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HYDRAULIC PUMP SYSTEM

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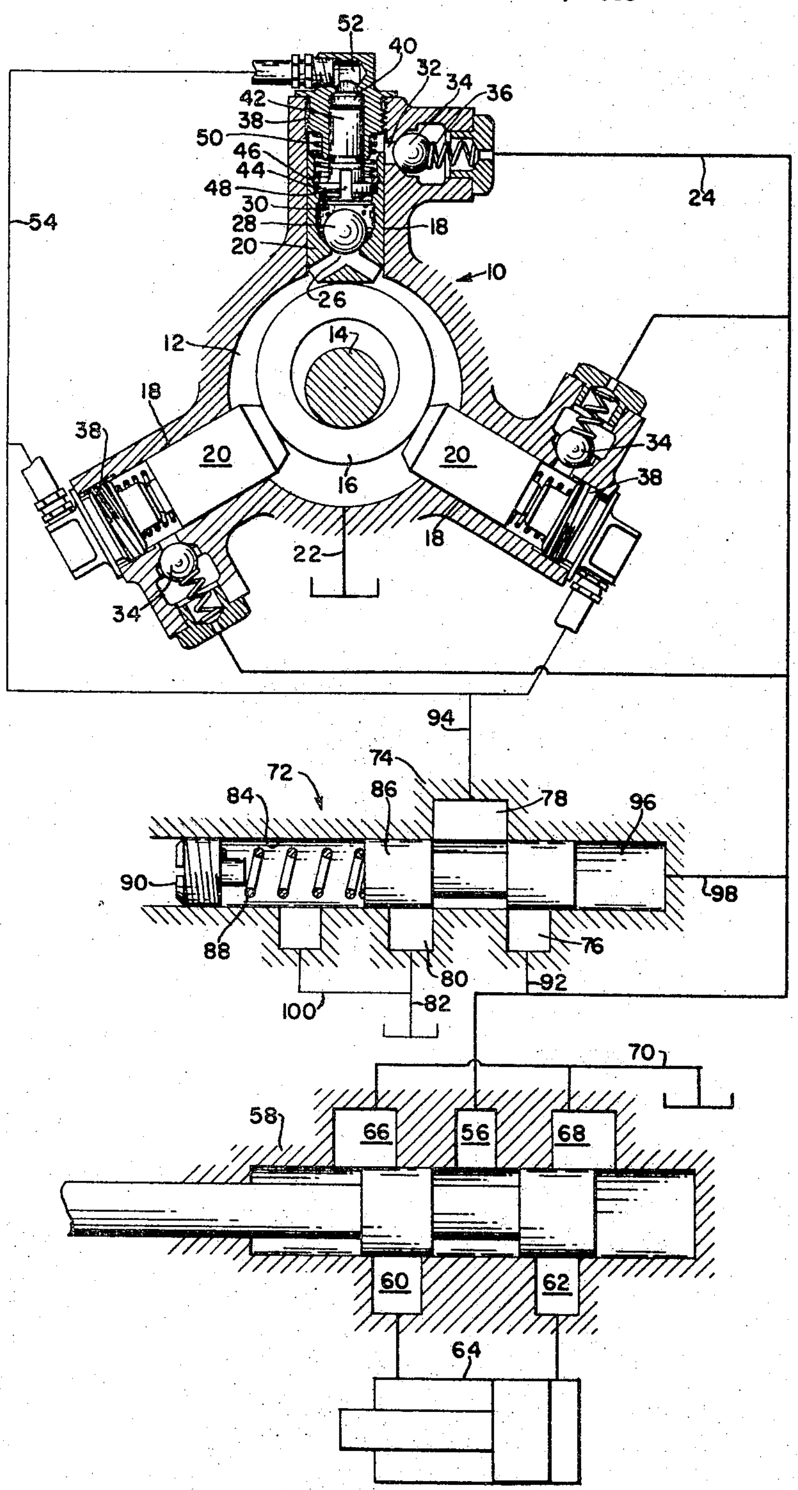

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HYDRAULIC PUMP SYSTEM

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This invention relates to a hydraulic pump system and more particularly to means for providing variable-volume output in a multi-piston pump, for example, by controlling the strokes of the pistons. More particularly, the control is imposed on the pistons on their intake strokes, whereby the length of such intake strokes may be varied, which of course concomitantly varies the length of the discharge stroke, thus varying the volumetric output.

