March 3, 1931. J. J. CRAIN 1,794,946

HYDRAULIC PUMP, MOTOR, AND THE LIKE

Filed April 24, 1929 5 Sheets-Sheet 1

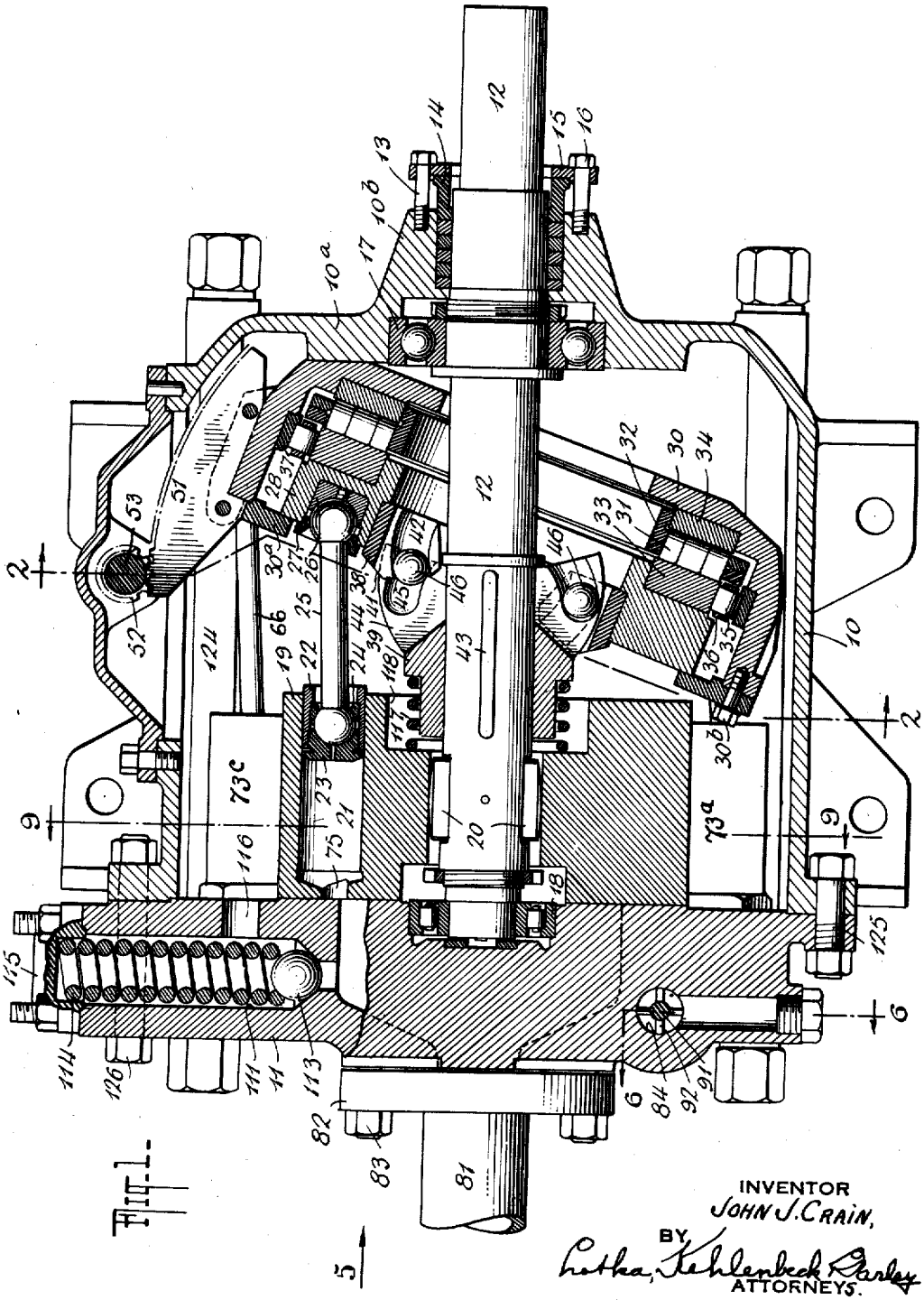


FIG. 1.

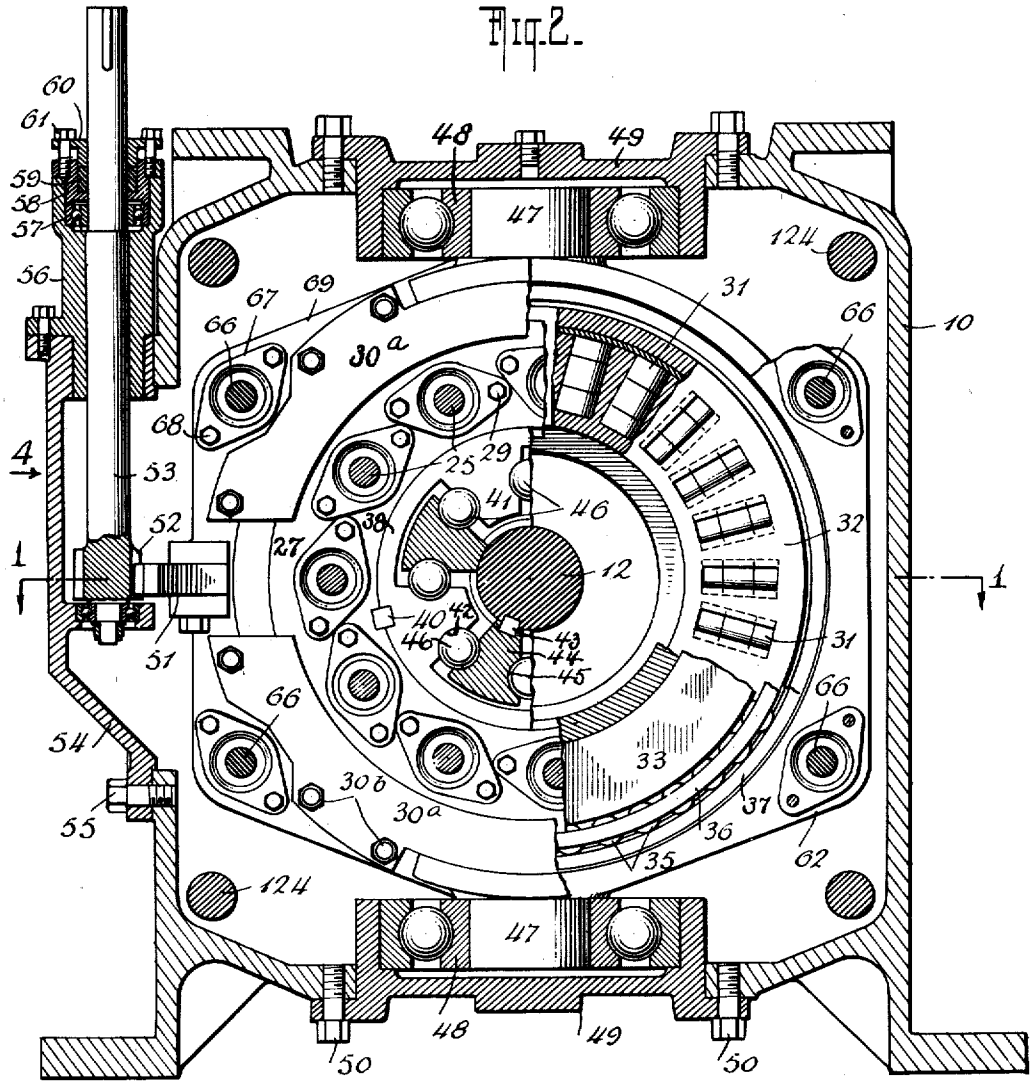
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HYDRAULIC PUMP, MOTOR, AND THE LIKE

