Oct. 25, 1960 R. C. MILLER 2,957,426

SERIES-PARALLEL PUMP

Filed Dec. 17, 1956 4 Sheets-Sheet 1

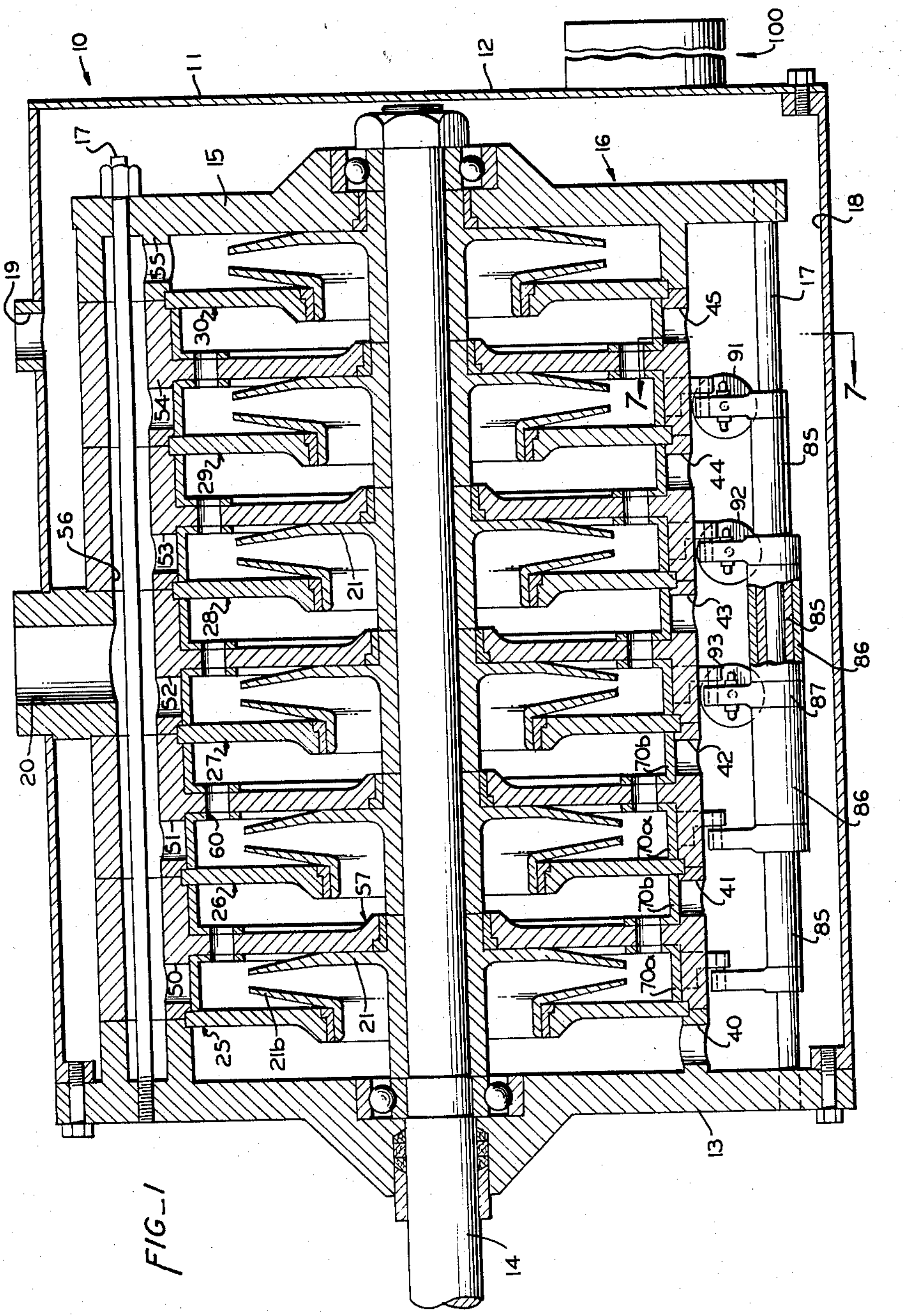

FIG_1

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SERIES-PARALLEL PUMP

