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2,862,449

POSITIVE ACTION FLOW DIVIDER

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3 Sheets-Sheet 1

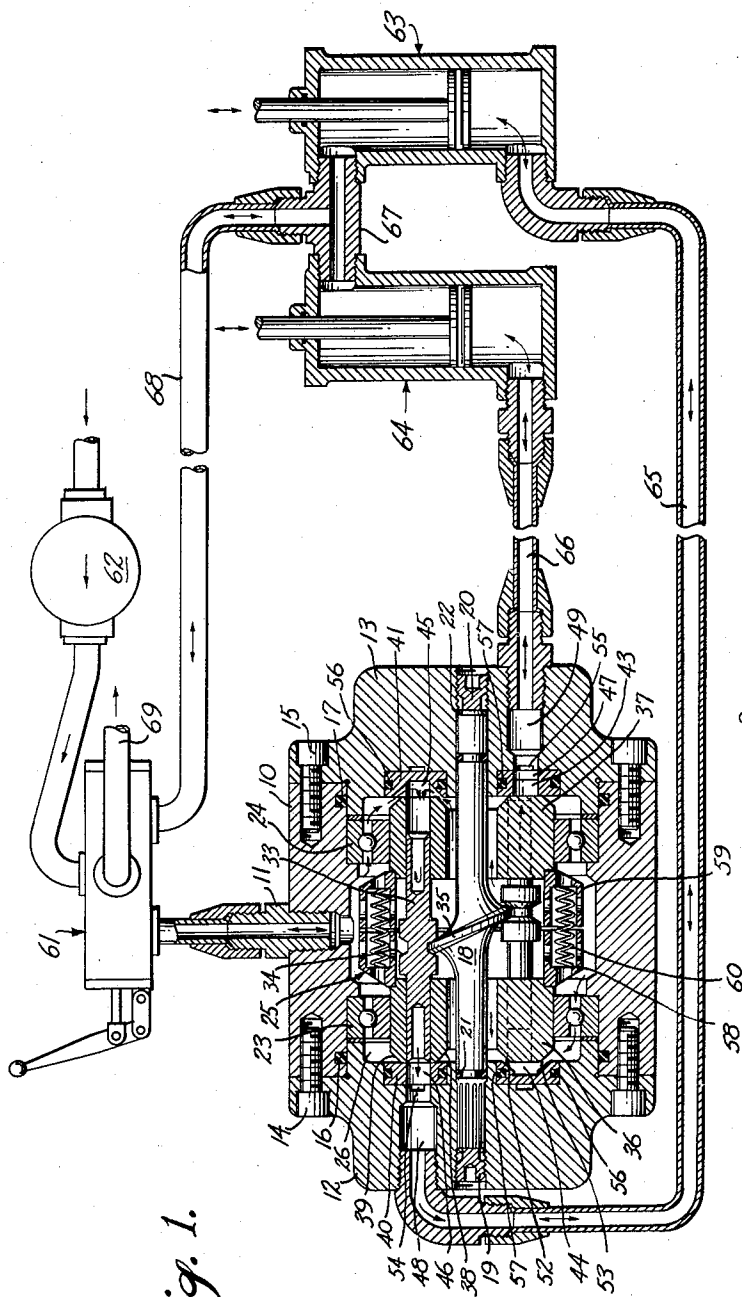


Fig. 1.

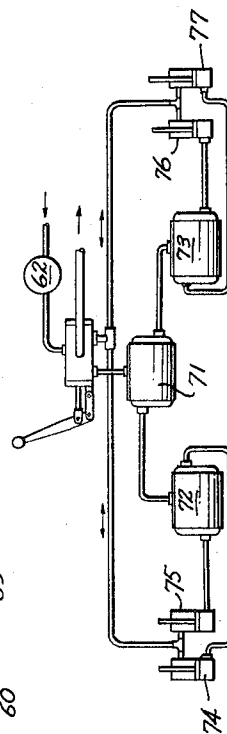


Fig. 6.