Variable-displacement pumps are of course known and various means have been provided for varying the output, such as varying the eccentricity of radial pistons and the like. In such systems, biasing means normally acts to increase the pump output by increasing the piston strokes, and pilot pressure taken off the system in general is used to oppose the bias and thereby to reduce the strokes and consequently to reduce the output. In other types of pumps, the pistons are moved forcibly on their discharge strokes and are returned on their intake strokes by relatively strong springs. One inherent disadvantage of that type of pump is that during low temperature operation, the pumping pistons may cling to their cylinder walls as a result of high viscosity of the fluid. According to the present invention, these and other disadvantages are overcome by means for positively returning the pistons on their full intake strokes or any increment thereof independent of oil viscosity and related factors. This feature is embodied in an improved pump in which the operational characteristics of the pump are such as to impose on the pistons a bias tending to retain them at the outer ends of their discharge strokes, plus fluid means operative to vary the extent to which this inherent bias is overcome and thereby to vary the extent to which the pistons will return on their intake strokes, thus enabling variation in pump output from no-stroke to full-stroke. Another feature of the invention is to utilize relatively light return springs operative only in priming the pump and having no effect on control of the stroke regulation. It is another object of the invention to provide an improved pump in which pilot pistons are respectively coaxial with pumping pistons, and fluid manifold means is provided for interconnecting the pilot cylinders for supplying fluid thereto. A significant feature of the invention resides in a regulating valve for automatically varying the volume in the manifold in pilot cylinders in accordance with load requirements on whatever device is connected to the pump.

The foregoing and other important objects and desirable features inherent in and encompassed by the invention will become apparent to those versed in the art as a preferred embodiment of the invention is disclosed, by way of example, in the single figure in the accompanying drawings and appended description.

The variable-displacement pump is indicated in its entirety by the numeral **10** and comprises means affording a crank case **12** in which a crank shaft **14** is operative to drive an eccentric **16**. The pump further includes a plurality of pump cylinders **18** disposed radially as respects the center of the crank shaft **14** and respectively carrying pump pistons **20**.

The crank case **12** is connected to reservoir, as at **22**, so that as the pistons are driven by the eccentric **16** on their intake strokes they take in fluid from the crank case and on their discharge strokes exhaust fluid to a discharge or high pressure line **24**. The discharge sides of the pistons are appropriately manifolded for connection to the line **24**, in a manner that will be obvious from the drawing without further description.

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One of the pistons is shown in section so as to disclose the interior components thereof. From this illustration it will be seen that the inner end of the piston has an intake port **26** in communication with the crank case **12** and normally closed by a ball **28** under action of a relatively light conical spring **30**. As the top piston moves down on its intake stroke, the ball **28** lifts from the port **26**, and fluid is taken into the interior of the piston for discharge via a discharge port **32** when the piston moves upwardly or outwardly on its discharge stroke. The discharge port is controlled by a ball **34** spring loaded at **36**.

The outer or discharge end of each cylinder **18** is closed, as by a threaded plug **38**, and this plug is hollow to afford a pilot chamber or cylinder **40**. In the preferred construction illustrated, the pilot cylinder **40** is coaxial with the respective pump cylinder **18**. A pilot piston **42** is reciprocable in the pilot cylinder **40** and is mechanically connected to the interior of the pumping piston **20** as by an enlarged head **44** and snap ring **46**. The head **44** is slotted at **48** to enable fluid to pass from the intake port **26** to the discharge port **32**. A relatively light spring **50** acts between the plug **38** and the pump piston **20** and normally urges the pump piston radially inwardly. However, this spring, as already stated, is relatively light and is instrumental primarily as means for facilitating the priming of the pump. This spring could be dispensed with if the arrangement involves a reservoir oil level higher than the pump and the regulating valve to be subsequently described. However, this detail is of minor importance in the present disclosure. Suffice it to note that the pump and pilot pistons **20** and **42** move in unison. The same construction is involved in the other two piston assemblies illustrated. The outer or upper end of the plug **38** is drilled at **52** so that the pilot pistons may be connected by a manifold **54**.

In the representative system shown, the high pressure line **24** is connected to the inlet side **56** of a closed center control valve **58** which has a pair of motor ports **60** and **62** connected respectively to opposite ends of a fluid motor **64**. In addition, the control valve **58** includes a pair of exhaust ports **66** and **68** which lead to reservoir at **70**. A regulating valve **72** is interposed between the high pressure line **24** and the manifold **54**. This regulating valve comprises any suitable housing **74** having an inlet **76**, an outlet **78** and a dump or reservoir port **80**, the latter being connected to reservoir as at **82**. A bore **84** in the regulating valve housing **74** carries a valve member **86** biased to a closed position by a spring **88** which is adjustable at **90**. When the valve is in its closed position, the ports **76**, **78**, and **80** are isolated from each other. The port **76** is connected to the high pressure line by a control line portion **92** and the outlet port **78** is connected to the manifold by a communicating control line portion **94**. The end of the regulating valve bore **84** opposite to the spring **88** affords a chamber **96** which is connected by a line **98** to the high pressure line **24** upstream of the control valve **58**.