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FIG_2

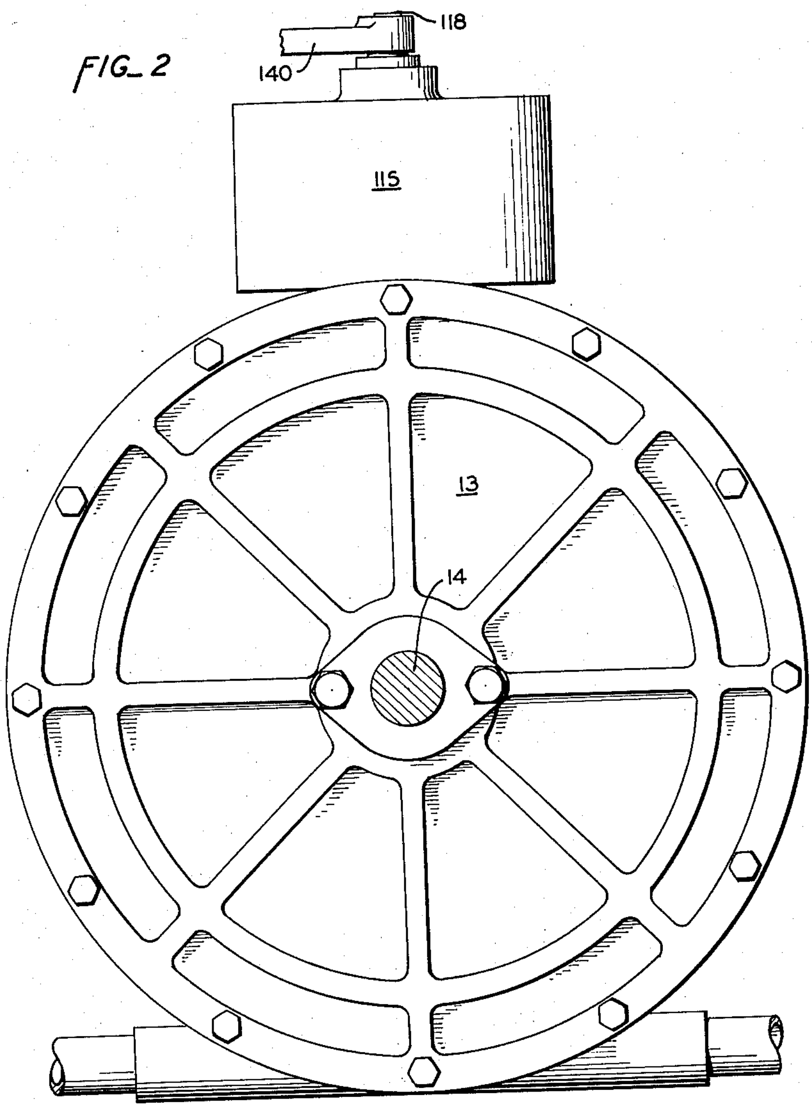


FIG_3

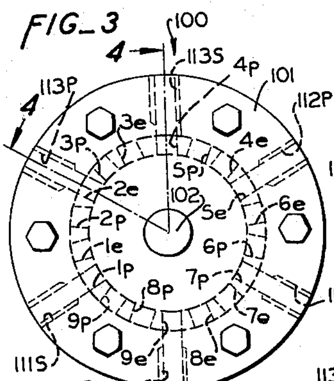
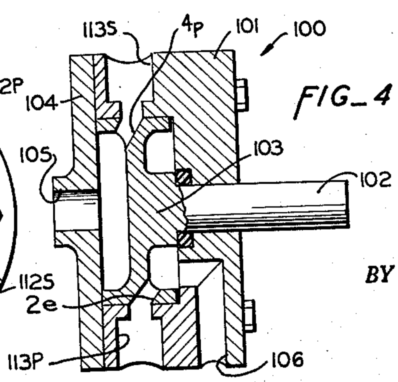