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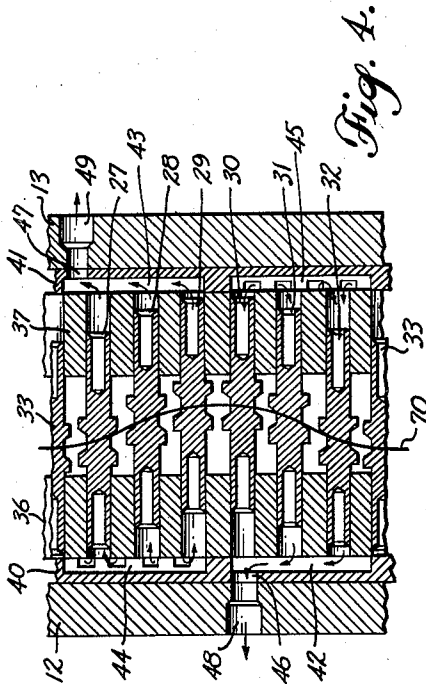
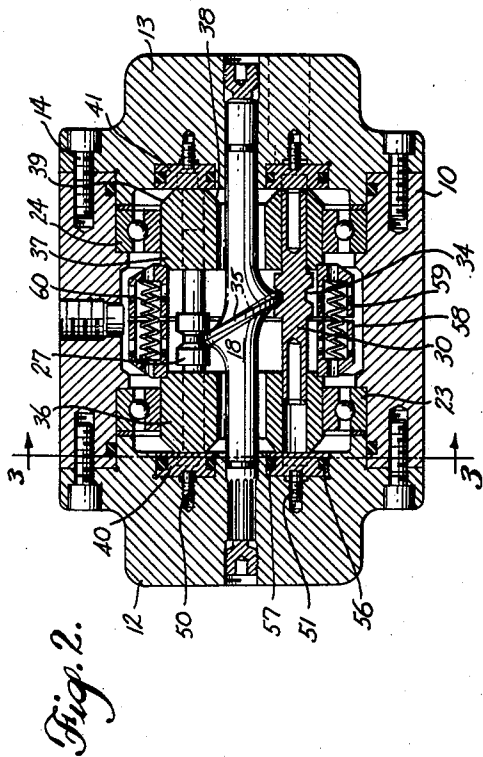
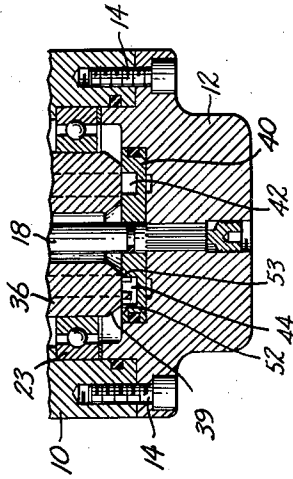
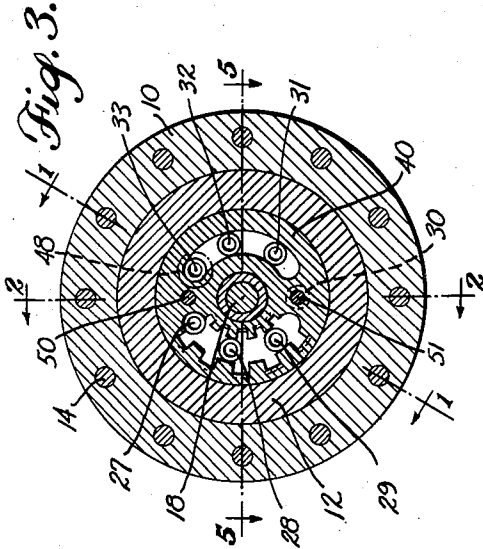
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3 Sheets-Sheet 2



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POSITIVE ACTION FLOW DIVIDER

