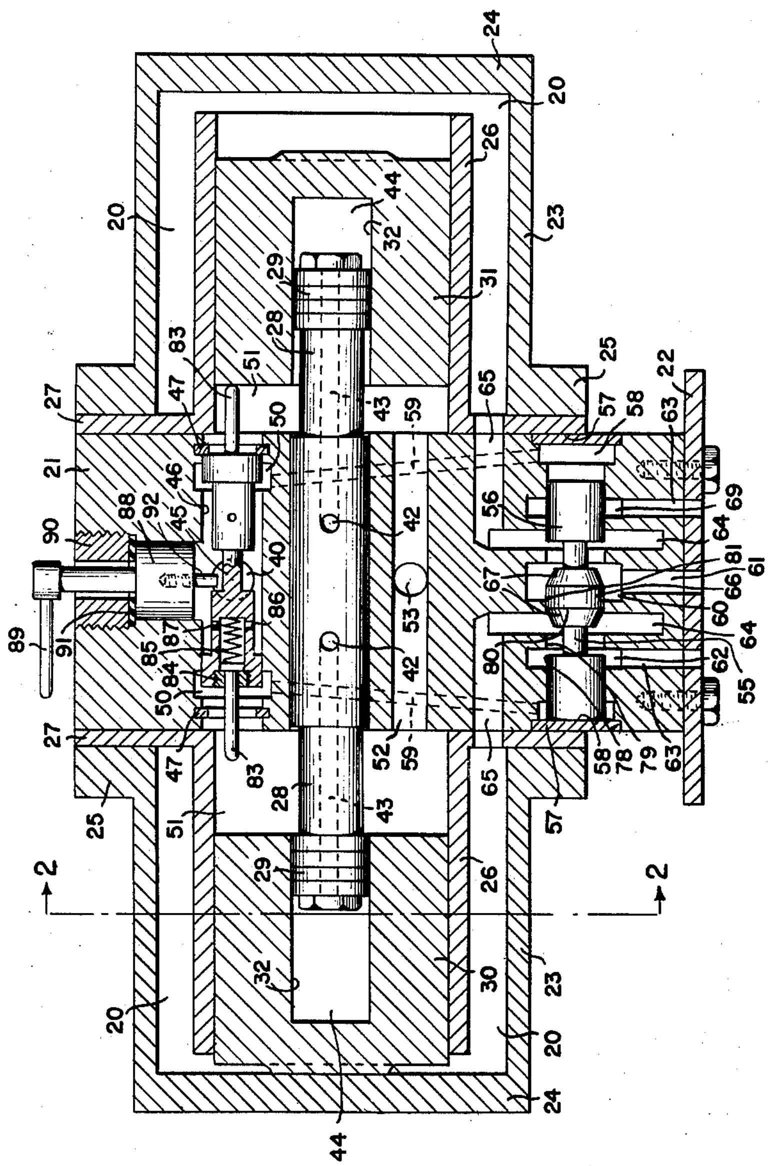

FIG. 1.

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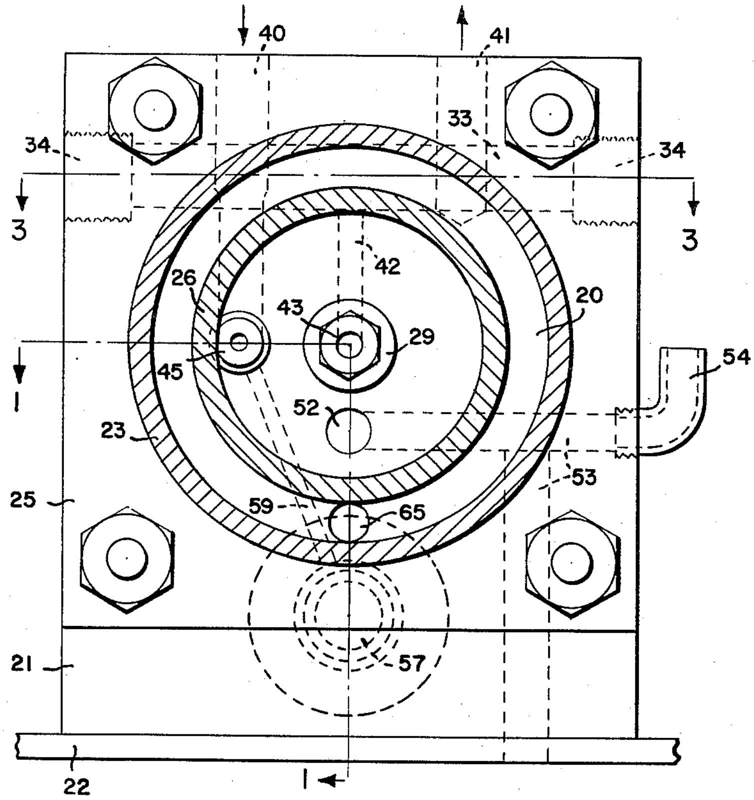