FIG_4



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SERIES-PARALLEL PUMP

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FIG_5

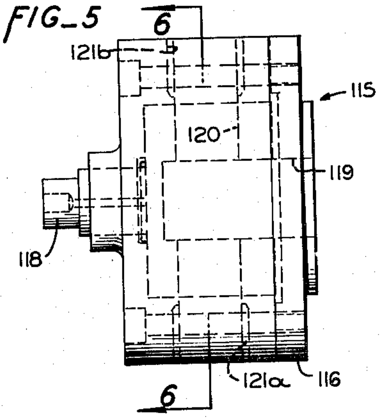


FIG_6

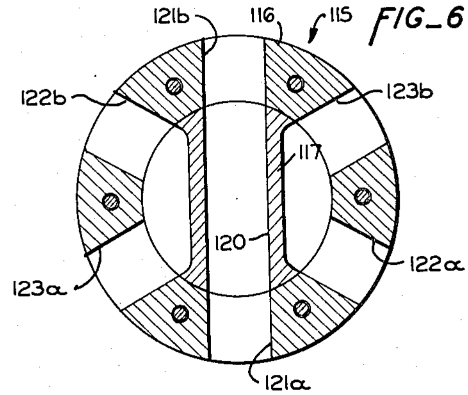


FIG_7

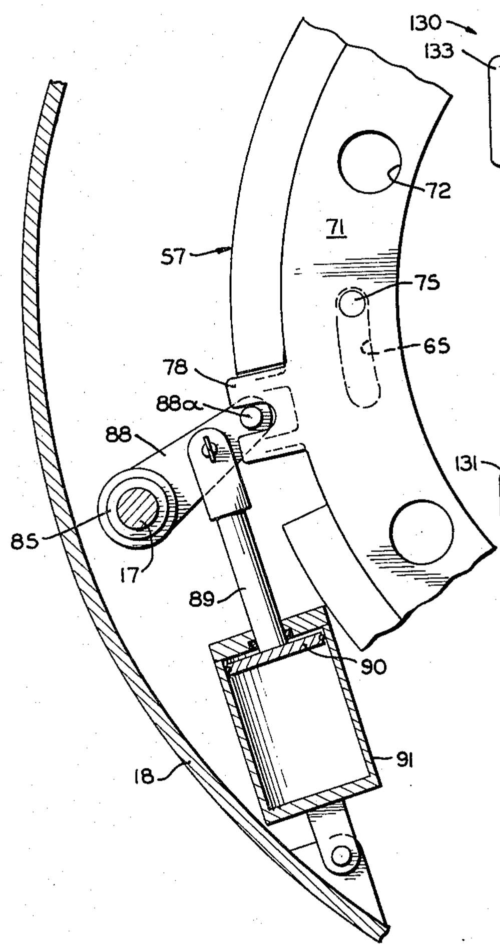
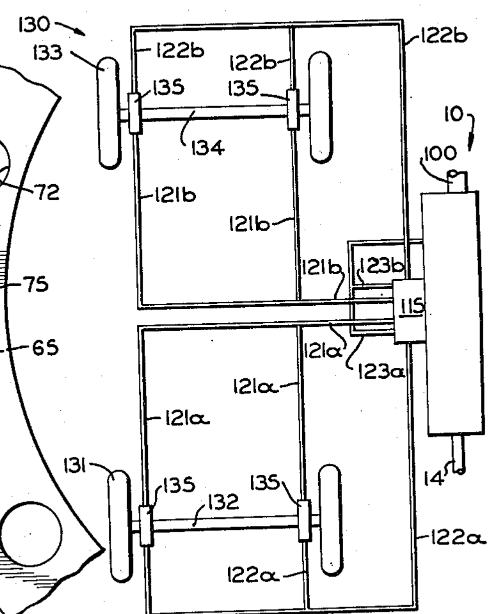


FIG_12



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SERIES-PARALLEL PUMP

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FIG_8

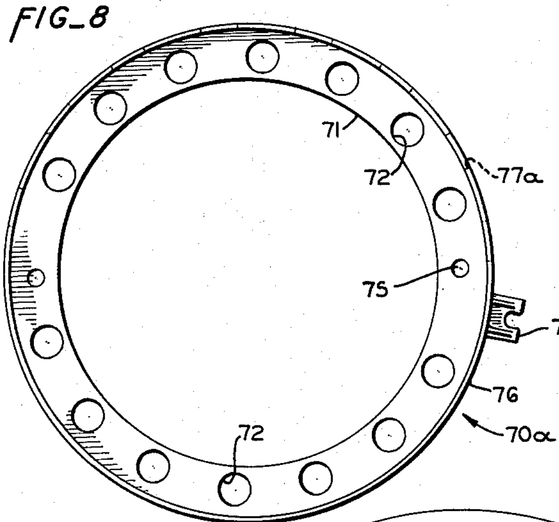


FIG_9

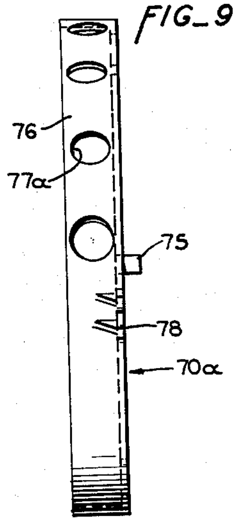
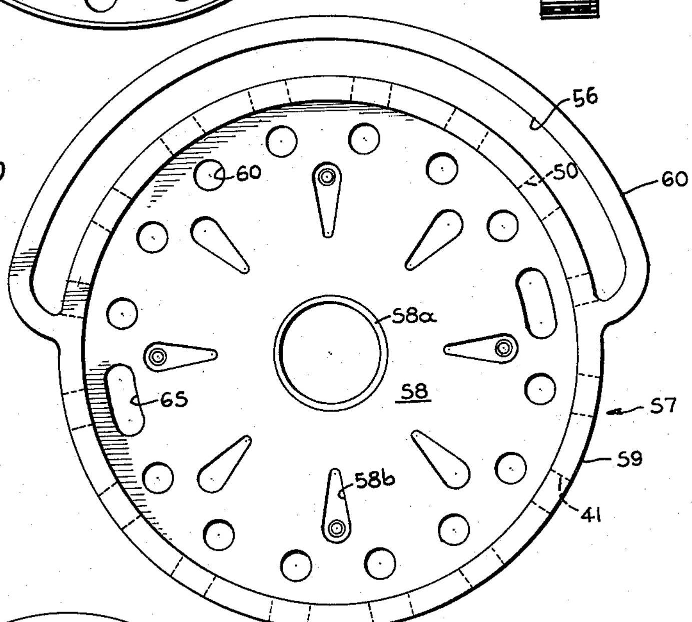


FIG_10



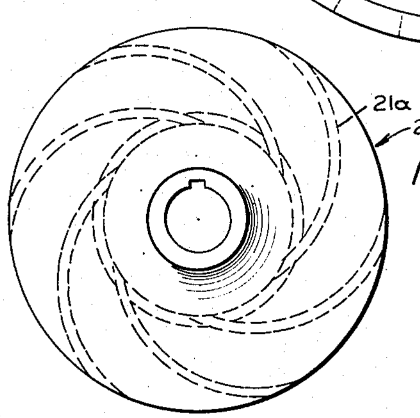


FIG_11

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United States Patent Office

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2,957,426

SERIES-PARALLEL PUMP

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Filed Dec. 17, 1956, Ser. No. 628,766

5 Claims. (Cl. 103—106)

This invention relates to a series-parallel, multiple stage hydraulic pump and to means for operating the same.