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3 Sheets-Sheet 3

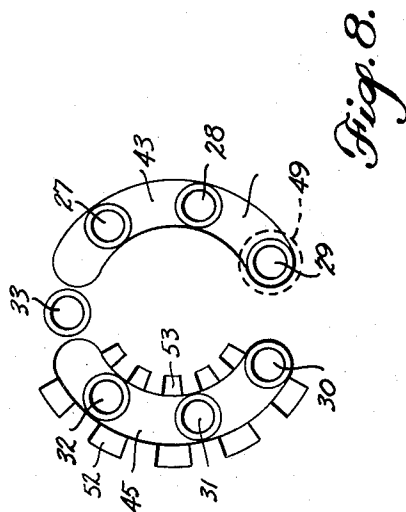


Fig. 8.

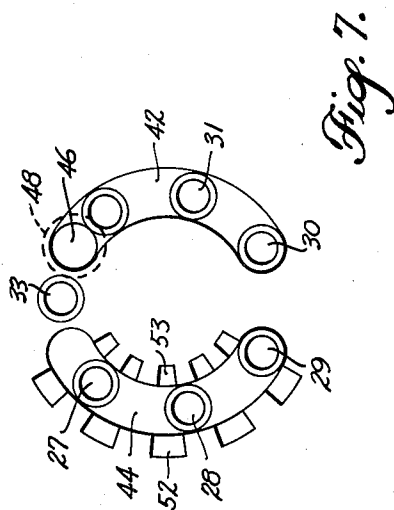


Fig. 7.

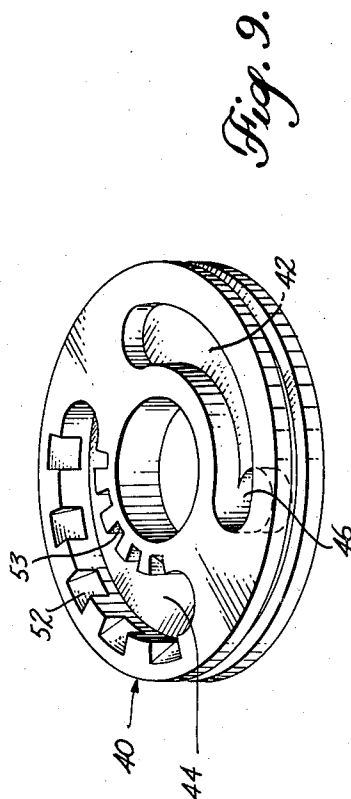


Fig. 9.

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POSITIVE ACTION FLOW DIVIDER

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9 Claims. (Cl. 103—49)

This invention relates to an improved hydraulic fluid dividing and metering device capable of receiving fluid under pressure through a single conduit, dividing the fluid into two equal or unequal parts, and delivering the divided parts continuously into two separate conduits without causing any appreciable pressure drop between the fluid pressure source and the two separate conduits.

By compounding several of the units the pressure fluid may be divided and delivered continuously in predetermined proportions into four, six, eight or more separate conduits, as desired.

A primary object of the invention is to solve the recognized industrial problem of precisely coordinating the distance travel of the pistons of two or more hydraulic cylinders whether the cylinders have equal or unequal displacement, and regardless of the loads imposed on the respective pistons during their movement in either direction. Depending on the piston performance desired, this invention is capable of metering fluid to two or more hydraulic working cylinders to produce simultaneous and equal piston travel in either the same or in opposite directions, or to produce a predetermined travel of one or more working pistons while simultaneously producing a proportionately greater or less travel by the other piston or pistons, regardless of load variations on the individual working pistons.

Another object is to provide a unit of the type mentioned which requires no auxiliary power for its operation. Instead the single rotor of the device is driven by the pressure fluid which it receives from the supply source and subsequently meters and delivers.

Another object is to provide a unit which may be used for metering identical quantities of fuel to two or more jet engines to obtain substantially balanced thrust on opposite sides of the longitudinal centerline of an aircraft or missile.