FIG. 2.

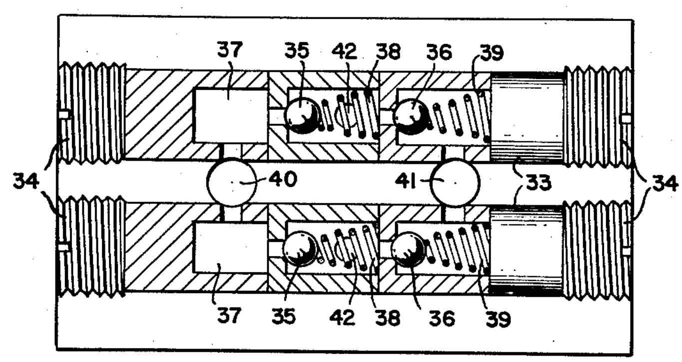

FIG. 3.

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HYDRAULIC TRANSFORMERS

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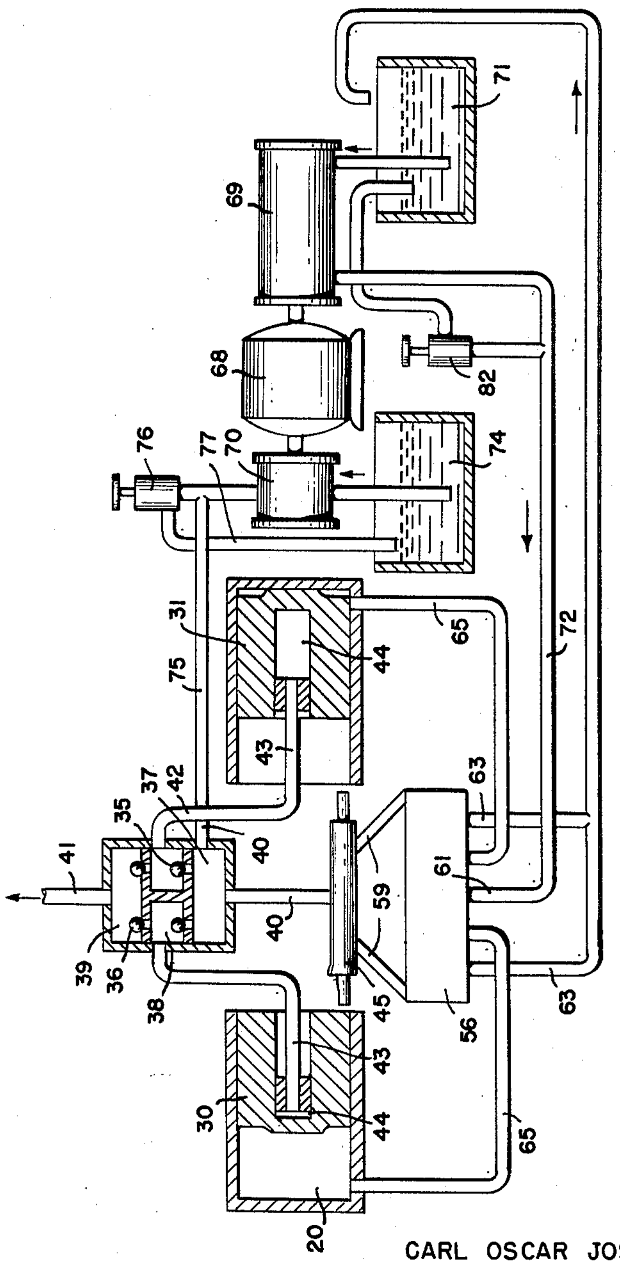

FIG. 4.

