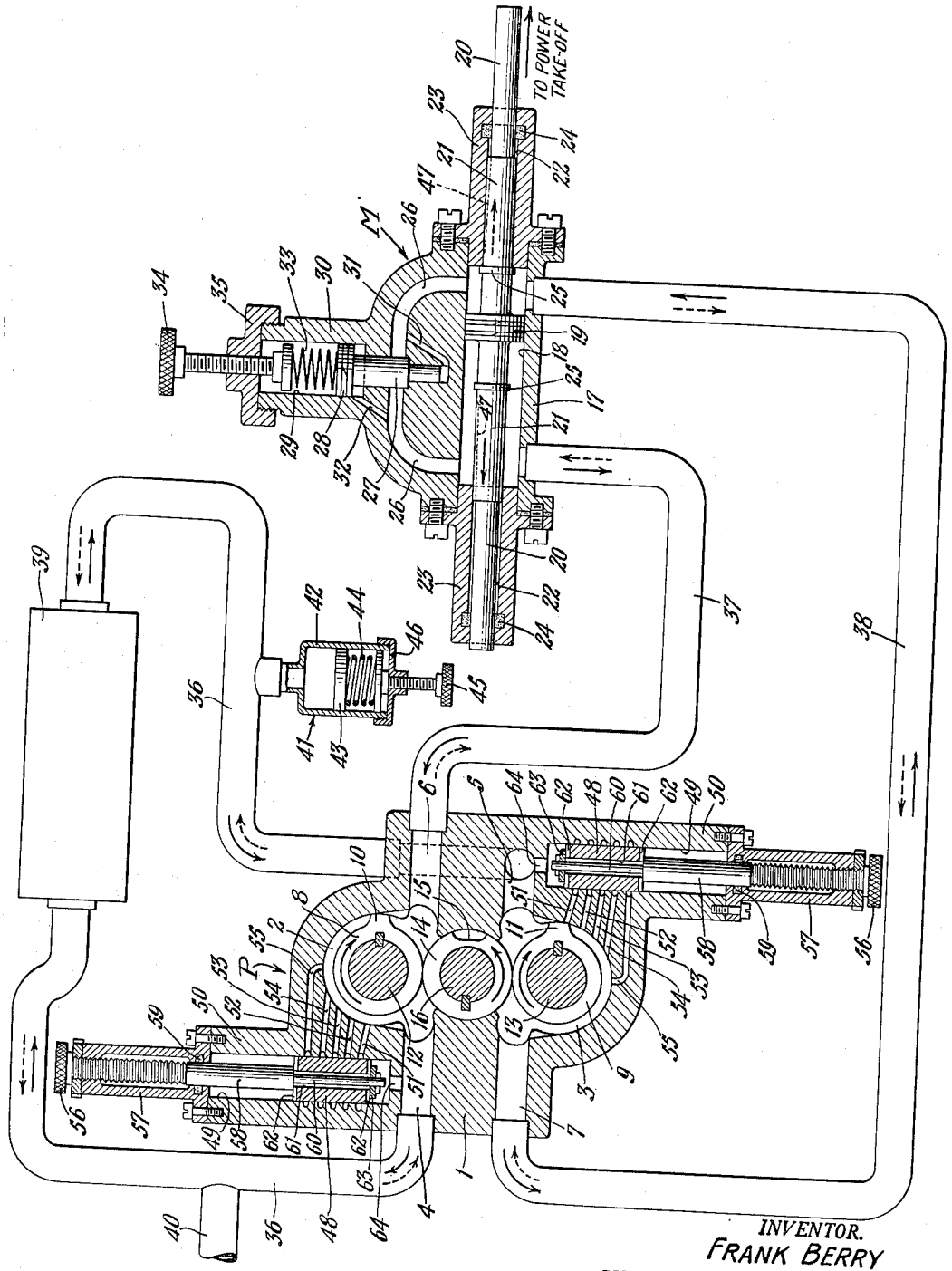
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HYDRAULIC POWER CONVERTER

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HYDRAULIC POWER CONVERTER

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The invention relates to hydraulic power converters.