Another object is to provide a flow divider which can be interposed between a source of fluid pressure and two hydraulic motors of any type, and which is capable of precisely dividing and metering the fluid to the motors so that they will operate in synchronism.

Another object is to provide a pressure fluid divider which includes a plurality of metering cylinders and pistons, and in which half the work done by each piston is accomplished when the piston travels in one direction and the other half of its work is done when the piston travels in the opposite direction, and in which the discharge from the various cylinders is substantially without pulsation.

Another object is to provide a flow divider having leakage minimizing and wear compensating features.

Still another object is to provide a flow divider in which the moving parts are hydraulically balanced thus substantially eliminating vibration and reducing bearing loads and friction.

The invention, together with other objects attending its production, will be more clearly understood when the

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following description is read with reference to the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view through a flow divider embodying my invention, and is taken in the plane indicated by the line 1—1 of Fig. 3. The view schematically shows the divider interposed in a hydraulic system which includes a pump, a flow control valve, and two hydraulic working cylinders;

Fig. 2 is a similar longitudinal sectional view through the unit taken in the plane indicated by the line 2—2 of Fig. 3;

Fig. 3 is a transverse sectional view taken along the line 3—3 of Fig. 2;

Fig. 4 is a hypothetical flat pattern view of the rotor and its pistons, cylinders, and valves, and is primarily to simplify explanation of the operation of the unit;

Fig. 5 is a fragmentary sectional view of one end of the unit, and is taken along the line 5—5 of Fig. 3;

Fig. 6 is a schematic view illustrating three flow dividers embodying my invention compounded and interposed in a hydraulic system for metering equal volumes of fluid to four working cylinders;

Figs. 7 and 8 are schematic views showing the arrangement of intake and exhaust valve ports at the opposite ends of the unit, and their relation to the respective cylinders at opposite adjacent ends of the rotor, the rotor being in the same position in both views; and

Fig. 9 is a perspective view of one of two identical valve rings constituting parts of the unit, and particularly illustrates the configuration of the fluid intake port.

Referring particularly to Figs. 1 and 2 that embodiment of the invention illustrated includes a generally cylindrical casing 10 provided with a pressure fluid inlet fitting 11, and sandwiched between a pair of heads 12 and 13 secured to the casing by means of studs 14 and 15. Conventional O-rings 16 and 17 seal between the casing and the respective heads. A cam shaft 18 is positioned concentrically in the casing and has its opposite ends seated in aligned central bores in the opposed heads. At least one of these bores has a longitudinally serrated wall to complementally receive a splined end of the cam shaft to prevent it from rotating. The outer end of each bore is threaded to receive plugs 19 and 20 which serve to adjust the longitudinal position of the shaft with respect to the casing 10. Near its opposite ends the cam shaft is provided with annular grooves which seat O-rings 21 and 22 which prevent leakage of the pressure fluid around the shaft 18.

Interiorly casing 10 journals the opposite ends of a rotor on spaced bearings 23 and 24, the rotor being designated as a whole by the numeral 25. The cavity or chamber in which the rotor operates is designated as a whole by the numeral 26.

The rotor design illustrated includes two banks of seven cylinders each, one bank at each end of the rotor, the cylinders being equally spaced and arranged concentrically with respect to the cam shaft 18, and the cylinders in one bank being longitudinally aligned with the respective cylinders in the other bank. It will be understood that a greater or lesser number of cylinders may be provided, and that the cylinders in both banks may have equal or proportionately unequal displacement depending on the proportionate division of fluid desired. In this case all cylinders have equal displacement.

Seven piston rods (Figs. 7 and 8) are provided, one for each opposed and aligned pair of cylinders, and each rod carries a pair of integral tandem pistons, one at each end of the rod. Since each rod and its two pistons are integral a single numeral is used to identify each assembly and the word "piston" used to indicate each assembly. The pistons are identical but are identified by separate numerals 27 to 33 inclusive to facilitate subsequent ex-

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planation of the operation of the unit. (Also see Fig. 4.)