Series-parallel hydraulic pumps having several stages which may be arranged all in series, all in parallel, or in various combinations thereof, are old in the art. However, it is advantageous to provide pumps of this character of sectional construction to facilitate the addition or subtraction of stages according to requirements; to provide a means for operating the valving of the stages to adjust the pump readily and speedily to operate in series, in parallel or in various series-parallel combinations; and to employ the pump for various useful purposes such as driving a vehicle.

It is an object of the present invention to provide improvements upon series-parallel hydraulic pumps.

It is a further object of the invention to provide a series-parallel hydraulic pump of sectional construction which facilitates the addition and subtraction of stages.

Yet another object of the invention is to provide an improved valving means for the stages of a series-parallel hydraulic pump.

A still further object of the invention is to provide valve control means for multiple stage series-parallel pumps of the character described whereby the adjustment of the pump can be carried out speedily and with ease.

Yet another object of the invention is to provide a pump of the character described and means whereby it can be integrated into a system for performing some useful function such as driving a motor vehicle forwardly and in reverse.

These and other objects of the invention will be apparent from the ensuing description and the appended claims.

One form of the invention is illustrated by way of example in the accompanying drawings, in which

Figure 1 is a view in longitudinal midsection through the multiple stage centrifugal pump of the invention.

Figure 2 is an end view as seen from the left of Figure 1.

Figure 3 is an end view of one of the control valves (the series-parallel control valve) of the pump of Figure 1, showing in phantom lines the ducting thereof.

Figure 4 is a staggered section taken along the line 4—4 of Figure 3.

Figure 5 is a view in side elevation of another control valve (the distributor valve) employed with the pump of Figure 1, showing in phantom lines some of the interior construction.

Figure 6 is a section taken along the line 6—6 of Figure 5.

Figure 7 is a fragmentary view taken along the line 7—7 of Figure 1, but on a larger scale, showing the manner in which the valve rings of the pump of Figure 1 are operated.

Figure 8 is a view in front elevation of one of the valve rings of the pump of Figure 1.

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Figure 9 is a view in side elevation of the valve ring of Figure 8 as seen from the right of Figure 8.

Figure 10 is a view in front elevation of one of the castings employed as the main frame member of one of the stages of the multiple stage hydraulic pump of Figure 1.

Figure 11 is a view in end elevation of one of the impellers of the multiple stage pump of Figure 1.

Figure 12 is a diagrammatic view showing a means whereby the pump of Figure 1 may be employed to operate a vehicle.

Referring now to the drawings and more particularly to Figure 1, a multiple stage, series-parallel hydraulic pump is there shown which is constructed in accordance with the invention and is generally designated by the reference numeral **10**. It is provided with a main housing **11** having end plates **12** and **13**. An impeller shaft **14** is journaled in the end plate **13** and also in the end plate **15** of an impeller housing **16**. The latter is fixed to the end plate **13** by stay bolts **17**. As will be apparent, the pump **10** is of sectional construction such that more or less stages may be employed, thereby increasing or decreasing the capacity of the pump. In the instance shown, six stages are employed. A reservoir **18** is provided which is located between the main housing **11** and the impeller housing **16**, such reservoir having an inlet at **19** and an outlet at **20** for the impeller housing. Impellers are provided at **21** which are fixed to the impeller shaft **14**. Each impeller **21** has spiral impeller blades **21*a*** (see Figure 11) and is of the enclosed type having an enclosure member **21*b***.

The six stages of the pump **10** are designated by the consecutive numerals **25, 26, 27, 28, 29** and **30**. Each stage has inlet openings at **40, 41, 42, 43, 44** and **45**, respectively, and outlet openings at **50, 51, 52, 53, 54** and **55**, respectively. The inlet openings **40** to **45** communicate with the reservoir **18** and the outlet openings **50** to **55** communicate through a manifold space **56** (see Figures 1 and 10) with the outlet opening **20**.

Referring now to Figures 1 and 10, each of the stages **25** to **30** comprises a casting **57** which serves as the main frame member of the stage. Each casting **57** comprises a plate **58** which has a central opening and a hub **58*a*** to receive the impeller shaft **14**. Ribs **58*b*** are provided for reinforcement purposes. Each casting **57** also comprises an annular rim or flange **59** in which are formed the inlet openings **41** (or **42, 43, 44** or **45**) and the outlet openings **50** (or **51, 52, 53** or **54**). Interstage ports **60** are formed in the plate **58**; also slots **65** which are diametrically opposite one another.

Referring now more particularly to Figures 8 and 9, one of the interstage valve rings is there shown and is generally designated as **70*a***. By referring to Figure 1, it will be seen that a pair of such rings, indicated at **70*a*** and **70*b***, are provided for each of the castings **57**. Each ring **70*a*** is intended to open and close the corresponding outlet ports **50, 51, 52, 53** or **54** and each ring **70*b*** is intended to open and close the corresponding inlet ports **41, 42, 43, 44** or **45**. Each ring **70*a*** has a vertical portion **71** formed with interstage ports **72**. Pins **75** project from the vertical portion **71** and are received in slots **65** of the corresponding casting **57**. Each ring **70*a*** also has a flange **76** which is formed about its top portion with outlet ports **77*a***. A fork member **78** is fixed to and projects from the ring member **70*a*** for a purpose explained hereinafter.