Filed April 24, 1929 5 Sheets-Sheet 2

Fig. 2.



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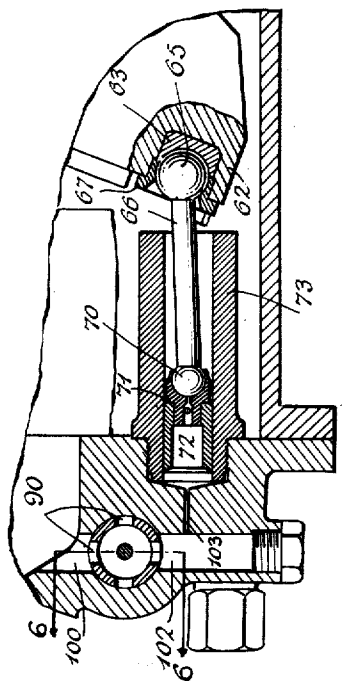


Fig. 3.

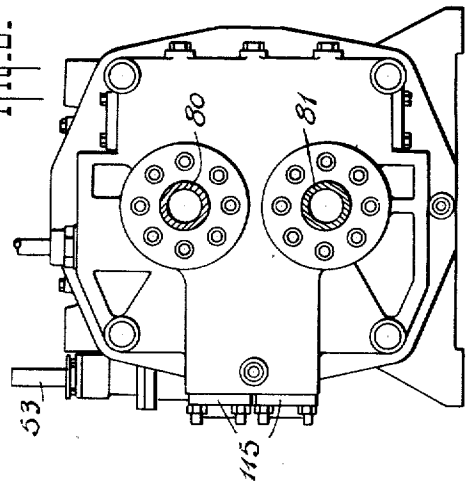


Fig. 5.

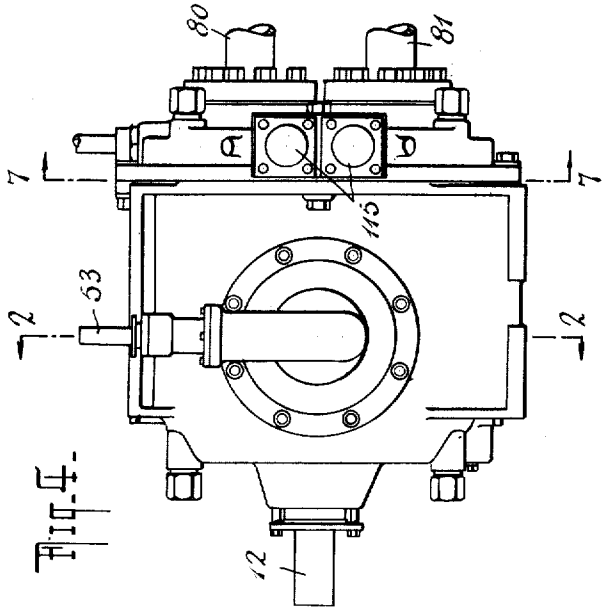


Fig. 4.

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HYDRAULIC PUMP, MOTOR, AND THE LIKE

Filed April 24, 1929

5 Sheets-Sheet 4

Fig. 6.

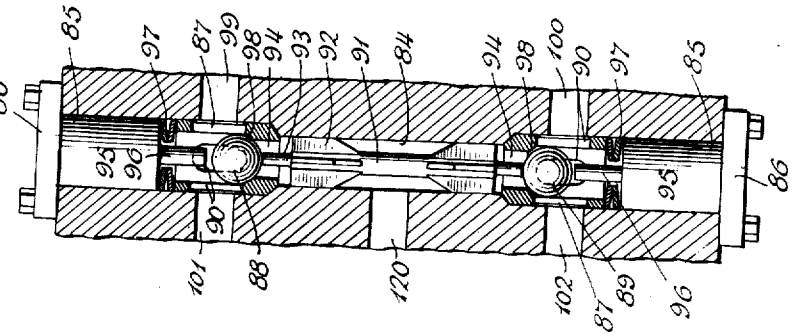


Fig. 7.