Intermediate its ends each piston is provided with an annular V-section groove 34 which is operably engaged by an inclined V-section cam 35 which is carried centrally by cam shaft 18. Cam 35, which is non-rotatable in the casing, thus serves to convert reciprocating motion of the pistons to simultaneous and synchronous revolving motion of the two cylinder banks and their pistons around the cam shaft as a unitary rotor.

In the rotor design illustrated the two banks of cylinders are formed in separate annular blocks 36 and 37. At their respective outer ends blocks 36 and 37 are chamfered internally as at 38, and externally as at 39 to provide a reduced area end face to thus reduce frictional drag as the entire rotor rotates.

Identical valve rings 40 and 41 are slidably seated in internal complementary annular seats formed in the respective heads 12 and 13. The details of construction are shown in Fig. 9. On their respective inner surface the rings are provided with arcuate superficial exhaust ports 42 and 43 (Figs. 4, 7 and 8), and with intake ports 44 and 45, each set of ports being arranged concentrically with respect to the open outer ends of each bank of cylinders, and adapted to register therewith as the rotor revolves. Exhaust ports 42, 43 communicate respectively with fluid delivery ports 46, 47 and the valve rings are oriented so that delivery ports 46, 47 are in continuous registry with outlet openings 48, 49 in the respective heads 12 and 13. While the valve rings are slidable in their seats toward and away from the respective adjacent ends of the cylinder blocks, they are prevented from rotating by pins 50, 51 seated in bored holes in the heads 12 and 13. It should be noted that intake ports 44 and 45 are each provided with a series of transverse inclined ports 52, 53 (Figs. 1 and 9) which afford open communication between the intake ports and the casing chamber 26 even when the outer end of the cylinder block is seated flat against the inner surface of the adjacent valve ring. This is clearly shown in Fig. 1, in which the arrows indicate the flow of fluid from chamber 26 through ports 52, 53 into arcuate intake port 44.

It will be understood that the outer end faces of the cylinder blocks and the adjacent inner faces of the respective valve rings should preferably be surface ground for good sealing contact. As a means of urging the valve ring faces into sealing contact the bottom of each annular valve ring seating groove is provided with an annular pressure fluid duct. These ducts are designated by the numerals 54, 55 and they communicate respectively with the outlet openings 48 and 49. The outer or back face of each valve ring is thus subjected to outlet fluid pressure which urges the ring into sealing contact with the end face of the cylinder block.

It will be noted that each valve ring carries outer and inner O-ring seals 56, 57 which seal against the walls of the grooves in which the valve rings are slidably seated. While it is entirely feasible to rigidly connect the cylinder blocks 36 and 37 one to the other, the preferred embodiment illustrated makes no such provision. Instead the inner end of each block is provided with a peripheral groove and these grooves seat and support cooperating spring pressure rings 58 and 59 which house and are urged outwardly by a plurality of circumferentially spaced compression springs 60. The combined axial length of these two pressure rings 58 and 59 is such as to permit a slight inward movement of the two cylinder blocks toward each other before the adjacent surfaces of the pressure rings make solid contact with each other. This described flexible connection between the two cylinder blocks eliminates a considerable amount of close tolerance machine work in the forming of the cylinder blocks. During operation the force applied by the fluid pressure against the outer surfaces of valve rings 40, 41 is sufficient to maintain the adjacent inner surfaces of pressure rings 58, 59 in firm and continuous contact.

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Referring again to Fig. 1, the described flow divider is shown connected into a hydraulic system which includes a three-position open-center four-way valve 61, a hydraulic pump 62 as a source of fluid pressure, two double acting working cylinders 63, 64, conduits 65 and 66 respectively connecting the working cylinders with the fluid outlet openings 48, 49 of the divider, a T-fitting 67 connecting the cylinders, and a conduit 68 connecting the T-fitting with valve 61.