SUMMARY

According to my invention, two rotary hydraulic pump devices mechanically driven from any source of rotary power, are hydraulically coupled to a reciprocatory hydraulic motor in alternate phase relationship so that each pump works one-half of the time, and so that during the time each pump is idling it is acting as a valve to by-pass liquid between the motor and the pump that is working; and I arrange a by-pass relief valve around the motor, this valve being adjustable to operate at a predetermined pressure to bring, and keep, the motor automatically in phase with the pump devices. In practice, I make the two pump devices as an integral unit driven from a common power source.

In my preferred construction I also provide a series of by-pass channels between each rotary pump cylinder and the fluid inlet to such cylinder, and a valve arranged to open or close one or more of such by-pass channels sequentially to predetermine the length of stroke of the reciprocatory motor piston.

It is a particular object of my invention to provide a direct hydraulic drive between the rotary pumps and reciprocatory motor without intervening valves of any kind, the only basic valve requirement being the auxiliary by-pass valve for automatic regulation of the phase relationship between the rotary and reciprocatory elements. There is no valve between the pump pistons and the motor piston.

Other objects and advantages of my invention will appear as the description proceeds.

DESCRIPTION

The drawing illustrates my invention in what I presently consider to be its best form and arrangement. The two pump devices in this case are made as an integral unit which, together with the reciprocatory motor, are shown in cross-section taken at the centerline of the cylinders, with the pistons, piston rod, piston rotors and rotary abutment shown in elevation. For simplicity of illustration the fluid conduits and the cooler unit likewise are shown in elevation.

I prefer to employ a rotary pump assembly of a kind which is generally known in the art as the rotary abutment type of unit. Details of the construction and operation of this type of unit are well known. See, for example, my prior patents, Nos. 2,464,481 and 2,536,486. A form of this unit which is particularly adapted for use in con-

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junction with my present invention is shown and described in my prior patent No. 2,614,503, known commercially as a "pancake" type unit in which there are two annular pump cylinders arranged in a common plane with the rotary abutment valve between so as to act as a valve for the pistons of both cylinders. However, this is incidental to the operation of my present invention which in essence requires the use of two rotary pump devices driven from a common source of rotary power in such phase relationship that in operation each spells the other, i. e. one pumps while the other idles, and vice versa.

The pump assembly

Referring to the drawing, the rotary pump assembly is indicated generally by reference P and the reciprocatory motor by reference M. The pump assembly comprises a casing 1 in which are formed a pair of annular pump cylinder 2 and 3, having fluid inlets 4 and 5 and fluid outlets 6 and 7, respectively.

Definition.—The terms "inlets" and "outlets" as used herein and in the appended claims are employed primarily with reference to the passageways or ports which act as inlets or outlets for the hydraulic fluid during the power stroke of the pump. Since, as I shall describe, the fluid flow through each pump reverses during that half of the cycle in which that pump is idling, it will be understood that the fluid then flows in through the "outlet" and out through the "inlet." This secondary function of the inlets and outlets need give rise to no confusion so long as it is remembered that I use the terms (1) to designate the passages irrespective of their function, and (2) to indicate the primary function of those passages during the power stroke of the pump.

Piston rotors 8 and 9 with pistons 10 and 11 are arranged in the respective annular cylinders 2 and 3. The pistons may be integral with the rotors, and the rotors may be integral with their shafts 12, 13 or affixed thereto. The rotors are driven from a rotary power source such as an electric motor or internal combustion engine.

In the preferred construction shown, a rotary abutment 14 having a recess 15 to clear each piston as it passes the abutment is arranged between the two annular pump cylinders 2 and 3. Shaft 16 of the rotary abutment is geared to the shafts 12 and 13 of the pumps in a gear ratio of 1:1. The prime mover for driving the pumps may be coupled to shaft 16 of the rotary abutment or to the shaft 12 or 13 of either of the pump rotors as desired. This concludes the gen-

eral description of the annular pumps. The volume or stroke control feature of these pumps will be described later, as this feature can best be understood following a description of the reciprocatory hydraulic motor and the manner in which the latter is driven from the pumps.