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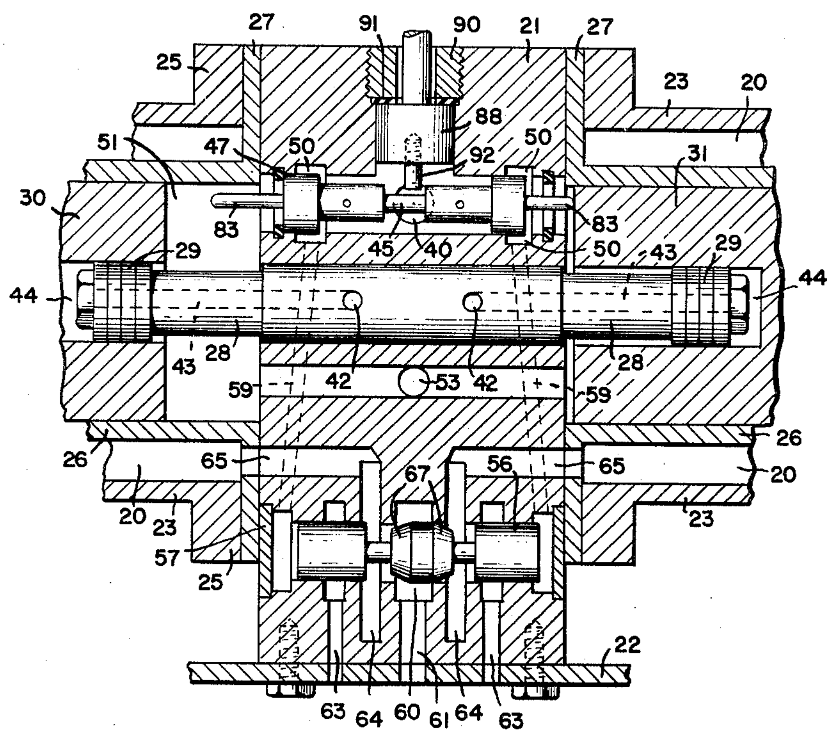

FIG. 5.

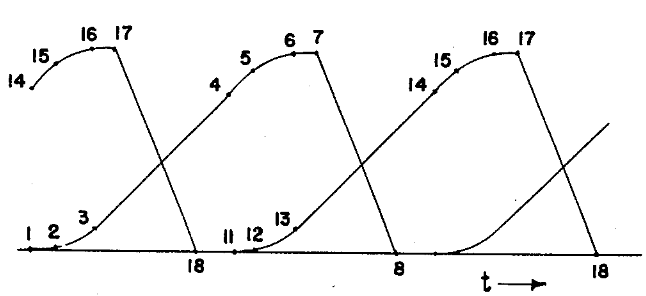

FIG. 6.