Operation

Assuming that this system is primed with fluid and that chamber 26 and all the cylinders, valve ports, etc., in the divider are filled, when the valve 61 is operated to connect fitting 11 with pump 62 and to simultaneously connect conduit 68 with return line 69, fluid under pressure enters chamber 26 in the divider. Assuming also that the pistons are in the relative longitudinal positions shown in Fig. 4, and in the positions shown in Figs. 7 and 8 with respect to the valve exhaust and intake ports, the differential pressure causes fluid to enter the cylinders at the left ends of pistons 27, 28, 29 through intake port 44, and to enter the cylinders at the right end of the pistons 30, 31, and 32 through intake port 45. The differential pressure causes pistons 27, 28, 29 to move to the right in Fig. 4, and causes pistons 30, 31, 32 to move to the left. The cylinders in which piston 33 operates are for the instant blocked off from both intake and both exhaust ports. The described longitudinal movement of the pistons is converted by the cam 35 into rotational movement of the entire rotor and its banks of cylinders and pistons.

Simultaneous with the described movement of the pistons fluid is forced out of the cylinders at the right ends of pistons 27, 28, 29 through exhaust port 43, delivery port 47, outlet 49, line 66 and into the lower end of cylinder 64, also fluid is forced out of the cylinders at the left ends of pistons 30, 31, 32 through valve exhaust port 42, delivery port 46 and line 65 into the lower end of cylinder 63.

Since in the illustrated example all 14 cylinders in the divider have the same displacement, the volume of fluid delivered to each working cylinder 63, 64 will be the same as the rotor revolves and the cylinders in both banks come into and out of registration with the valve intake and exhaust ports in numerical order. Also it will be understood that flow through both conduits 65 and 66 to the working cylinders will be continuous. The reciprocation of all seven pistons, as coordinated by their continuous revolving contact with cam 35 is simulated by the sinuous line 70 in Fig. 4.

It will be understood that the volume of fluid delivered by the flow divider into each of the conduits 65, 66 will be proportionate to the displacement of the cylinders in each bank of the rotor. If the cylinders in block 37 have twice the displacement as the cylinders in block 36, then conduit 66 and working cylinder 64 will receive twice the volume of fluid received by cylinder 63. By varying the cylinder displacement during fabrication any desired ratio can be obtained in order to meet the requirements of a specific job.

After the desired equal travel of the pistons in working cylinders 63, 64 has been obtained, valve 61 is adjusted to cut off fluid flow to the divider. To move the pistons in cylinders 63, 64 in the opposite direction valve 61 is adjusted to connect fitting 11 with return line 69, and to connect line 68 with the pressure line from pump 62. Fluid pressure then causes the pistons in cylinders 63, 64, to start downward. Fluid beneath the pistons is respectively delivered into valve exhaust ports 42 and 43. Fluid pressure is now delivered to the rotor pistons in the opposite direction, and the cam forces the rotor to rotate in the opposite direction. The cylinders in both banks sequentially meter and deliver fluid through intake ports 44 and 45 into chamber 26, through inlet 11 to return line 69. The positive metering of the fluid by the cylinder

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ders in both banks assures an equal distance travel downward by the pistons in both working cylinders 63, 64, regardless of load difference on their pistons.

Referring to Fig. 6, the illustrated system includes three of the described flow dividers compounded, identified by numerals 71, 72, 73. Divider 71 receives pressure fluid from pump 62 and delivers equal volumes of continuous flow to dividers 72, 73. Each of the latter dividers divides and meters the fluid it receives, and delivers equal volumes continuously to working cylinders 74 to 77. It is evident then, based on the above described operation of the divider of this invention, each cylinder will receive an identical volume of fluid in a given period of time, and assuming that the four cylinders are identical in size, the respective pistons in these cylinders will travel identical distances during such time. Other methods of compounding will be apparent to those familiar with this art.