The hydraulic motor

The reciprocatory hydraulic motor comprises in its general arrangement a casing 17 in which is formed a cylinder 18 carrying a fluid driven reciprocatory piston 19. A rod 20 extends from the piston to a reciprocatory power take-off (not shown). Rod 20 has a section 21 forming a plunger reciprocating in an auxiliary cylinder 22 communicating with motor cylinder 18. In the construction specifically illustrated, rod 20 is formed as an integral extension of the piston 19 and is of stepped construction at each side of the piston so as to provide plunger 21 at each side thereof, and there are auxiliary cylinders 22 for each of the plungers formed in end casing members 23 bolted to the main casing 17. Suitable glands or O rings 24 are received in recesses in the ends of the auxiliary cylinders to afford a seal where the reciprocatory rod 20 extends through the end casing members. Stops 25 on the rod limit the extent of travel of the piston 19 in either direction.

Inclined channels 47 in each of the plungers 21 provide for variable flow of the hydraulic fluid between motor cylinder 18 and the respective auxiliary cylinders 22. Because the channels are inclined, and therefore progressively smaller in cross-section in the direction toward the piston 19, the flow of the hydraulic fluid from auxiliary cylinder 22 into the main motor cylinder 18 becomes more and more restricted as the plunger 21 moves into the auxiliary cylinder. This restricting or "pinching off" of the flow provides a shock control which cushions the action of piston 19 as it reaches the end of its stroke and reverses direction. Thus this shock control feature comprises the provision of a passageway 47 of variable cross-section (progressively greater cross-section in a direction away from the piston) so that liquid flowing from the auxiliary cylinder 22 into the motor cylinder 18 must pass through a channel which becomes progressively smaller as the piston 19 reaches the end of its stroke.

Automatic timing means

A by-pass channel 26 connects the two ends of the motor cylinder together and a valve 27 in this channel is operable in response to a predetermined fluid pressure in either end of the motor cylinder to open the channel 26 and by-pass liquid until the motor piston 19 reaches the end of its stroke. Valve 27 is received in bores of casing 17 and carries at its upper end a piston 28 received in a cylinder 29 formed in an extension 30 of the casing. A passage 31 connects the inner end of the valve bore with the by-pass channel 26 at one side of the valve 27 and passage 32 connects the inner end of cylinder 29 with the by-pass channel 26 at the other side of the valve. The valve 27 is urged inwardly toward its closed position by means of a compression spring 33, the initial compression of which is adjusted by hand screw 34 threaded in the end cap 35 of cylinder 29. Operation of the motor and its automatic timing device can best be considered after a description of the hydraulic connections between the pumps and motor which here follows:

It will be remembered that there is a pair of fluid inlets 4 and 5, and a pair of fluid outlets 6 and 7, in each case one for each pump cylinder. In the preferred construction illustrated, inlets 4 and 5 are connected together by fluid conduit 36, outlet 6 is connected to one end of motor cylinder 18 by conduit 37, and outlet 7 is connected to the other end of the motor cylinder by conduit 38. An alternative arrangement which is equally satisfactory is to connect the outlets 6 and 7 together and connect the inlets 4 and 5 to the respective ends of the motor cylinder 18, the arrangement being otherwise exactly as shown in the drawing. At any convenient point in the hydraulic system a cooler 39 of conventional construction may be installed. Oil or other operating fluid is introduced, and from time to time replenished as need be, through a suitable connection 40. Also it is desirable to provide a spring-loaded accumulator 41 communicating with one of the fluid conduits. This consists of a simple cylinder device 42 in which is a piston 43, spring-pressed by compression element 44 the initial compression of which is adjustable by means of a thumb screw 45 threaded in the end cap 46 of cylinder casing 42.