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HYDRAULIC TRANSFORMERS

Filed July 13, 1954 5 Sheets-Sheet 5

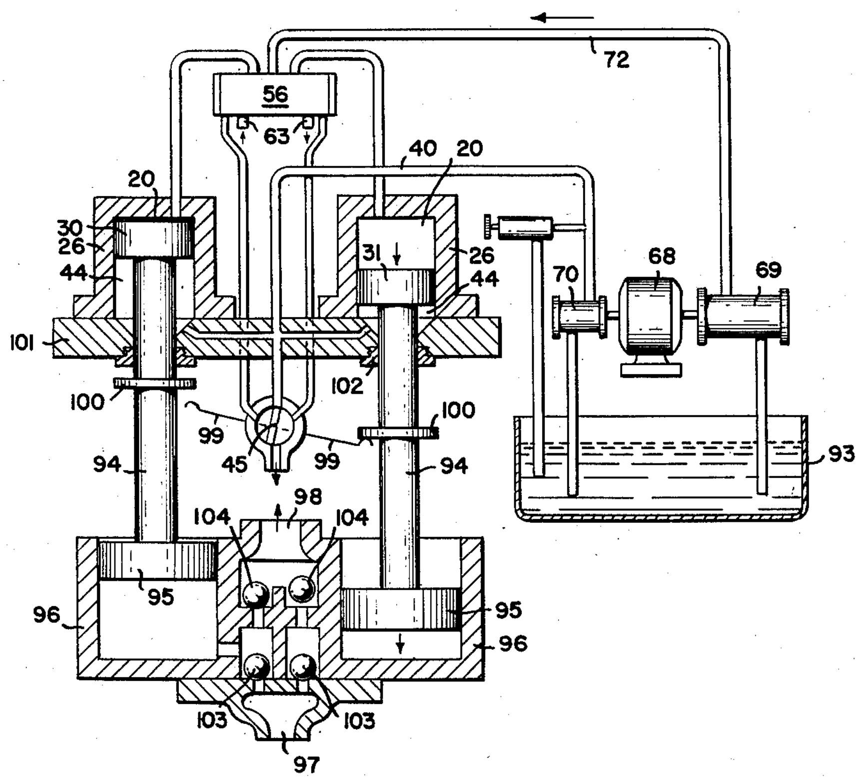

FIG. 7.

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HYDRAULIC TRANSFORMERS

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7 Claims. (Cl. 103—49)

The present invention relates to hydraulic transformers for continuously transforming a supplied stream of liquid to another stream of liquid having a higher or lower pressure and a correspondingly lower or higher rate of flow respectively, and relates more particularly to a hydraulic transformer of the type comprising at least two pistons, each operating in a cylinder and to one side of which in order to effect the working stroke a pressure liquid is supplied by means of one or more reversing valves and in which the return stroke of the pistons is effected by pressure liquid supplied to the opposite side of the pistons. In accordance with the present invention, the pressure liquid employed for the return stroke of the pistons is separate from the pressure liquid used for the working stroke, the latter pressure liquid being used solely to effect the working stroke, and the amount of pressure liquid used to return the pistons is so regulated in relation to the amount of pressure liquid used to effect the working stroke, that the total time of reversing the valves and returning a piston is less than the time of the working stroke of a piston, whereby in every working position of the device the discharge transformed liquid stream will be uniform with respect to rate of flow as well as pressure. The reversing valve or valves may be so arranged that before a piston reaches the end point of its working stroke a second piston is gradually put into operation with a simultaneous decrease of the rate of pressure liquid supplied to the first piston, in order that the hydraulic output will be maintained uniform. Preferably the reversing valve is adapted to be reversed directly or through a limit valve by the intermediary of resilient abutments actuated by the pistons in one of their end positions. Preferably, the limit valve is also adapted to be manually actuated.

In one embodiment of the invention each movable piston has a concentric bore closed at one end and forming a cylinder for a stationary piston.

In a modified form of the invention the working movable pistons have piston rods extending through gaskets in the cylinder end walls and each driving a piston pump with suction and pressure valves for pumping a second liquid.

The invention will be explained in greater detail below, with reference to the annexed drawings in which two embodiments of the invention are illustrated.

Figure 1 is a longitudinal cross-section taken along line 1—1 in Figure 2.

Figures 2 is a transverse cross-section taken along line 2—2 in Figure 1.

Figure 3 is a cross-section taken along line 3—3 in Figure 2.

Figure 4 is a diagrammatic view of the piping arrangements.

Figure 5 shows a fragment of the same longitudinal cross-section as Figure 1 with the moving parts in another position.

Figure 6 is a graphic representation of the operative positions of the pistons.

Figure 7 illustrates the second embodiment.