Having described the invention with sufficient clarity to enable those familiar with this art to construct and use it, I claim:

1. A positive action fluid flow divider comprising: a housing having a fluid outlet opening at each of its opposite ends and one fluid inlet opening; a rotor journaled within said housing and having a central longitudinal opening therethrough; a concentric inclined cam within the rotor and nonrotatably secured in the housing; two axially spaced banks of respectively axially aligned open ended cylinders in said rotor, one bank arranged concentrically around each end thereof; a tandem piston assembly reciprocable in each pair of aligned cylinders in the two banks; an annular concentric cam track or groove intermediate the ends of each piston assembly receiving and cooperating with the peripheral edge portion of the inclined fixed cam to convert reciprocal movement of the pistons into rotational movement of the rotor; two valves non-rotatably secured in the housing, one in slidable sealing contact with each end face of the rotor; concentrically arranged exhaust and intake ports in each valve cooperating with the open ends of the cylinders in the respective adjacent banks, the respective intake ports openly communicating with the housing fluid inlet opening and the registering open ends of the adjacent cylinders, and the respective exhaust ports openly communicating with the adjacent housing fluid outlet opening and with the registering open ends of the adjacent cylinders.

2. The flow divider described in claim 1 in which the ports in the valves are arranged so that a plurality of cylinders in one bank are in registry with the adjacent exhaust port while the aligned cylinders in the other bank are in registry with the adjacent intake port.

3. A positive action fluid flow divider comprising: a housing having two fluid outlet openings one at each of its ends, and one fluid inlet opening; two valves having planar faces and fluid distributing ports therein, one non-rotatably secured within each end of the housing with their adjacent faces parallel, one port in each valve being in open communication with a respective one of said fluid outlet openings; a rotor journaled in said housing, its opposite end faces being parallel and planar, each rotor end face being in slidable flat sealing contact with a respective inner face of one valve; two banks of open ended cylinders in said rotor, one bank in each end thereof, the axes of the cylinders in each bank being arranged concentrically about and parallel to the rotor axis or rotation, the respective axes of the cylinders in one bank being in alignment with the axis of the cylinders in the other bank, the open outer ends of the cylinders in each bank being located to move into and out of registry with the fluid distributing ports in a respective one of said valves as the rotor rotates; a tandem piston assembly reciprocable in each aligned pair of cylinders in the two banks; a fixed inclined cam in said housing located concentrically with respect to said rotor and its

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piston assemblies; and means carried centrally by each piston assembly for contacting said cam and cooperating therewith to convert reciprocal piston movement into rotational movement of the rotor.

4. The flow divider described in claim 3 and duct means for directing fluid under pressure against the respective outer faces of said valves to urge their respective inner faces into sealing contact with the respective adjacent end faces of the rotor.

5. A positive action fluid flow divider comprising: a housing defining a pressure sealed rotor chamber and having a fluid inlet and two fluid outlet openings, one at each end of the housing; an elongated cam shaft extending through the rotor chamber and secured against rotation in said housing, said shaft centrally carrying an inclined cam all points on the periphery of which are equidistant radially from the longitudinal axis of the cam shaft; a generally tubular rotor surrounding the cam shaft concentrically and journaled near each of its ends within said rotor chamber; two banks of open ended cylinders in said rotor, one bank is each end thereof, each bank having an identical number of cylinders and the cylinders in one bank being aligned axially with the respective cylinders in the other bank, the longitudinal axes of the respective aligned cylinders being arranged concentrically about the long axis of the cam shaft; a tandem piston assembly reciprocable in each aligned pair of cylinders in the two banks, the opposite ends of each piston assembly serving as pistons in the respective aligned pairs of cylinders; an annular groove intermediate the ends of each piston assembly for receiving a peripheral portion of and for coacting with said inclined cam to cause rotation of the rotor as said pistons are reciprocated by differential fluid pressure on their opposite ends; a non-rotatable valve ring in said housing immediately adjacent and seating flat against the outer open ends of each bank of cylinders in said rotor; superficial intake and exhaust ports in the inner seated face of each valve ring arranged concentrically with respect to the respective adjacent banks of cylinders to register with the open ends of said cylinders as the rotor revolves; and a fluid delivery port in each valve ring affording open communication between the exhaust port therein and one of the fluid outlet openings in said housing.