The arrangement is such that when pressure in the line **24** is at a predetermined value, the valve **86** is balanced between this pressure and the spring **88** to incur the closed position shown in the drawing, whereby the volume of fluid in the manifold **54** is constant. Thus, although the pilot pistons **42** move with the pump pistons **28** and have a pumping action, the fluid in the manifold merely circulates from one pilot cylinder **40** to the other. When the control valve **58** is in neutral, as shown, the pressure in the line **24** is that predetermined by the spring **88**, and the pistons **20** are reciprocated on strokes having sufficient length to provide the volume and pressure necessary. When the control valve 58 is closed, there are no volumetric requirements, ignoring leakage. When the control valve is opened, or shifted to either side of the neutral position shown, to effect operation of the motor 64 via connection of 56—60 or 56—62, pressure in the line 24 will drop. Thus, the spring 88 will overcome fluid pressure in the line 98 and chamber 96 and the valve member 86 will move to the right, interconnecting ports 76 and 78 and thus supplying fluid from the high pressure line 24 to the manifold 54 via 92—76—78—94. This fluid will of course enter the pilot cylinders 40 and will increase the stroke of each piston 20 for the following reason: during operation of the pump, rotation is so rapid that the pistons 20 tend to stay out to their discharge ends and consequently fail to completely return on their intake strokes. Thus, their effective strokes are shorter than their predetermined maximum strokes. If this condition persists, and the regulating valve member 86 is in its closed position as shown, the volume of fluid in the manifold 54 and pilot chambers or cylinders 40 is constant, and the intake stroke cannot be increased. Thus, the volumetric output of the pump will depend upon the extent to which the pumping pistons 20 return on their intake strokes.

In the example just assumed, with the pressure drop in the line 24 because of opening of the control valve 58, fluid from the line 24 is supplied to the manifold 54 and thus forces the pistons further on their intake strokes, which consequently means an increase in their discharge strokes as well, thereby increasing the volumetric output. The pressure in the line 24 depends of course upon the load encountered by the motor 64, and when this pressure increases enough to overcome the spring 88, the regulating valve member 86 will return to neutral and will maintain the constant volume of fluid in the manifold 54 and pilot cylinders 40 as long as the volumetric requirement remains unchanged. If the requirement increases, the valve member 86 will again shift to the right and add fluid. In the event that the line 24 achieves an instantaneous pressure rise, as by the motor 64 reaching the end of its stroke or encountering an obstacle that it cannot overcome, pressure rise in the regulating valve chamber 96 will cause the valve member 86 to shift to the left, thus interconnecting ports 78 and 80, whereby fluid will be subtracted from the manifold and pilot cylinder volume via 94—78—80—82.

The valve bore 84 is connected behind the valve member 86 to reservoir by a drain line 100 for accepting leakage past this valve member.

In short, and assuming a stabilized pump running condition, wherein fluid viscosity and pump speed are considered constant, an increase in pump stroke follows decrease of line pressure in line 24, which of course entails decrease in pressure acting via the line 98 on the right hand end of the valve member 86 in the chamber 96. Likewise, a decrease in pump stroke follows an increase in the pilot pressure in the chamber 96 as a result of a decrease in line pressure. For any constant volumetric output, the total quantity of fluid remains approximately constant in the pilot manifold 54 and pilot cylinders 40, since the pilot fluid circulates from one pilot cylinder to another. If an external control means, such as the control valve 58, incurs a situation in which more oil flows into the pilot manifold line, the pilot pistons, which act integrally with the pump pistons 20, must move toward the center of the pump, consequently forcibly moving the pump pistons 20 on their intake strokes so that the output of the pump is increased.

From the foregoing, it will be seen that the pump construction itself is compact and simple, and in a preferred embodiment the pilot cylinders and pistons are respectively coaxial with the pump cylinders and pistons. The regulating valve 72 affords means for automatic regulation of the volume of fluid in the pilot manifold, and this regulating valve controls pump displacement according to volumetric requirements of the hydraulic motor 64, for example. Other features not categorically enumerated will readily occur to those versed in the art, as will many modifications and alterations in the preferred embodiment disclosed, all of which may be achieved without departure from the spirit and scope of the invention.

What is claimed is:

1. A hydraulic system, comprising: a variable-displacement pump having a discharge line and further having a plurality of consecutively reciprocable pumping elements for pressurizing said line, each element being movable on intake and discharge strokes of predetermined length and conditioned by forces during operation to tend toward the end of its discharge stroke whereby the length of the intake stroke is less than said predetermined length; means connected to the pump and providing a plurality of fluid chambers, one for each element; a plurality of pistons, one in each chamber and connected to and movable with the pumping element in that chamber; a fluid manifold interconnecting the chambers; supply means connected between the discharge line and manifold for supplying fluid to the chambers via said manifold to move the pistons and thereby to return the elements forcibly on their intake strokes in opposition to the aforesaid condition; and means connected to and operative on the supply means in response to variations in the volumetric requirements imposed on the discharge line to vary the amount of fluid in said manifold and chambers and thus to incur increase and decrease in the length of the intake strokes of the elements respectively according to increase and decrease in the volumetric requirements imposed on the discharge line.