Having regard to the alternative arrangements of the fluid connections, it will be observed that selected pairs of the fluid inlets 4, 5 and outlets 6, 7 are connected by fluid conduits as follows: one pair connected together, one member of the other pair connected to one end of the motor cylinder and the other member of said other pair connected to the other end of the motor cylinder.

Operation of the converter and automatic timer

Operation will first be considered without regard to the stroke control mechanism which remains to be described. It has been stated that the two rotary pump devices are in such phase relationship that in operation each spells the other, i. e. one pumps while the other idles, and vice versa. Flow of the hydraulic fluid through the several conduits is indicated in the drawing by means of arrows. There are two sets of these arrows, one in which the stems of the arrows are represented by full lines and the other in which the stems are dotted. The full line arrows indicate the direction of flow when the lower one of the two rotary pump devices is pumping and the upper one idling, i. e. when piston 11 is in its power stroke in cylinder 3 of the lower pump. The dotted line arrows indicate the direction of flow when the upper pump is working and the lower pump idling. Similarly the full line arrow superimposed on the left-hand plunger 21 of the hydraulic motor M indicates the direction of movement of the motor piston assembly when the lower pump is operating in its power stroke, and the dotted line arrow superimposed on the right-hand plunger 21 indicates the direction of movement of the motor piston assembly when the upper pump is operating in its power stroke. With the position of the movable parts of the pumps as shown in the drawing, the piston 11 of the lower pump is beginning its power stroke and the piston 10 of the upper pump is beginning to idle. During the power stroke of the lower pump, liquid is discharged under pressure from outlet 7, flows through conduit 38 and moves motor piston 19 to the left in the direction of the full line arrow superimposed on left-hand plunger 21. On what is then the low pressure side of motor piston 19, i. e. to the left thereof, the low pressure liquid is withdrawn through conduit 37, thence through the idling upper pump, conduit

36, cooler 39, and finally is drawn into the pump casing at the low pressure side of piston 11.

As the piston of the lower pump reaches the end of its power stroke and piston 10 of the upper pump the beginning of its power stroke, flow is reversed to the direction indicated by the dotted line arrows throughout, and motor piston 19 is moved in the direction of the dotted line arrow superimposed on plunger 21 at the right of the motor piston assembly. Thus the lower pump moves piston 19 to the left, thereafter the upper pump moves it back to the right, and so on. This is accomplished entirely without the use of valves between the pump pistons and the motor piston.

The manner in which the motor is timed automatically to bring it into proper phase relationship with the pumps will now be described. Let us assume the existence of a temporary condition under which the motor and pumps are slightly out of phase so that, for example, piston 19 reaches the end of one of its strokes before pressure is reversed by the pumps. In this case excessive pressure will be built up at one end of the motor cylinder. Suppose the case where piston 11 of the lower pump is supplying fluid to the motor to drive motor piston 19 to the left, i. e. in the direction of the full line arrow superimposed on left-hand plunger 21. Suppose further that motor piston 19 has reached the limit of its leftward-moving stroke at a moment when piston 11 of the lower pump has not reached the end of its pumping stroke and is therefore continuing to supply fluid to the right-hand end of the motor cylinder 18. Under these conditions further movement of pump piston 11 will build up excessive pressure in the right-hand end of motor cylinder 18. When this pressure has reached a predetermined amount, valve 27 of the automatic timer is lifted upwardly by means of the pressure communicated through the passage 31 of the timer. This permits a certain amount of the hydraulic fluid to flow through by-pass channel 26 of the timer until pump piston 11 has reached the limit of its leftward-moving stroke. Valve 27 will then close under the action of compression spring 33. At this point piston 19 will be in proper phase relationship to the piston and the pumps. That is, piston 19 is at the end of its stroke substantially at the moment that pressure is reversed by the pumps.

Similarly when the pressure to the left of motor piston 19 reaches a predetermined amount, this pressure will be communicated via passage 32 of the timer to the underside of valve piston 28, again raising the valve and allowing a certain amount of the hydraulic fluid to pass through by-pass channel 26 to the other side of the motor cylinder. Again, when the piston 19 has reached the end of its stroke, and the proper phase relationship has been restored, valve 27 will close under the action of the compression spring 33. The proper pressure balance in the timer is obtained through adjustment of the hand screw 34 to increase or decrease the force exerted by spring 33 as may be required.