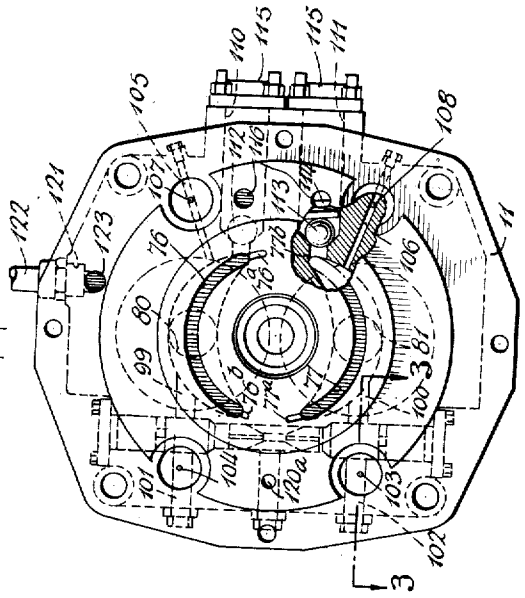
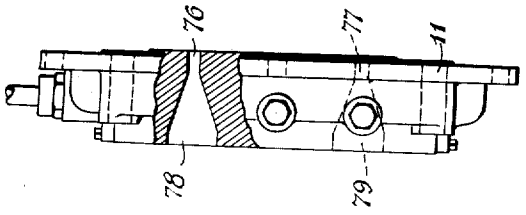


Fig. 8.



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March 3, 1931. J. J. CRAIN 1,794,946

HYDRAULIC PUMP, MOTOR, AND THE LIKE

Filed April 24, 1929 5 Sheets-Sheet 5

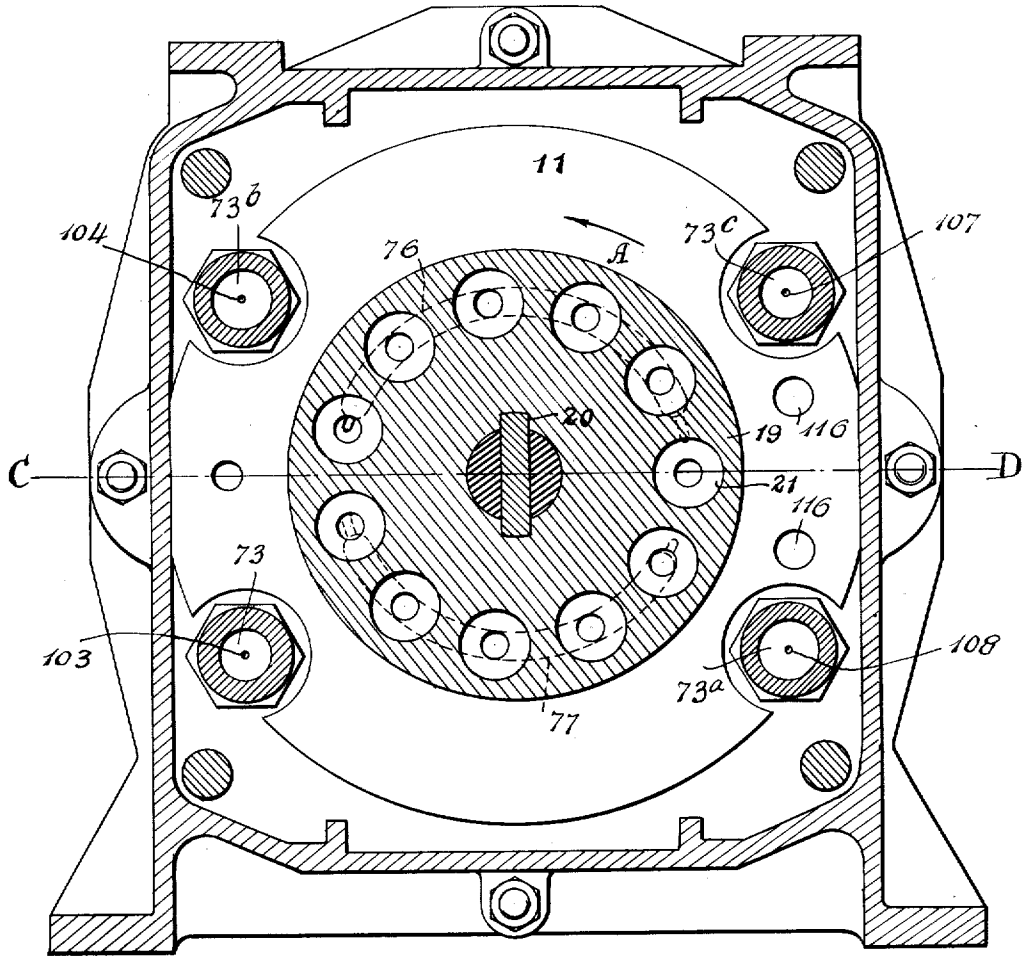


Fig. 9.

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UNITED STATES PATENT OFFICE

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HYDRAULIC PUMP, MOTOR, AND THE LIKE

Application filed April 24, 1929. Serial No. 357,640.

This invention relates to hydraulic speed gears and particularly to the well known Waterbury type of gear in which fluid is circulated from a fluid pressure pump to a fluid pressure motor, the pump and motor being of similar construction and each consisting of a rotating cylinder barrel having a plurality of cylinders aranged in parallelism with the axis of the driving shaft. Each cylinder has mounted for reciprocation therein a piston connected by a suitable piston rod with a plate, known in the art as a swash plate, which plate is mounted for rotation in a ball or other anti-friction race carried by a tilting box. In the pump the tilting box is usually made angularly adjustable with respect to the axis of rotation of the cylinder barrel while in the motor the tilting box is usually held at a fixed inclination. When the tilting box of the pump is in a position perpendicular to the axis of rotation, the pistons have no stroke and no fluid is pumped. This is called the "neutral" position. When the tilting box is moved in either direction from the perpendicular position, fluid is pumped by the pump in one or the other direction according to the direction of movement of the tilting box. The greater the extent of movement of the box from the perpendicular position the greater the stroke of the piston and consequently the greater the output of the pump.