Each of the valve rings **70*b*** is similarly formed except that its ports **77*b*** are located at the bottom to register with the inlet ports **41** (or **42, 43, 44** or **45**).

Consider now, the second stage **26**. Its outlet valve ring **70*a*** works with the inlet valve ring **70*b*** of the third stage **27**, and its inlet valve ring **70*b*** works with the outlet valve ring **70***a* of the first stage **25**. Thus, the pins **75** of the ring **70***b* of the second stage **26** and the pins **75** of the ring **70***a* of the first stage **25** are located in the slots **65** of the first casting **56**. Accordingly, these rings must move in unison. When this pair of rings **70***a* and **70***b* is moved to one extreme position (which is determined by the respective slots **65**, and which may be called the "series" position) the following conditions prevail: The interstage ports **72** of the rings **70***a* and **70***b* are in registry with the interstage ports **60** of the first casting **57**; therefore, liquid will flow from the first stage **25** into the second stage **26**. Therefore, these two stages are connected in series. Moreover, the outlet ports **77***a* of the ring **70***a* are out of registry with the outlet ports **50** in the impeller housing **16**; and the inlet ports **77***b* of the ring **70***b* are out of registry with the inlet ports **41** of the impeller housing **16**.

If the rings **70***a* and **70***b* are rotated to their other extreme position (which is also determined by the slots **65**, and which may be called the "parallel" position) the interstage ports **72** of the rings **70***a* and **70***b* will be out of registry with the interstage ports **60** of the casting **57**. Therefore, the stages **25** and **26** are not interconnected. Moreover, the outlet ports **77***a* of the ring **70***a* will be in registry with the outlet ports **50**, and the inlet ports **77***b* will be in registry with the inlet ports **41**. Therefore, the stages **25** and **26** will be in parallel.

Similarly, each of the castings **57** has a pair of valve rings **70***a* and **70***b* which operate together and determine whether the two associated pump stages are connected in series or are in parallel.

If all of the five pairs of valve rings **70***a*, **70***b* are rotated to their "series" positions, then all of the stages will be in series and the pump will operate as a six stage series pump with liquid entering through the ports **40** (one of which is shown at the lower left in Figure 1 and which are always open) and will leave through the ports **55** (one of which is shown at the upper right in Figure 1 and which are always open), thence out through the manifold chamber **56** and outlet **20**. A minimum volume of liquid will, therefore, be pumped at a maximum pressure.

If, on the other hand, all of the five pairs of valve rings **70***a*, **70***b* are rotated to their "parallel" positions the pump will operate as a six stage parallel pump with liquid entering the six stages through the ports **40**, **41**, **42**, **43**, **44** and **45** and leaving through the ports **50**, **51**, **52**, **53**, **54** and **55**, thence out through the manifold space **56** and outlet **20**. The pump will, therefore, pump a maximum volume of liquid at minimum pressure.

If the pair of valve rings **70***a*, **70***b* which are associated with the third casting **57** are placed in their "parallel" position and the other pairs of rings are placed in their "series" positions, the pump will operate as two three stage series pumps operating in parallel; i.e., liquid will enter the first three stage pump at **40** and will leave at **52** and liquid will enter the second three stage pump at **43** and will leave at **55**.

If the pairs of valve rings **70***a*, **70***b* associated with the second and fourth castings **57** are placed in their "parallel" positions and the other valve rings are placed in their "series" positions the pump will function as three two stage pumps operating in parallel. Liquid will enter through the ports **40**, **42** and **44** and will leave through the ports **51**, **53** and **55**.

It will, therefore, be apparent that a series-parallel hydraulic pump has been provided in which all of the stages may be operated in series, in parallel or in various series-parallel combinations to provide in one case (series operation) a minimum volume output at maximum pressure, in another case (parallel operation) a maximum volume output at minimum pressure and, in the intermediate cases (series-parallel combinations) with intermediate volumes and pressures.

Referring now to Figures 1 and 7, one of the stay bolts **17**, which is shown at the bottom of Figure 1 serves also as a shaft to support three concentric sleeves **85**, **86** and **87**. The innermost sleeve **85** is rotatable on the stay bolt **17**; the intermediate sleeve **86** is rotatable on the sleeve **85**; and the outermost sleeve **87** is rotatable on the intermediate sleeve **86**. The innermost sleeve **85** is the longest of the three sleeves. At its right-hand end (as viewed in Figure 1), the sleeve **85** is connected by a lever **88** and pin **88***a* to the fork **78** of the valve ring **70***a* associated with the fifth casting **57**. The lever **88** is connected by a rod **89** to a double acting piston **90** which is reciprocable within a cylinder **91**. It will be apparent that, by introducing fluid under pressure into one end of a cylinder **91** and exhausting fluid from the other end of the cylinder, the corresponding pair of valve rings **70***a*, **70***b* will be rotated to their "series" position, and by operating the cylinder **91** in the reverse direction the same pair of valve rings **70***a*, **70***b* will be rotated to their "parallel" position.