The stroke control mechanism

The volume or stroke control feature referred to at the end of the preceding description of the pump assembly will now be described. My preferred form of stroke control mechanism comprises a valve 48 for each of the pumps, these valves being adjustable to control by-pass channels between the respective annular pump cylinders and the inlets or low pressure sides of the pumps. The valves for each of the two pumps may be of the same construction so the description will proceed in the singular. Valve 48 comprises a hollow cylinder or sleeve movable axially in valve cylinder 49 formed in pump casing 1, the casing having an extension 50 forming the outer end of this cylinder. A series of by-pass channels 51, 52, 53, 54, 55 is provided between annular pump cylinder 3 and the fluid inlet 5 to said cylinder. Valve 48 is arranged to open and close these by-pass channels sequentially to predetermine the length of stroke of the reciprocatory motor piston 19. For this adjustment I provide a hand screw 56 threaded in the end cap 57 of cylinder 49. The central portion 58 of hand screw 56 is sealed at the end of cylinder 49 as by means of a suitable packing or O ring 59 carried in a recess of the end cap 57. A reduced portion 60 at the inner end of the adjusting screw 56 passes through the center bore 61 of valve 48 with sufficient clearance to allow the flow of hydraulic fluid from one side to the other of valve 48 as it is being adjusted. Transverse channels 62 at each end of valve 48 provide communication between the center bore 61 of the valve and the respective ends of valve cylinder 49. Adjusting screw 56 is rotatable with respect to valve 48 but restricted against endwise movement with respect thereto by means of a washer 63 and suitable fastening pin therefor.

The stroke control valves for the two pumps are adjusted together to the same respective positions. As shown both of them block all five of the by-pass channels 51 to 55 inclusive. Both may be adjusted to open only by-pass channel 51 by retracting them until the inner ends of valve cylinders 48 are moved outwardly to an extent which permits direct communication from the respective pump cylinders through channels 51 to the inner ends of valve cylinders 49 which are in communication with the inlets 4 and 5 respectively via openings 64. It is of course possible to link the two adjusting screws 56 together for simultaneous adjustment or setting, or if preferred they may be linked together hydraulically by any well-known means, in either case assuring that the effective stroke of each pump will be equal so as to produce the same extent of movement of the motor piston 19 in each direction.

Operation of the stroke control mechanism

With the stroke control mechanism, the general operation of the converter and automatic timer remains as described hereinabove, and if the valves 48 are adjusted to the position shown in the drawing, operation is exactly the same as though there were no stroke control mechanism provided. Therefore it will be understood that if a variable stroke is not desired, this mechanism may simply be omitted. Thus with the valves 48 in the position shown, the maximum volume of the pump discharge, and therefore maximum stroke of the motor, are obtained. If a shorter stroke is desired, valves 48 are retracted by means of adjusting screws 56 to provide communication through passages 51 to the inlets 4 and 5. With this adjustment and considering that the lower pump is entering its power stroke, the pumping action of piston 11 is modified by reason of the fact that some of the hydraulic fluid ahead of the piston flows through passage 51 back around to the low pressure side of the piston. This has the effect of reducing the total discharge of hydraulic fluid from the lower pump

during its complete working stroke. Thereafter the piston 19 is moved to the left as before, but to a shorter distance. Similarly when the upper pump begins its power stroke, fluid is by-passed through its channel passage 51 back around to the low pressure side of piston 10, reducing the length of the return stroke of piston 19 to the right.

Further retraction of valves 48 to sequentially place additional passages 52, 53 etc. into communication with low pressure sides of the respective pistons further reduces the working stroke of motor piston 19. When the valves 48 are withdrawn to the limit of their adjustment, all five by-pass channels 51 to 55 are placed in communication with the low pressure side of the respective pistons, substantially reducing the volume of fluid pumped during a complete working stroke of the pumps, and further reducing the stroke of the reciprocatory hydraulic motor M.