In Figures 1 and 2, the numeral 21 represents a valve body affixed to the top wall 22 of a liquid tank. Two casings 23, each closed at one end by an end-plate 24, are formed at their opposed ends with square flanges 25 which are screwed to opposed sides of the body 21, while simultaneously clamping therebetween the flanges 27 of a pair of cylinders 26 so that these cylinders will be concentric with a stationary piston rod 28 extending through the body 21. The piston rod 28 has packing rings 29 at its outer ends. Two movable pistons 30 and 31, each having a central bore 32 extending part way therethrough are adapted to slide on and to engage sealingly the inner surfaces of the cylinders 26 as well as the packing rings 29. Two bores 33 provided in the body 21 and extending above the stationary piston rod 28 are shown in Figures 2 and 3. These bores 33 are closed at opposite ends by threaded plugs 34 and receive sleeves which contain four non-return valves 35 and 36, which allow liquid to pass from the chambers 37 to the chambers 38 and from the chambers 38 to the chambers 39, but not in the opposite direction. A pressure liquid inlet passage 40 communicates through lateral passages in the sleeve walls with the two chambers 37, while a pressure liquid outlet passage 41 communicates in a similar manner with the two chambers 39. Each of the two intermediate chambers 38 communicates through transverse bores 42 in the housing 21 and longitudinal bores 43 in the stationary piston rod 28 with one of the working chambers 44 within the pistons 30 and 31, as seen in Figure 1. 45 is a piston limit valve and 55 a reversing valve which are shown in different positions in Figures 1 and 5 in cross-section taken along line 1—1 in Figure 2. The piston 45 of the limit valve may be displaced a short distance between two abutment rings 47 at the ends of a bore 46 provided in the housing 21 and open at both ends. The intermediate space of the piston valve 45 is maintained under pressure through the pressure conduit 40 and when the valve piston is displaced towards one or the other side, one of the two grooves 50 is set under liquid pressure, while the other groove 50 is brought into communication with the chamber 51 outside the valve body 21. The two chambers 51 communicate through the transverse bore 52 and are kept at atmospheric pressure via an outlet 53 and an air intake 54, as seen in Figure 2.

The piston 56 of the reversing valve 55 is displaceable in its bore, which is closed at each end by a cover-plate 57. Each of the two end chambers 58 between the piston 56 and the cover-plates 57 communicate with one of the grooves 50 through the inclined bores 59 (Figures 1, 2 and 5). When the valve piston 45 is moved from one side to the other, the pressure difference between the chambers 58 will be reversed and the piston 55 will move from one end position to the other. The piston bore of the reversing valve 55 has five grooves. To the intermediate groove 60 pressure liquid is supplied from the inlet 61 while the two outer grooves 62 have free discharge to a liquid reservoir through the outlets 63. The two remaining grooves 64 are deeper than the other grooves and each of them communicates through a bore 65 with one of the chambers 20 between the outer casing 23, the outside of the cylinder 26 and the outer end of the piston 30 or 31. The intermediate portion of the valve piston 55 is formed with a cylindrical part 66 having slightly tapered ends 67 so formed that when the valve piston 55 is displaced the pressure groove 60 is gradually connected with one of the grooves 64 and simultaneously the previously open communication from the pressure groove 60 to the other groove 64 is gradually closed.

The arrangement is shown diagrammatically in Figure 4. A motor 68 drives a main pump 69 as well as an auxiliary pump 70. The main pump 69 takes liquid from a reservoir 71 and delivers the liquid through the conduit 72 to the pressure liquid inlet 61 (see Figures 1, 4 and 5) from which the liquid in accordance with the position of the valve piston 55 passes to one or both of the chambers 20. The auxiliary pump 70 takes liquid from a liquid reservoir 74 and delivers it through the conduit 75 to the pressure inlet 40 (Figures 1, 2, 3, 4 and 5). The pressure in the conduit 75 is controlled by an overflow valve 76 having an outlet 77 to the reservoir 74.

When e. g. the right-hand piston 31 during its working stroke is displaced to the left by pressure liquid supplied from the main pump 69 and introduced into the chamber 20 through the groove 60, the right-hand groove 64 and the right-hand bore 65, liquid previously supplied from the auxiliary pump through the pressure inlet 40, one of the non-return valves 35, one of the chambers 38 and the bores 42, 43 to the cylinder space 44 will be forced through the bores 43, 42 to one of the chambers 38 and from this through one of the non-return valves 36 and the chamber 39 to the pressure conduit 41. In the embodiment illustrated, the liquid stream delivered to the chamber 20 by the main pump 69 and having a relatively low pressure and a relatively high rate of flow will thereby be transformed into a liquid stream taken from auxiliary pump 70 and having a relatively low rate of flow, but a relatively high pressure.