As illustrated in Figure 1, the sleeve **85** extends to the valve rings **70***a*, **70***b* at the opposite end of the pump and is connected thereto in similar manner. Therefore, two pairs of valve rings **70***a*, **70***b* (those associated with the first and fifth castings **57**) are operated in unison. Similarly the sleeve **86** extends between the second and fourth pairs of valve rings **70***a*, **70***b* and is connected thereto to operate the same in unison. A cylinder **92** is provided in like manner to rotate these valve rings. The sleeve **87** is associated with only the third pair of valve rings **70***a*, **70***b*, which are associated with the third casting **57**, and these rings are operated by a third cylinder **93**.

It will, therefore, be apparent that the three cylinders **91**, **92** and **93** can be used to place the six stages **25**, **26**, **27**, **28**, **29** and **30** all in series, all in parallel, or in either of the two series-parallel combinations, i.e., two three stage pumps operating in parallel or three two stage pumps operating in parallel.

Each of the cylinders **91**, **92** and **93** may be regarded as having a "series" end and a "parallel" end. That is, if fluid under pressure is delivered to the "series" end of a cylinder, it will operate that cylinder to move the corresponding valve rings **70***a*, **70***b* to their "series" position, and if fluid is delivered under pressure to the "parallel" end of a cylinder it will move the corresponding valve rings **70***a*, **70***b* to their "parallel" position.

Referring now to Figures 3 and 4, a control valve is there shown which is generally designated as **100** and which is intended to operate the hydraulic cylinders **91**, **92** and **93** to accomplish the permissible operations described hereinabove. That is, it is the function of the valve **100** to control the delivery of pressure to the cylinders **91**, **92** and **93** so that the pump **10** can be operated in four different ways, to wit, as a six stage series pump, as a pump operating with six stages in parallel, and in the two series-parallel combinations described above, i.e., two three stage pumps operating in parallel and three two stage pumps operating in parallel.

The valve **100** has a valve body **101** in which a rotor shaft **102** is journaled and to the inner end of which (at the left as viewed in Figure 4) is fixed a rotor **103**. A cover plate **104** is mounted as shown, such cover plate having a central opening **105** for incoming fluid under pressure from a suitable source of pressure such as an hydraulic pump (not shown). The valve body **101** is formed with a fluid outlet at **106** which connects to a suitable reservoir (not shown).

The valve body **101** is also formed with six ports which are arranged in pairs. The ports **111S**, **112S** and **113S** are connected by suitable ducts (not shown) with the "series" ends of the cylinders **91**, **92** and **93**, respectively, whereas the ports **111P**, **112P** and **113P** are connected by suitable ducts (not shown) with the "parallel" ends of the cylinders **91**, **92** and **93**, respectively.

The rotor **103** is formed with nine pressure ports which are indicated by the reference numerals **1***p*, **2***p*, **3***p*, **4***p*, **5***p*, 6p, 7p, 8p and 9p, and it is also formed with nine exhaust ports which are designated as 1e, 2e, 3e, 4e, 5e, 6e, 7e, 8e and 9e. Two such ports (the pressure port 4p and the exhaust port 2e) are shown in the staggered section of Figure 4. It will be seen that the pressure port 4p is adapted to register with a series port (e.g., the port 113S) in the valve body but that it cannot register with a parallel port in the valve body. It will also be seen that the exhaust port 2e is adapted to register with a parallel port (e.g., the port 113P) but that it cannot register with a series port. Similarly each of the pressure ports 1p, 2p, 3p, etc. is adapted to register only with a series port 111S, 112S or 113S and each of the exhaust ports 1e, 2e, 3e etc. is adapted to register only with a parallel port 111P, 112P or 113P. Also each of the pressure ports 1p, 2p, etc. connects with the pressure inlet 105 of the valve 100 and each of the exhaust ports 1e, 2e, etc. connects with the pressure outlet 106 of the valve 100.

It is intended that the rotor 103 be rotated in twenty degree increments between the position shown in Figures 3 and 4 (which will be referred to as "position A") and a position sixty degrees from that shown in a clockwise direction (such position being referred to as "position D"). There will be two stops between position A and position D, i.e., a position twenty degrees and another position forty degrees from position A; such intermediate stops or positions being referred to as "position B" and "position C," respectively.

In position A, it will be seen that pressure ports 1p, 4p and 7p connect the series ports 111S, 113S and 112S, respectively, and that exhaust ports 9e, 5e and 2e connect with parallel ports 111P, 112P and 113P, respectively. Therefore each of the cylinders 91, 92 and 93 is connected to pressure at its series end, hence all of the valve rings 70a and 70b will be placed and held in their series positions. Therefore, the pump 10 will operate as a six stage series pump.

Assume now that the rotor 103 is turned 20° in clockwise direction to position B. It should be noted that suitable spring-actuated detent means (not shown) may be employed to hold the rotor in each of its four positions and that suitable stops (not shown) may be employed to prevent the rotor from passing beyond position A in one direction or position B in the other direction.