While machines of the type above described have gone into extensive use and have operated with marked success, it has been found difficult to overcome certain objectionable features such as lack of uniformity of the flow of the fluid pumped, vibration and pounding, and excessive wear on some of the parts. In order to reduce to a minimum the vibration effects, and also the excessive wear above referred to, it has been found necessary in the past with the constructions heretofore employed, to use great care in the manufacture of the various parts which comprise the complete machine and to machine many of the parts separately. As a result modern high speed production methods could not be successfully used to manufacture speed gears of the type to which the present invention relates and therefore the production cost and sales price of such machines have been comparatively high.

Gears of the above type are shown in many patents among which may be noted United States Letters Patent No. 1,659,374 to Robson, granted February 14, 1928. Considered in its most general aspects, the principal object of the present invention is to improve upon the gear shown in the said Robson patent and to provide a new and improved construction for a hydraulic speed gear of the type described therein, in which vibration and pounding effects are reduced to a minimum and are in fact practically, entirely eliminated; which will be smooth in its action and which will insure a more uniform flow of the fluid circulated.

A further object is to improve upon the construction of the mounting of the tilting box so that it can be adjusted by the exertion of less physical effort.

Another object is to provide a new construction in which means are provided to overcome the tendency, manifested in the constructions heretofore employed, of the tilting box to return towards its neutral position when the speed gear is in operation.

A further object is to improve upon the construction of the replenishing fluid valves by means of which the suction line is always maintained full of fluid and to so construct such valves that they will act as shuttle, or back pressure, relief valves.

Another object is to simplify the construction of the stuffing box for the driving shaft so that the cost of the manufacturing operations connected therewith will be reduced and in addition so that the operation of repacking the stuffing box will be facilitated.

Other objects of the invention are to provide a construction in which practically all of the manufacturing and assembling operations are simplified and the cost thereof reduced and to provide a more sturdy and rugged construction that will stand up better under severe operating conditions, and as a result operating and maintenance costs will be materially reduced.

The above and other objects of the inven-

tion will appear more fully from the following more detailed description and by reference to the accompanying drawings forming a part hereof, wherein Fig. 1 is a longitudinal section taken substantially on the line 1—1 of Fig. 2; Fig. 2 is a section taken on the line 2—2 of Fig. 1; Fig. 3 is a sectional detail taken substantially on the line 3—3 of Fig. 7; Fig. 4 is a side elevation on a reduced scale of the device as seen from the arrow 4 in Fig. 2; Fig. 5 is an end elevation as seen from the arrow 5 in Fig. 1; Fig. 6 is a section taken substantially on the line 6—6 of Fig. 3; Fig. 7 is an elevation of the end or valve plate, with a part thereof broken away, this view being taken substantially on the line 7—7 of Fig. 4; Fig. 8 is a side view partly in elevation and partly in section of the structure shown in Fig. 7, and Fig. 9 is a section on the line 9—9 of Fig. 1.

In the drawings I have shown the principles of the invention as exemplified in the pump unit, or A-end, as it is usually termed, of a hydraulic speed gear. The numeral 10 indicates the pump housing, one end of which is closed by an end wall 10^a preferably made integral with the side walls of the housing. The other end of the housing is closed by a valve plate 11 the constructional details of which will hereinafter be set forth more fully. The end wall 10^a is provided with a central aperture through which the driving shaft 12 projects, said aperture passing through a boss-like projection 10^b which is counterbored to provide a stuffing box. Located within the stuffing box is any suitable packing material 13 held in place by means of a packing gland 14, which is of split ring construction and is tightened by means of a clamp 15 and bolts 16. A suitable recess provided in the inner face of the end wall 10^a receives a ball or other suitable anti-friction bearing 17.

As clearly shown in Fig. 1 of the drawings, the driving shaft 12 projects through the housing 10 and has its inner end reduced and mounted within a roller or other suitable anti-friction bearing 18 seated within a recess of the end plate 11. Immediately adjacent to the end plate 11 and within the housing 10 is located a cylinder barrel 19 which is mounted on the shaft 12 for longitudinal sliding movement relatively thereto, but which is keyed against rotation thereon by means of the keys 20. The cylinder barrel 19 is provided with a plurality of cylinders 21, the axes of which extend in parallelism with the shaft 12. Each cylinder has mounted therein a piston formed by a sleeve 22 and screw cap 23. The sleeve 22 is counterbored to provide a shoulder against which is seated a bearing piece 24 and the outer end of the counterbore is screwthreaded for the reception of the screw cap 23. The bearing piece 24 and the screw cap 23 co-operate to provide a means for securing to the piston the ball-shaped end of the piston rod 25, the bearing surfaces of the bearing piece and cap having a spherical configuration similar to that of the end of the piston rod which engages with said surfaces. The other end of each piston rod is provided with a similar, though larger ball-shaped end, which is located between a bearing block 26 and a flanged clamping member 27. It will be understood that a plurality of cylinders are provided in the cylinder barrel 19, the number of such cylinders in the constructional example shown being 11. The bearing blocks 26 for the piston rods are seated within suitable recesses formed in a swash plate 28, and the flanged clamping members 27 are clamped against the front face of said swash plate by bolts 29 which pass into suitable screwthreaded holes provided in the swash plate. It will be understood that the swash plate is provided with a recess, bearing piece 26 and clamping member 27 for each cylinder, there being therefore eleven sets of these parts on the swash plate.

The swash plate is mounted for rotation within a tilting box 30, anti-friction bearings being interposed between the swash plate and tilting box. In the example illustrated the anti-friction bearings consist of a plurality of rollers 31 having their axes disposed radially with respect to shaft 12. Said rollers are mounted in a cage or spider 32 in accordance with the usual construction of such anti-friction bearings. A pair of hardened annular race ways 33, 34 are interposed between the swash plate 28 and the tilting box, respectively, and said rollers 31.