6. A liquid flow divider comprising: a housing; a rotor journaled in the housing, said rotor having parallel planar end faces; a like plurality of cylinders in each end of the rotor having their major axes parallel to the rotor axis and arranged concentrically thereabout, the axes of the cylinders in one end of the rotor being in alignment with the respective axes of the cylinders in the other end of the rotor and said cylinders being open at both ends; a pair of non-rotatable valves having planar inner faces in frictional sealing contact with the respective planar end faces of said rotor; open ports recessed into the planar inner face of each valve positioned to register with the open outer ends of the respective adjacent cylinders; a tandem piston assembly reciprocable in each pair of axially aligned cylinders; a fixed cam in the housing positioned concentrically and inclined with respect to the rotor axis and about which the rotor and its piston assemblies rotate; means carried intermediate its ends by each piston assembly for contacting said cam and cooperating therewith to convert reciprocal movement of the piston assemblies to rotary movement of the rotor; a fluid inlet opening in the housing in open communication through the housing interior with an inlet port in each valve; and two outlet ports in the housing, one in open communication with an outlet port in each valve, whereby fluid under pressure received through the housing inlet exerts a force against each piston whose cylinder is in registry with a respective valve inlet port, and piston movement causes the rotor to revolve, and as it revolves the cylinders come into registry consecutively with said inlet ports and alter-

nately with the respective outlet ports, through which the fluid under pressure is delivered.

7. A device for dividing and metering liquid pressure comprising: a rotor housing; a rotor journaled within the housing and having a central longitudinal opening throughout its length and having planar parallel annular end faces; two banks of longitudinally disposed cylinders in said rotor, one bank in each of its ends, each bank including the same number of cylinders, and the cylinders in one bank being axially aligned with the respective cylinders in the other bank, all cylinders being open at both ends; a tandem piston assembly reciprocable in the respectively aligned cylinders in each bank; a rotor actuating inclined cam extending coaxially through the longitudinal opening in said rotor and secured in said housing against rotation; cam cooperating means carried by each tandem piston assembly intermediate its ends and between said cylinder banks for contacting said inclined cam and causing the rotor to rotate as the piston assemblies reciprocate; a non-rotatable planar valve at each end of said rotor, each valve seated flat against a respective rotor end face and cooperating with the open ends of the cylinders therein as the rotor rotates; an intake port in each valve registerable with the adjacent cylinder ends and in open communication with the interior of the rotor housing; a pressure fluid inlet in the rotor housing; an exhaust port in each valve also registerable with the adjacent open cylinder ends; and a fluid outlet opening adjacent each valve and in communication only with

the exhaust port therein, whereby liquid under pressure entering the housing through the inlet causes piston reciprocation and, through cam action, rotor rotation, and the liquid is metered consecutively to the cylinders in each bank during their registry with the respective intake ports, and is discharged by them during their registry with the respective exhaust ports, and the liquid delivered into the respective exhaust ports is directly proportional to the displacement of the aligned cylinders in each bank.

8. The device described in claim 7 in which the rotor includes two separate cylinder blocks having limited relative axial movement; and means resiliently urging said blocks apart axially and into seating contact with the respective valves.

9. The device described in claim 7 in which said valves are mounted for limited axial movement with respect to the rotor; and ducts connected with the respective exhaust ports for directing liquid under pressure against the respective outer faces of the valves to urge them into firm seating contact with the respective end faces of the rotor.

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