When the rotor 103 is in position B the ports will align as follows: Pressure port 9p will register with series port 111S and exhaust port 8e will register with parallel port 111P. Therefore, cylinder 91 will remain undisturbed.

Pressure port 2p will register with parallel port 113P and exhaust port 3e will register with series port 113S. Therefore, cylinder 93 will be reversed and will be in its parallel position.

Exhaust port 4e will register with parallel port 112P and pressure port 6p will register with series port 112S. Therefore, cylinder 92 will remain undisturbed.

With cylinders 91 and 92 in series position and cylinder 93 in parallel position it follows that stages 25, 26 and 27 will be in series with one another; that stages 27 and 28 will be parallel to one another; and that stages 28, 29 and 30 will be in series with one another. Therefore, the pump in position B will operate as two three stage pumps in parallel with one another.

Assume now that the rotor is turned another 20° clockwise to position C. The alignment of the ports will be as follows:

Exhaust port 7e will register with parallel port 111P and pressure port 8p will register with series port 111S. Therefore cylinder 91 will be in series position.

Exhaust port 1e will register with parallel port 113P and pressure port 3p will register with series port 113S. Therefore, cylinder 93 will be in series position.

Pressure port 5p will register with parallel port 112P and exhaust port 6e will register with series port 112S. Therefore, cylinder 92 will be in parallel position.

With cylinder 91 in series position, cylinder 92 in parallel position and cylinder 93 in series position the first and second stages 25 and 26 will be in series with one another; the third and fourth stages 27 and 28 will be in series with one another; and the fifth and sixth stages 29 and 30 will be in series with one another. Each of these pairs of stages (i.e., 25, 26; 27, 28; 29, 30) will be parallel to the other pairs. Therefore, the pump in position C will operate as three two stage pumps operating parallel to one another.

Finally, assume that the rotor is turned another 20° clockwise to position D. In this position the ports will align as follows:

Pressure port 7p will register with parallel port 111P and exhaust port 9e will register with series port 111S.

Pressure port 1p will register with parallel port 113P and exhaust port 2e will register with series port 113S.

Pressure port 4p will register with parallel port 112P and exhaust port 5e will register with series port 112S.

It will, therefore, be apparent that in position D, the parallel end of each of the cylinders 91, 92 and 93 is connected with pressure. Therefore, all of these cylinders will be in their parallel position; hence all of the valve rings 70a and 70b will be in their parallel positions. Therefore, the pump 10 will operate at six single stage pumps operating in parallel to one another.

It will, therefore, be apparent that the control valve 100 is effective to operate the pump 10 in the intended manner as a six stage series pump; as a parallel pump consisting of six single stage pumps operating in parallel; and in the intermediate 2—3 and 3—2 series-parallel combinations.

It will also be apparent that, in addition to the detent means and stop means referred to above, a pointer (not shown) may be attached to the rotor shaft 102 and an index may be attached to the valve body 101 so that all an operator need do is rotate the shaft 102 until the pointer points to the desired position on the index.

One of the purposes of the pump 10 is to operate a vehicle such as a truck or bus by supplying hydraulic fluid under pressure to hydraulic motors at the wheels of the vehicle. It will be apparent that the pump 10 is well adapted for this purpose. Thus, it can be operated in position A (six-stage, series) to give maximum power at low speed (i.e., a small volume rate of flow), thereby providing a lowest gear ratio between the prime mover and the traction wheels. It may also be operated in position D (six single stages in parallel), hence at lowest pressure and maximum volume rate of flow to provide a highest gear ratio; and at positions B and C to provide intermediate gear ratios. In the meantime the prime mover, which may be a gasoline, diesel engine or any other suitable type of prime mover, may be operated at constant speed and under conditions of maximum efficiency.

In employing the pump 10 in this manner it is desirable to provide a control valve capable of delivering fluid under pressure from the pump 10 to the motor of each traction wheel in a "forward" direction to turn such wheel forwardly; or in a "reverse" direction to turn each wheel rearwardly; and also to by-pass the hydraulic motors of the wheels altogether for idling, e.g., when it is desired to arrest progress of the vehicle without shutting off the prime mover and terminating operation of the pump 10. For this purpose there is provided a valve which is illustrated in Figures 5 and 6 and is generally designated by the reference numeral 115.

The valve 115 comprises a valve body 116 in which is rotatable a rotor 117 having a shaft 118. The valve body 116 is formed at one end with a fluid inlet 119.

The valve rotor 117 is formed with a diametral passageway 120 which connects with the inlet 119. The valve body 116 is formed with ports 121a and 121b which will be called the "forward" ports; it is also formed with ports 122a and 122b which will be called the "reverse" ports; and it is also formed with ports 123a and

123*b* which will be called "return" ports. It will be seen that each pair of ports, e.g., the ports **121*a*** and **121*b***, are diametrically opposite one another, and that the six ports are spaced 60° apart.