The function is illustrated by the graphical representation in Figure 6, where the horizontal axis represents the time and the vertical axis the positions of pistons 30 and 31. The numbers 1 to 8 refer to the various positions of piston 30. The numbers 1, 2 and 8 correspond to the outer end position of the piston 30 as shown in Figure 1, while the numbers 6 and 7 correspond to the inner end position of piston 30. In the same manner the numbers 11 to 18 correspond to the positions of piston 31.

In the positions of the valves and pistons which are shown in Figure 1, the valve piston 45 is in its right-hand end position. The pressure in the pressure conduit 40 communicating with the auxiliary pump 70 is transmitted to the right-hand groove 50 and from this it enters through the bore 59 the right-hand end-chamber 58 of the piston valve 55, whereby the valve piston 56 will be brought into its left-hand end position. The space 20 around the left-hand cylinder 26 which communicates through bore 65 with the left-hand groove 64 of the reversing valve 56 then communicates with the groove 62 and its outlet 63, wherefore it is pressure-free. The chamber 44 within the piston 30, on the other hand, is under pressure in that that chamber communicates through one of the nonreturn valves 35, one of the chambers 38 and the bores 42 and 43 with the pressure liquid supply conduit 40, so that the piston 30 is kept in its outer end position. The other piston 31 receives pressure liquid from the main pump 69 through conduit 72, inlet 61, the passage from the groove 60 to the right-hand groove 64 and through the bore 65 to the chamber 20 at the outer end of the piston 31. Thereby, the piston 31 will be displaced inwardly, whereby the liquid in its chamber 44 will be forced through the bores 43 and 42 to the chamber 38 (Figure 3) and from this through a non-return valve 36 to the chamber 39 and to the pressure liquid outlet conduit 41, as explained above.

Point 14 in Figure 6 refers to the position of piston 31 in which this engages the limit valve 45, as shown in Figure 1. In the continued movement of piston 31, the valve 45 will be displaced to the left, whereby the pressure of the auxiliary pump 70 through the pressure conduit 40 and the corresponding bore 59 will act in the left-hand chamber 58 instead, whereby the valve piston 56 will be displaced to the right. In this movement first the chamber 20 of the piston 30 will be disconnected by the edge 78 of the piston valve 55 reaching the edge 79 of the groove 62 and a moment later, when the edge 80 of the valve 55 has passed the edge 81 of the pressure groove 60 the chamber 20 corresponding to the piston 30 will be subjected to pressure. Thus, both pistons 30 and 31 will move inwardly simultaneously. In Figure 6 this is represented by the curve portions 15—16 and 2—3. As the passage from the groove 61 to the piston 30 is at first very little to increase gradually, the speed of the piston 30 will increase gradually from point 2 to point 3, while the speed of piston 31 will diminish gradually, as seen from the curve portion 15—16. Figure 5 shows the position corresponding to points 3 and 16, when the piston 31 has stopped in its inner end position, point 16, while piston 30 moves at full speed in the direction from 3 to 4 in Figure 6. If the rate of liquid supply of pump 69 is uniform, the speeds of pistons 30 and 31 will be equal (curve portions 3—4 and 13—14 respectively), and in the transition period (curve portions 2—13 and 15—16 respectively) in each instant the sum of the speeds will be uniform and equal to the full speed of either piston. The rate of liquid delivered from the two spaces 44 within the pistons 30 and 31 to the high-pressure outlet 41 will therefore be entirely uniform, due to the fact that the total amount of liquid delivered by the main pump 69 is in each instant employed solely to drive pistons 30 and 31 inwardly. Therefore, if also the pump 69 is provided with a safety valve 82, this must not be opened in normal circumstances.