My hydraulic power converter is useful for a variety of applications, indeed for almost any case in which it is desired to have simple and positive hydraulic means for converting rotary power to reciprocatory power as, for example, in industrial machines having reciprocating tools driven by electric motors, such as punch presses, shapers, and in farm machinery, such as mowing machines, shakers, harvesting machines, etc. The invention also has wide application in mining and oil industries or wherever reciprocating pump elements are to be operated from a rotary power source.

The terms and expressions which I have employed are used in a descriptive and not a limiting sense, and I have no intention of excluding such equivalents of the invention described, or of portions thereof, as fall within the purview of the claims.

I claim:

1. A hydraulic power converter for converting rotary motion to reciprocatory motion comprising a pair of annular pump cylinders each with a fluid inlet and a fluid outlet so that there is a pair of fluid inlets and a pair of fluid outlets, piston rotors with pistons in the annular cylinders, said rotors driven from a rotary power source, a rotary abutment having a recess to clear each piston as it passes the abutment, a motor cylinder and a fluid-driven reciprocatory piston therein, a rod extending from the reciprocatory piston to a reciprocatory power take-off, selected pairs of said fluid inlets and outlets being connected by fluid conduits as follows: one pair connected together, one member of the other pair connected to one end of the motor cylinder and the other member of said other pair connected to the other end of the motor cylinder, the action of the pistons in the two pump cylinders being timed as follows: one piston completing its power stroke substantially at the moment that the other piston begins its power stroke, and vice versa, and means for automatically timing the action of the pumps to the action of the motor, said means comprising a by-pass channel connecting the two ends of the motor cylinder together and a valve in said channel responsive to a predetermined fluid pressure in either end of the motor cylinder to open said channel and by-pass liquid until the motor piston reaches the end of its stroke.

2. A hydraulic power converter as defined by claim 1 in which said valve is adjusted to said predetermined fluid pressure by adjusting the pre-compression of the spring which normally holds the valve in closed position.

3. A hydraulic power converter as defined by claim 1 in which said rod extending from the reciprocatory piston has a section forming a plunger reciprocating in an auxiliary cylinder communicating with said motor cylinder through a passageway of variable cross-section so that liquid flowing from the auxiliary cylinder into the motor cylinder must pass through a channel which becomes progressively smaller as the piston nears the end of its stroke.

4. A hydraulic power converter as defined by claim 1 in which said rod extending from the reciprocatory piston has plunger sections reciprocating in auxiliary cylinders at either end of the motor cylinder, said plunger sections having tapered channels therein of progressively greater cross-section in a direction away from the piston.

5. A hydraulic power converter as defined by claim 1 in which a by-pass channel is provided between each annular cylinder and the fluid inlet to said cylinder, and a valve for opening and closing said by-pass channels to predetermine the length of stroke of the reciprocatory motor piston.

6. A hydraulic power converter as defined by claim 1 in which a series of by-pass channels is provided between each annular cylinder and the fluid inlet to said cylinder, and a valve arranged to open and close said by-pass channels sequentially to predetermine the length of stroke of the reciprocatory motor piston.

7. In combination, two rotory hydraulic pump devices mechanically driven from a source of rotary power, a reciprocatory hydraulic motor alternately driven by the high pressure fluid discharge from first one of said pump devices and then the other, with the low pressure fluid discharge from said motor being returned to the intake of first one pump device and then the other, and means for automatically timing the action of the pump devices to the action of the motor comprising a by-pass channel in the motor and a valve in said channel responsive to a predetermined fluid pressure in the motor.

8. In combination, two rotary hydraulic pumps hydraulically connected to a reciprocatory hydraulic motor in alternate phase relationship so that each pump is effective to discharge liquid under pressure during only one half of each complete revolution of the pump rotor and so that during the time each pump is idling it is acting as a by-pass valve, and a by-pass relief valve arranged in a channel between the ends of the motor operable at a predetermined pressure to keep the motor automatically in phase with the two pumps.

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