A second anti-friction bearing consisting of a plurality of rollers 35 mounted in a roller cage 36 is also provided. These rollers 35 are interposed between the outer periphery of the race 33 and an annular race 37 seated within the tilting box, the rollers 35 having their axes arranged at right angles to the rollers 31. The annular raceways 34 and 37 are preferably press fitted within the bore of the tilting box 30, while the raceway 33 is preferably press fitted upon a boss like rearward extension of the swash plate 28. After the raceways have been seated home, the bearing cages 32, 36, carrying the rollers 31 and 35, and the swash plate are placed within the cup shaped housing formed by the tilting box and the latter parts are held rotatably within said housing by an annular face plate 30^a secured to the front of the tilting box by the cap screws 30^b.

The swash plate 28 is fixed to the shaft 12 for rotation therewith and as the angle of inclination of the swash plate is adjustable with respect to the axis of the driving shaft 12 means are provided for permitting said adjustment. This means consists of a uni-

versal ballbearing formed by a pair of members 38, 39 connected in driving relationship, but so that the angular position of one member to the other may be varied. The member 38 is seated within a central bore of the swash plate 28 and is seated against a shoulder formed by a counterbore of said central bore. In assembling the parts a press fit is preferably made between the member 38 and the counterbore of the swash plate and the two parts are held together against relative rotation by any suitable means such as the key 40, shown in Fig. 2. As shown in Figs. 1 and 2 the member 38 is provided with a plurality of inwardly extending spaced segments 41 which terminate short of the shaft 12. Each side wall of each segment 41 is provided with an arc-shaped groove 42 of semi-circular cross section. The member 39 has an apertured boss portion mounted upon the shaft 12 and secured against rotation relatively thereto by any suitable means, such as the key 43. Projecting from and preferably formed integral with said boss portion is a plurality of spaced segments 44 which project into the spaces formed between the segments 41 of the member 38. The side walls of the segments 44 are also formed each with a curved groove 45. It will be noted by referring to Figs. 1 and 2 that each groove 42 is opposed to a cooperating groove 45 and that each pair of opposed grooves 42, 45, has seated therein a ball 46. The grooves 42, 45 are eccentric with respect to each other but are so arranged that when the tilting box and swash plate are moved to an angular position such as shown in Fig. 1 of the drawings, this movement is readily permitted by the curvature of the grooves. The balls 46 act as interlocking devices which hold the two parts 38, 39 against rotation relatively to each other and said balls also serve as anti-friction members to permit the angular displacement of the swash plate and tilting box to be readily accomplished by the exertion of a minimum force.

In order that there be no unbalanced weight upon the tilting box when it is moved to an angular adjusted position said box is mounted for rotation upon a vertical axis. The means for mounting the tilting box comprises a pair of trunnions 47 preferably formed integral with said box. These trunnions project into anti-friction bearings 48, each seated within a bearing plate 49 seated within suitable apertures formed in the top and bottom walls of the housing and detachably secured in position by means of the bolts or cap screws 50.

For the purpose of adjusting the position of the tilting box and swash plate, the tilting box has secured to one side thereof a segmental gear rack 51, the teeth of which mesh with the teeth of a pinion 52. The pinion 52 is secured upon the lower end of a control shaft 53 mounted for rotation in a bracket 54 bolted to the side wall of the housing 10 as by the bolts 55. In order to permit the ready removal of the control shaft 53, the bracket 54 is provided at the upper end thereof with an aperture in which is seated a bearing block 56 having a counterbore, in the upper end of which is received an anti-friction bearing 57, held between the bottom of the counterbore and a bearing cap 58. The latter is preferably bolted within the block 56 by bolts (not shown). The bearing cap 58 also performs the function of a stuffing box and is counterbored for the reception of any suitable packing material, such as indicated by the reference character 59, a packing gland 60 and bolts 61 being provided to hold the packing 59 in position.

In order to overcome vibration and the tendency of the tilting box to return towards its neutral position manifested when the pump is delivering fluid the tilting box is provided at four diametrically opposite points thereof with lugs 62 each of which is recessed, as shown in Fig. 3 of the drawings, to provide a pocket for the reception of a bearing block 63. The bearing block 63 is provided with a bearing surface in which is seated the ball-shaped end 65 of a piston rod 66. The end 65 of the piston rod is held against the bearing block 63 by means of a flanged clamping member 67 similar to the members 27, and said clamping members 67 are clamped by means of the bolts 68 to a flange 69 formed integral with the tilting box. There are, as shown in Fig. 2 of the drawing, four piston rods 66 each of which has the tilting box end thereof secured in the manner just described within its respective lug 62. The other end of each piston rod is provided with a similar, though smaller, ball-shaped end 70 secured, by means of a bearing piece 71, to a piston 72. The latter is slidably mounted within a cylinder block 73 screwed into the inner end of the end plate 11. There are four cylinders similar to the cylinder 73. These cylinders are shown most clearly in Fig. 9 wherein they are indicated by the reference characters 73, 73^a, 73^b and 73^c. As shown in Fig. 9 these four cylinders are arranged at diametrically spaced points outside of the outer periphery of the cylinder barrel 19.

As shown in Fig. 1 of the drawings the pump cylinders 21 are each provided at their inner end with a port 75 which port is adapted to be brought alternately into registry with arc-shaped ports 76, 77 formed in the inner face of the valve plate 11 (see Fig. 7). As shown in Fig. 7 the ports 76, 77 are concentric with respect to the axis of rotation of the cylinder barrel 19 and driving shaft 12, and each port is provided at the ends thereof with the port extensions designated by the reference characters 76^a, 76^b, 77^a and 77^b. It

will be noted that the port extensions 76^a, 77^a are longer than the extensions 76^b, 77^b, the longer extensions 76^a, 77^a being on the leading edge of the ports for a purpose presently to be more fully set forth. The ports 76, 77 are located respectively at the inner end of arc-shaped conduits 78, 79, which, as clearly shown in Fig. 8 of the drawing, are diverging, the outer ends of said conduits having a width substantially equal to the diameter of the pipes 80, 81, (shown in dotted lines in Fig. 7) with which said conduits are respectively in communication. Each of the pipes is connected to the valve plate by a flange 82 and studs 83, (see Fig. 1).