It will be noted that when piston 31 has reversed the limit piston valve 45 and this has stopped against its abutment 47, the piston 31 has not yet reached the end of its movement. It is therefore preferable to make the abutments 83 of piston 45 resilient. In the embodiment shown in Figure 1, said abutments are formed as small pistons, each of which is movable in a bushing 84 screwed into valve 45 and is subjected to fluid pressure in the chamber 85, which communicates through bores 86 with the pressure conduit 40 of the auxiliary pump. A spring 87 can be employed instead of or together with the hydraulic resiliency.

It may happen that the system does not operate due to the fact that the pistons and valves are not initially in their correct positions or due to the fact that the overflow valve 76 of the auxiliary pump has been set at too low a pressure and the pistons 30 and 31 cannot be returned sufficiently rapidly. To remove this disadvantage, the valve body may be provided with a piston 88 which extends through a threaded plug 90 with a gasket 91 and can be turned through a certain angle by means of a handle 89. An eccentric pin 92 secured to the piston 88 will then act upon the piston 45 and displace it towards either side. By turning the handle 88 in either direction, the device can always be started in a desired manner. The condition to be fulfilled in order that the device shall function in the desired manner is that the pistons 30 and 31 are always returned at the right moment, i. e. that (see Figure 6) the point 18, when the piston 31 is in its outer end position, occurs prior to point 4 when the piston 30 reverses valve 45 and that similarly, the point 8, when the piston 30 is in its outer end position occurs prior to point 14 when piston 31 reverses the valve 45. This means that the combined time of the valve moment, 14—17 and 4—7 respectively, and of the return strokes of the pistons, 17—18 and 7—8 respectively, shall be shorter than the duration of the working stroke which is equal to the duration of a cycle, e. g. from 8 to 18 or from 7 to 17 etc. Since the period of valve reversal as well as that of the return of the pistons are dependent on the capacity of the auxiliary pump 70, while the duration of the working stroke or the time of a cycle depends on the capacity of the main pump 69, it is necessary in order that the pump shall operate in accordance with this invention that the minimum capacity of the auxiliary pump must be a certain proportion of the capacity of the main pump. An unnecessarily great capacity of the auxiliary pump, however, has no other consequence than unnecessarily rapid return movements of the valves and pistons and an unnecessarily great effect requirement thereof.

The embodiment illustrated which has separate liquid reservoirs **71** and **74** is convenient in case the high-pressure conduit **41** shall convey a poorly lubricating liquid, since then it is possible to have the main pump **69** operating with a more suitable liquid. In the case that corrosive or impure liquids shall be pumped, the embodiment of Figure 7 is suitable. Both the main pump **69** and the auxiliary pump **70** in this embodiment take liquid, suitably lubricating oil, from the same reservoir **93** and the working pistons **30** and **31** have stout piston rods **94**, each driving a single-acting piston **95** movable in a cylinder **96** having suction valves **103** and pressure valves **104**, a suction inlet **97** and a pressure outlet **98** for the corrosive or impure liquid. To keep this liquid further removed from the other operating parts of the device, the pistons **30** and **31** with their pump cylinders are attached to a common bottom plate **101** having gaskets **102** for the piston rods **94**. The conduit arrangement of the main pump is entirely similar to that described in connection with Figure 4. The auxiliary pump **70** on the other hand delivers its pressure liquid directly without non-return valves to the chambers **44** below the pistons **30** and **31**, while the discharge conduit **41** of Figures 2, 3, 4 with the non-return valves **36** is omitted. In this embodiment the limit valve **45** is suitably formed as a rotary valve actuated by resilient arms **99**, which are operated in the movement of the piston rods **94** by abutment flanges **100** secured thereto.

The function and the movement schedule according to Figure 7 are entirely the same as described above. In this case, too, the liquid pumped through the intake **97** and the pressure outlet **98** will be completely uniform in rate of flow and free from pulsations provided that the main pump **69** delivers a completely uniform and pulsation-free liquid flow.