2. A hydraulic system, comprising: a variable-displacement pump having a discharge line and further having a plurality of pump cylinders and a plurality of consecutively reciprocable pump pistons respectively in said cylinders for pressurizing said line, each pump piston being movable on intake and discharge strokes of predetermined length and conditioned by forces during operation to tend toward the end of the discharge stroke whereby the length of the intake stroke is less than said predetermined length; means connected to the pump and providinging a plurality of pilot cylinders, one coaxial with and at the discharge end of each pump cylinder; a plurality of pilot pistons, one in each pilot cylinder and connected to and movable with the associated pump piston; a fluid manifold interconnecting the pilot cylinders; supply means connected between the discharge line and manifold for supplying fluid to the pilot cylinders via the manifold in opposition to the aforesaid condition to increase the return of the pump pistons on their intake strokes; and means connected to and operative on the supply means in response to variations in the volumetric requirements imposed on the discharge line to vary the amount of fluid in said manifold and pilot cylinders and thus to incur intake strokes of the elements respectively according to increase and decrease in the volumetric requirements imposed on the discharge line.

3. A hydraulic system, comprising: a variable-displacement pump having a plurality of consecutively reciprocable pumping elements, each movable on intake and exhaust strokes of predetermined length and conditioned by forces during operation to tend toward the end of the discharge stroke whereby the length of the intake stroke is less than said predetermined length; a high-pressure line connected to the discharge side of said pumping elements; means connected to the pump and providing a plurality of fluid chambers, one for each element; a plurality of pistons, one in each chamber and connected to and movable with the associated pumping element; a fluid manifold interconnecting the chambers; a control line connected to the high-pressure line and to the mani-

fold for supplying fluid to the chambers via said manifold to move the pistons and thereby to return the elements forcibly on their intake strokes in opposition to the aforesaid condition; and a regulating valve in said control line having open and closed positions respectively opening and blocking said control line and including a piston portion open to the high-pressure line, said regulating valve being operative to incur its closed position in response to a predetermined pressure in said high-pressure line so as to maintain a constant predetermined fluid volume in the manifold and chambers and to incur its open position in response to a decrease in pressure in said high-pressure line to add fluid to said manifold and chambers.

4. The invention defined in claim 3, in which: the regulating valve has a dump position achievable in response to a predetermined increase in pressure in the high-pressure line to dump fluid from the manifold and chambers.

5. A hydraulic system, comprising: a variable-displacement pump having a discharge line and further having a plurality of consecutively reciprocable pumping elements for pressurizing said line, each element being movable on intake and exhaust strokes of predetermined length and conditioned by forces during operation to tend toward the end of the discharge stroke whereby the length of the intake stroke is less than said predetermined length; means connected to the pump and providing a plurality of fluid chambers, one for each element; a plurality of pistons, one in each chamber and connected to and movable with the associated pumping element; a fluid manifold interconnecting the chambers; a control line interconnecting the discharge line and manifold for supplying fluid to the chambers via said manifold to move the pistons and thereby to return the elements forcibly on their intake strokes in opposition to the aforesaid condition; a regulating valve in said control line having open and closed positions respectively opening and blocking said control line and including a fluid-receivable portion communicating with the discharge line, said regulating valve being operative to incur its closed position in response to a predetermined pressure in said discharge line so as to maintain a constant predetermined fluid volume in the manifold and chambers and to incur its open position in response to a decrease in pressure in said discharge line to add fluid to said manifold and chambers.

6. The invention defined in claim 5, in which: the regulating valve has a dump position achievable in response to a predetermined increase in pressure in the discharge line to dump fluid from the manifold and chambers.

7. A hydraulic system, comprising: a variable displacement pump having a plurality of consecutively reciprocable pumping elements, each movable on intake and discharge strokes of predetermined length and conditioned by forces during operation to tend toward the end of its discharge stroke whereby the length of the intake stroke is less than said predetermined length; means connected to the pump and providing a plurality of fluid chambers, one for each element; a plurality of pistons, one in each chamber and connected to and movable with the pumping element in that chamber; a fluid manifold interconnecting the chambers; supply means connected between the discharge side of the pump and manifold for supplying fluid to the chambers via said manifold to move the pistons and thereby to return the elements forcibly on their intake strokes in opposition to the aforesaid condition; and means connected to and operative on the supply means for varying the amount of fluid in said manifold and chambers and thus to vary the extent to which the elements are returned on their intake strokes.

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