The valve plate 11 to one side of the ports 76, 77 is provided with a through, vertically extending bore 84, see Fig. 6, which is counterbored at each end thereof as indicated by the reference character 85, the ends of said counterbores being closed by the closure plates 86. Mounted within each of the counterbores 85 is a ball cage 87, each containing a ball valve, said ball valves being indicated by the reference characters 88, 89. Each ball cage 87 is provided with a plurality of longitudinal extending slots 90 for a purpose presently to be described. Mounted within the conduit 84 between the ball valves 88, 89 is a slider 91 which is guided for movement within the bore 84 by the spaced fins 92 which project radially from the slider and fit neatly within the bore 84, there being four of such fins, as shown adjacent each end of the slide in Fig. 1 of the drawings. Each end of the slider is provided with a teat 93 which projects into a central aperture indicated by the reference character 94 provided in each ball cage 87. The teats 93, as will be readily understood, are adapted to be engaged by, or to engage with, the respective balls 88, 89, according to pressure conditions as will be set forth.

In order to prevent leakage of fluid past the closure plates 86, and to provide a stop for limiting the extent of movement of the balls 88, 89, each counterbore 85 has fitted therein a spacing block or plunger 95. Each plunger is provided with a teat 96 which projects into the open end of its adjacent ball cage and serves as a stop to limit the movement of its respective ball valve 88 or 89. Interposed between the end of each plunger and its adjacent ball cage is a packing 97 of any suitable material. It will be understood that each ball cage is provided with a joint surface indicated by the reference character 98 against which the ball valves are adapted to seat.

The valve cage in which the ball 88 is mounted communicates through its elongated slots 90 with a conduit 99 which, as shown in Fig. 7, communicates with the conduit 78 and port 76, while the ball cage in which the valve 89 is mounted communicates through a similar conduit 100 which in turn communicates with the conduit 79 and port 77. In a like manner the cages for the valves 88, 89 communicate with conduits 101, 102. The conduit 102 is in communication by means of a small branch conduit 103 with the cylinder 73 and the conduit 101 is in communication by means of a similar branch conduit 104 with the cylinder 73^b. It will thus be seen that the cylinders 73^b and 73 are adapted to be placed in communication with the conduit 78, port 76, and conduit 79 and port 77 respectively, such communication however being under the control of the valves 88 and 89 respectively The cylinders 73^c and 73^a communicate with the conduits 78, 79, respectively through the lateral conduits 105, 106 and branch conduits 107, 108, the latter being similar to the branch conduits 103, 104.

The valve plate 11 is furthermore provided with a pair of valve bores 110, 111 which communicate at their inner end through reduced ports with the conduits 76, 77 respectively. The bores 110, 111 have mounted therein the ball valves 112, 113, each of which is normally held by a spring 114 against a valve seating surface formed at the inner end of each bore. The outer ends of the bores are closed by closure plates 115. Each of the bores 110, 111 are in communication with the interior of the housing 10 by means of a hole 116 drilled laterally of each respective conduit through the valve plate (see Fig. 1).

In order to prevent leakage between the meeting faces of the valve plate 11 and the cylinder barrel 19, the latter is held against the inner face of the valve plate by means of a spring 117, which seats at one end against the inner end of a recess 118 formed in the cylinder barrel and at its other end abuts against a shoulder provided by an enlargement of the universal joint member 39.

The valve plate 11 is provided with a conduit 120 located substantially midway between the conduits 101, 102; this conduit 120 serves to connect the low pressure or suction side of the valve plate with the interior of the casing through the lateral port 120^a and is also employed for filling or replenishing the device with fluid. In order to permit expansion of the fluid under the influence of heat the valve plate is furthermore provided with an aperture 121 preferably screw-threaded for the reception of a pipe 122 which may lead, in accordance with the usual constructions employed for devices of the type to which the invention relates to an expansion tank, not shown. The aperture 121 communicates through a lateral branch 123 with the interior of the housing 10. Any suitable means such as the bolts 124 may be provided for securing the valve plate to the housing. These bolts preferably, as shown in Fig. 1, extend entirely through the housing 10 and valve plate. Additional flange bolts, such as

indicated by the reference character 125, 126 may also be provided for securing the valve plate to the housing.

The manner in which the device operates is as follows: Let it be assumed that the shaft 12 is connected with any suitable driving members such as an electric motor, that the tilting box 30 and swash plate 28 have been adjusted to a position such as shown in Fig. 1 of the drawings and that the cylinder barrel is rotated in the counter clockwise direction as indicated by the arrow A in Fig. 9. The rotation of the shaft 12 will cause the cylinder barrel 19 to be rotated. As each cylinder 21 passes the center line C—D, Fig. 9, the swash plate end of its respective piston rod 25 will be carried with the cylinder and due to the inclination of the swash plate the pistons 22, 23 will be caused to move inwardly of the cylinder. It will be noted from Fig. 9 that during a short period of each cylinder's rotation before and after it crosses the center line C—D that the port 75 at the inner end of the cylinder will be closed by what is termed in the art the mid-plate portion of the valve 11. Shortly after the center line C—D is passed the port 75 will come into registry with the extension 76^a of the valve port 76. The travel of the swash plate end of the piston rod along the inclined swash plate causes the piston to continue its inward movement through 180° of the revolution of the cylinder barrel and through the larger portion of this part of the revolution the port 75 will be in full communication with the port 76. After the cylinder again crosses the center line C—D, the piston will start to move outwardly. It will be seen by referring to Fig. 9 that a number of cylinders 23 will be in communication with the ports 76 at any one time. In order however to avoid shocks that would occur were an even number of cylinders employed and diametrically opposed cylinders would be simultaneously placed in communication with the suction and pressure ports, an uneven number of cylinders is preferably employed. In the present constructional example I have shown eleven cylinders and it will be seen from Fig. 9 that as the uneven number of cylinders are equally spaced, simultaneous communication of a pair of cylinders with the suction and pressure ports can not occur.