Having now particularly described the nature of the invention and the manner of its operation what is claimed is:

1. A hydraulic transformer for continuously transforming a supplied liquid stream into a liquid stream of different flow rate and pressure comprising two stationary cylinders, two pistons movable in said stationary cylinders and having cylinder forming bores, two stationary pistons each extending into one of said cylinder forming bores, means for alternatingly supplying a first pressure liquid to the other sides of each of said movable pistons to effect the piston working stroke, means for supplying a second pressure liquid to the cylinder forming bores in each of said movable pistons to effect the piston return stroke and to form upon the working stroke of its piston the transformed liquid stream, means for receiving the transformed liquid streams from both pistons, valve means restricting the transformed liquid flow to flow from said pistons to said receiving means, said second pressure liquid completing the return stroke of each piston before the other piston reaches the end of its working stroke, said first mentioned supplying means acting to supply the first pressure liquid to each piston before the other piston reaches the end of its working stroke and including means for supplying pressure liquid to each of the pistons before interrupting the supply thereof to the other piston in order that in each operative position of the transformer the delivered transformed liquid stream shall be maintained substantially uniform in rate of flow as well as in pressure.

2. A hydraulic transformer as specified in claim 1 in which said stationary cylinders are in opposed longitudinal axial positions, said stationary pistons are in opposed longitudinal axial positions and in which the supply of second pressure liquid is through said stationary pistons to the cylinder forming bores in said movable pistons.

3. A hydraulic transformer for continuously transforming a supplied liquid stream into a liquid stream of different flow rate and pressure comprising two cylinders, two movable pistons each operating in one of said cylinders, means actuated by said pistons for alternatingly supplying a first pressure liquid to one side of each of said pistons to effect the piston working stroke, means for supplying a second pressure liquid to the other sides of each of said pistons to effect the piston return stroke and forming upon the working stroke of its piston the transformed liquid stream, means for receiving the transformed liquid streams from both pistons, valve means restricting the transformed liquid flow to flow from said pistons to said receiving means, said second pressure liquid completing the return stroke of each piston before the other piston reaches the end of its working stroke, said first mentioned supplying means acting to supply the first pressure liquid to each piston before the other piston reaches the end of its working stroke and including means for supplying pressure liquid to each of the pistons before interrupting the supply thereof to the other piston and means for gradually decreasing the rate of supply of said first pressure liquid to each piston while gradually increasing the rate of supply of said first pressure liquid to the other piston in order that in each operative position of the transformer the delivered transformed liquid stream shall be maintained substantially uniform in rate of flow as well as in pressure.

4. A hydraulic transformer for continuously transforming a supplied liquid stream into a liquid stream of different flow rate and pressure comprising two cylinders, two movable pistons each operating in one of said cylinders, a fluid operated reversing valve for alternatingly supplying a first pressure liquid to one side of each of said pistons to effect the piston working stroke, valve means actuated by said pistons for controlling flow of operating fluid to said reversing valve, means for supplying a second pressure liquid to the other sides of each of said pistons to effect the piston return stroke and forming upon the working stroke of its piston the transformed liquid stream, means for receiving the transformed liquid streams from both pistons, valve means restricting the transformed liquid flow to flow from said pistons to said receiving means, said first pressure liquid being used solely to effect the piston working stroke, said second pressure liquid completing the return stroke of each piston before the other piston reaches the end of its working stroke, each piston actuating said second mentioned valve to actuate said reversing valve before the piston reaches the end of its working stroke, and said reversing valve including means for supplying pressure fluid to each of the pistons before interrupting the supply thereof to the other piston in order that in each operative position of the transformer the delivered transformed liquid stream shall be maintained uniform in rate of flow as well as in pressure.

5. A hydraulic transformer as specified in claim 4 in which said reversing valve includes means for gradually decreasing the rate of supply of said first pressure liquid to each piston before it reaches the end of its working stroke while gradually increasing the rate of supply of said first pressure liquid to the other piston in order that the hydraulic output will be maintained uniform.

6. A hydraulic transformer as specified in claim 4 in which the valve means actuated by the pistons for controlling flow of operating fluid to the reversing valve is actuated by said pistons through resilient abutments.

7. A hydraulic transformer as specified in claim 5 including means for manually actuating said second mentioned valve means.

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