Referring now to Figure 12, the hydraulic pump or motor **10** is there shown together with the control valves **100** and **115**, in connection with a vehicle which is shown schematically and is generally designated by the reference numeral **130**. The vehicle **130** has four traction wheels, the front wheels being designated by the reference numeral **131** and being connected by a front axle **132**, the rear wheels being designated as **133** and being connected by a rear axle **134**. Each of the wheels **131** and **133** is provided with an hydraulic motor which is generally designated by the reference numeral **135**. Any suitable type of hydraulic motor may be employed, preferably of positive displacement type, for example, gear pumps. As is well known, a device of this character having a positive displacement will operate at a speed corresponding to the throughput of liquid, that is, the volume rate of flow of liquid.

The connections of the control valve **115** will be apparent from an inspection of Figure 12. Thus, the forward ports **121*a*** and **121*b*** are connected by lines **121*a*** and **121*b*** to the hydraulic motors **135**, the connections being such that each of these motors will be driven in the forward direction if fluid is delivered through these lines. Fluid discharged from the motors **135** will return through the lines **122*a*** and **122*b*** to the control valve **115**, whence it will return through the ports **123*a*** and **123*b*** (see Figure 6) and similarly numbered lines shown in Figure 12, to the reservoir **18** (see Figure 1). Accordingly, the vehicle will be driven in the forward direction.

If it is desired to drive the vehicle in the reverse direction the valve rotor **117** will be turned 60° to the right, i.e., in counterclockwise direction as viewed in Figure 6 to bring the diametral passageway **120** of the valve rotor **117** into registry with the reverse ports **122*a*** and **122*b***. It will be apparent that hydraulic fluid will be forced through the motors **135** in the reverse direction, returning through the lines **121*a*** and **121*b***. Hence the vehicle will be driven in reverse.

If it is desired to disengage the pump **10** from the wheels of the vehicle, this is accomplished by rotating the valve rotor **117**, 60° to the left from the position shown in Figure 6, thereby bringing the diametral passage **120** of valve rotor **117** into registry with the return ports **123*a*** and **123*b***. It follows that fluid entering the valve through the inlet **119** (see Figure 5) will be recycled to the reservoir. Accordingly, no fluid will be delivered to the hydraulic motors **135**, the wheels **131** will not be driven and the pump **10** will idle.

It will be further apparent from the description above and from the drawings that in driving the vehicle in either the forward or reverse direction, the power supply can be delivered at a low gear ratio (with the valve **100** in position A and the six stages of the pump operating in series); or in high gear (with the control valve **100** in position D and the six stages operating in parallel); or in either of two intermediate gears. A control lever **140** (see Figure 2) and a scale or index (not shown) may be employed to operate the valve **115**.

It will, therefore, be apparent that an hydraulic pump has been provided having certain advantageous features among which are a sectional or segmental construction allowing the addition or subtraction of units to suit particular requirements; and a high degree of flexibility, being capable of operating at very high, very low and intermediate gear ratios. It will further be apparent that novel and very useful control valves have been provided for the operation of the pump. Among the advantages of operating a vehicle by the system described may be mentioned the following: A prime mover may be employed

such as a gasoline motor or a diesel engine which is allowed to operate at constant speed, the speed being selected for maximum efficiency of operation. The vehicle can be operated forwardly and in reverse at any gear ratio desired and can be caused to idle.

I claim:

1. A multiple stage series-parallel rotary pump comprising a shaft, a plurality of rotors fixed thereto and each adapted to impart an increment of pressure to a liquid; enclosure means for each rotor formed with series inlet and outlet ports and parallel inlet and outlet ports to operate such rotor in series and in parallel, respectively, in relation to fore and aft stages; and means for selectively opening and closing such ports comprising rotatable valve rings associated with each impeller to open the series ports and close the parallel ports when in a first position and to reverse such ports when in a second position; said selective means also comprising a plurality of concentric rotatable sleeves, means connecting each sleeve with at least one set of valve rings and fluid pressure operated, double-acting cylinder means for rotating said sleeves.

2. Series-parallel apparatus of the character described comprising: A rotatable shaft; a plurality of impellers fixed to said shaft in tandem; a partition between each adjacent pair of impellers; and a housing enclosing said impellers; said impellers being N in number and being designated in succession as the first through the Nth impeller, N being an even number not less than 4; said housing having an inlet for the first impeller, an outlet for the Nth impeller, outlet apertures for the first through the (N−1)th impellers and inlet apertures for the second through the Nth impellers; each said partition having an opening for connecting its respective pair of impellers in series; each said partition having also a first face nearer the first impeller and a second face more remote from the first impeller; said apparatus also comprising a first set of valve plates rotatable on the first faces of the said partitions and a second set of valve plates rotatable on the second faces of said partitions; each such first valve plate also having an outlet aperture for registration with the adjacent outlet aperture of the housing; each such second valve plate having an inlet aperture for registration with the adjacent inlet aperture of the housing; each pair of valve plates associated with a partition having a pair of openings for registration with the opening of such partition, each pair of valve plates being interconnected in such a manner that they rotate in unison between a first position connecting the respective pair of impellers in series and a second position connecting such pair of impellers in parallel.

3. The apparatus of claim 2 including fluid pressure operated means for operating said valve plates.

4. The apparatus of claim 2 including a plurality of concentric shafts and means connecting said shafts to said valve plates to operate the latter by selective rotation of the shafts.

5. The apparatus of claim 4 including also a master control valve for selective rotation of said shafts.

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