It should be readily understood that due to the travel of the piston rods about a circular path volumetric displacements of the fluid will not be uniform throughout each piston stroke, the speed of travel of the pistons increasing gradually during a quarter of a revolution of the cylinders after passing the line C—D and decreasing gradually during the quarter of a revolution in which they are approaching said line. It will be obvious that while the pistons are moving inwardly and while their ports 75 are in communication with the port 76 of the valve plate that fluid will be pumped through the port 76 and conduit 78 to the pipe 80, while when the ports 75 are in communication with the port 77 the pistons will be moving outwardly and fluid will be sucked through the port 77 and conduit 79 from the pipe 81. Due to the fact that there will tend to be a higher pressure in each cylinder towards the end of the piston stroke than during the first half of such stroke, the extensions 76^a, 77^a have been made somewhat longer than the port extensions 76^b and 77^b, the ports 76 and 77 with their extensions being shifted approximately from 5° to 7° relatively to the line C—D and being non-uniformly disposed or asymmetric with respect to said line. As a result of this lengthening of the port extensions the center of pressure of the cylinders, with respect to the piston travel therein is brought closer to the center of the piston stroke and a more perfect balancing of the reactions on the tilting box are secured, whereby the effort required to adjust the tilting box by means of the control shaft 53 is considerably reduced.

The more ready adjustment of the tilting box by the control shaft is also facilitated by mounting the tilting box upon a vertical axis thereby eliminating all unbalanced weight of the tilting box and parts carried thereby, and also by the ball bearing mountings for the trunnions 47.

When the tilting box 30 and swash plate 28 are adjusted, as shown in Fig. 2 of the drawings, and the cylinder barrel 19 is rotated in the counter-clockwise direction described, the port 76 as above pointed out will be the pressure port. The pressure of the fluid within the port 76 and conduit 78 will be communicated through the conduit 99 and will cause the ball valve 88 to be moved and held to its seat 98 as shown in Fig. 6 of the drawings. With the ball valve 88 in this position its engagement with its co-operating teat 93 of the slider 91 will cause the slider to be moved towards the ball valve 89 and the teat 93 at the other end of the slider to hold the latter ball valve off of its seat. The low pressure side or port 77 will therefore be placed in communication through the conduit 100, ball cage 87 for the ball valve 89 and conduits 84, 120 and 120^a with the interior of the housing 10.

The pressure within the conduit 99 is communicated through the conduit 101 and lateral branch 104 with the balancing cylinder 73^d. Balancing cylinder 73^c will also be placed in communication with the pressure side through the conduit 105 and branch conduit 107. On the suction side the balancing cyinders 73 and 73^a will be in communication with the port 77 and conduit 79 through the conduit 102 and its branch 103 and through the conduit 106 and its branch 108 respectively. For the purpose of over-

coming the tendency manifested in devices of this type of the tilting box and swash plate to be pushed backward towards the neutral position as a result of the variable pressures exerted by the piston rods 25 upon the swash plate and tilting box, the cylinders 73^b and 73^a are made slightly larger in diameter than the cylinders 73 and 73^c.

If the tilting box is adjusted to the opposite angle to that shown in Fig. 1 of the drawings, the port 77 will then become the pressure port and the port 76 the suction port. The ball valves 88, and 89, with the slider 91 will therefore be pushed to the opposite end of their limit of movement from that shown in Fig. 6. The conduit 78 will then be in communication with the interior of the casing and the cylinders 73 and 73^a will be under pressure while the cylinders 73^b and 73^c will be under suction. With this latter adjustment of the tilting box it will be understood that the direction of flow of the pump will be reversed. It will also be noted that the longer extension 77^a of the port 77 will be at the leading edge of the port and that the larger cylinder 73^a of the two lower cylinders 73, 73^a will exert a thrust upon the tilting box in a direction such as to counteract a tendency of the box to be returned to its neutral position.

In addition to functioning in the manner just described to overcome the tendency of the tilting box to return to neutral, the balancing cylinders 73, 73^a, 73^b, 73^c also function as dash pots to prevent vibration of the tilting box about its trunnions.

The increase in the number of cylinders insures a smoother action and more uniform oil flow than in constructions heretofore employed. The provision of the ball bearing universal joint is also an important factor in securing smoother and more uniform action of the pump as this type of ball bearing has no errors of angular displacement such as is present in the ordinary universal joint, and, in addition, not only reduces to a considerable extent the objectionable friction and wear manifested with the prior constructions but reduces the effort required to adjust the tilting box.

The provision of the ball bearing trunnions for the tilting box together with the mounting thereof upon a vertical axis and the inclusion of the hydraulic balancing cylinders results in securing an exceptionally well balanced condition for the control shaft so that the latter may be adjusted with such little effort it can be geared directly to a well known Selsyn control, thus making it possible to dispense with the use of any servo-motor system for operating the control shaft. The hydraulic mechanism of the type to which the present invention relates has been used extensively for ships' steering gears and in such gears it has heretofore been considered necessary to provide a servo-motor for the control shaft of the pump. With the present invention steering gear installations are markedly simplified.

The operation of the relief valves 112, 113 will be readily understood. Such valves are loaded by their respective springs 114 to open at a predetermined pressure. Whenever the pressure of the fluid being pumped under pressure through the port 76, or 77, as the case may be, exceeds a predetermined value, the valve 112 or 113 will open and permit a portion of the fluid to escape to the housing. It will be noted that the valves 112, 113 act as one-way valves and that when either port 76 or 77 is under suction no fluid will be sucked past the valve which controls the conduit to the respective port.

The construction of the bearing mountings for the ball shaped ends of the piston rods 25 permits the use of a much larger ball on the piston end of the connecting rod than was heretofore employed. In addition not only are the manufacturing operations required for the sleeve type of piston shown markedly simplified and thereby the production costs reduced, but the weight thereof is considerably decreased while at the same time the arrangement of the piston parts results in the production of a stronger and sturdier construction. Likewise the construction of the bearing members at the swash plate end of the piston rods also has been materially simplified and the objectionably large diameter threads of the prior constructions eliminated.

As a result of the split ring construction of the packing gland 14, the operation of repacking the stuffing box is greatly facilitated. In general, the construction of all of the parts which comprise the device have been simplified and improved upon whereby not only are the manufacturing and maintenance costs reduced but in addition the operation has been rendered more uniform, smoother and practically vibrationless, the adjustment of the swash plate much more readily performed by the exertion of less force, whereby greater accuracy and uniformity of adjustment may be secured.

While the invention has been described as exemplified in a pump, or A-end, of a speed gear in which the swash plate is adjustable, it will be understood that the device shown is adapted for use as either a pump or a motor and that when used as a motor the means for varying or adjusting the angle of inclination of the swash plate may, if desired, be dispensed with and the swash plate and tilting box constructed to be held at a fixed angle of inclination.

It will also be understood that the principles of the invention are not limited to such specific constructional details as the relative sizes, number, or position of the parts but that many changes, variations and modifica-

tions may be resorted to without departing from such principles.

I claim:

1. A fluid pressure transmission device of the type wherein a cylinder barrel having a plurality of cylinders therein is mounted in a casing upon a main shaft with the cylinders in parallelism to said shaft, and a piston slidably mounted in each of said cylinders is connected by a piston rod to a swash plate rotatably mounted in an angularly adjustable tilting box characterized by the fact that there is interposed between said tilting box and a fixed part of said casing a plurality of balancing cylinders and pistons, certain of which are of greater diameter than the others.

2. A fluid pressure transmission device as set forth in claim 1 in which the tilting box is mounted for rotation upon a vertical axis, a plurality of balancing cylinders and pistons are interposed between said tilting box and a fixed part of said casing said cylinders being arranged in pairs, the members of each pair being diametrically opposed upon opposite sides of the axis of rotation of said swash plate and means are provided for automatically placing the opposite members of each pair of balancing cylinders in communication respectively with the suction and pressure sides of the device.

3. A fluid pressure transmission device as set forth in claim 1 in which there is interposed between the tilting box and a fixed part of the casing, a plurality of balancing cylinders, said cylinders being arranged in pairs, and the members of each pair being of different cross-sectional area and arranged diametrically on opposite sides of the axis of rotation of the swash plate, and means for automatically placing the larger of said balancing cylinders in communication with the pressure side of said device, said larger cylinder being so located with respect to the axis of adjustment of the tilting box that its piston will exert a pressure on said tilting box in a direction opposite to the movement of said box towards neutral position.

4. A fluid pressure transmission device as set forth in claim 1 in which there is secured to the swash plate and driving shaft a pair of joint members, each of which is provided with a plurality of wing sectors, with the sectors of one member arranged in alternation with the sectors of the other member, the opposed faces of said sectors being provided with arcuate grooves, and a ball mounted in each co-operating pair of arcuate grooves.

5. A fluid pressure transmission device as set forth in claim 1 in which the swash plate is provided with a plurality of laterally projecting webs arranged in spaced relationship to each other around the driving shaft and the latter is provided with radially extending spaced webs arranged in alternation with said first named webs and projecting into the spaces between the latter, and balls are interposed between each adjacent pair of said webs.

6. A fluid pressure transmission device as set forth in claim 1 in which a valve plate provided with a pair of arcuate ports is located at the end of the cylinder barrel with said ports adapted to communicate alternately with said cylinders, said ports being provided at their ends with port extensions, the port extensions at the leading edges of said ports being longer than the extensions at the other edges thereof.

7. A fluid pressure transmission device as set forth in claim 1 in which a valve plate provided with a pair of arcuate ports is located at the end of the cylinder barrel, said ports being located on opposite sides of driving shaft and the cylinders of said barrels communicating alternately during their rotation with said ports, and said ports being asymmetrically disposed with relation to the central line passing through said valve plate perpendicular to the plane in which lies the axis upon which the tilting box is adjusted.

8. A fluid pressure transmission device as set forth in claim 1 in which a valve plate provided with a pair of arcuate ports is located at the end of said cylinder barrel for communication with the cylinders thereof during the rotation of said barrel, said ports being shifted relatively to the midplate portions of said valve plate approximately from 5° to 7° to bring the leading edges of said ports closer to said midplate portions and thereby to shift the center of pressure in the cylinders as they are performing a pressure stroke.

9. A fluid pressure transmission device as set forth in claim 1 in which each piston comprises a tubular sleeve provided between its ends with a shoulder, an annular bearing piece seated against said shoulder, a screw cap closing one head of said sleeve and forming the head of said piston, and the piston rod extending through said annular bearing piece and being provided with a ball shaped end secured to said piston between said bearing piece and screw cap.

10. A fluid pressure transmission device as set forth in claim 1 in which each piston rod is provided with a ball shaped end and each piston comprises a tubular sleeve into which the ball shaped end of said piston projects, an annular bearing secured within said sleeve and surrounding said piston rod, and a cap forming the piston head secured to said sleeve, said cap and annular bearing being provided with bearing surfaces of spherical contour and serving to secure said piston rod pivotally to said sleeve.

11. A fluid pressure transmission device as set forth in claim 1 in which a valve plate is mounted at the end of the cylinder barrel, said valve plate being provided with a pair of

arcuate ports with which the cylinders of said barrel communicate in alternation as said barrel is rotated, and a valve chamber having a shuttle valve slidably mounted therein, a pair of conduits connecting said ports with said valve chamber on opposite sides of said valve and a third conduit leading to said valve chamber between said pair of conduits and in communication with the casing, said valve and valve chamber functioning automatically to place the one of said ports which is under suction with the interior of said casing.

In testimony whereof I have hereunto set my hand.

JOHN J. CRAIN.

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DISCLAIMER

1,794,946.—*John J. Crain*, Waterbury, Conn. HYDRAULIC PUMP, MOTOR, AND THE LIKE. Patent dated March 3, 1931. Disclaimer filed December 29, 1938, by the patentee; the assignee, *The Waterbury Tool Company*, assenting.

Hereby enters this disclaimer to claims 1, 2, and 3 of said Letters Patent.

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