May 2, 1950 R. S. HOAR ET AL 2,505,771

DIFFERENTIAL CYLINDER-PISTON ASSEMBLY

Filed June 16, 1948 2 Sheets-Sheet 1

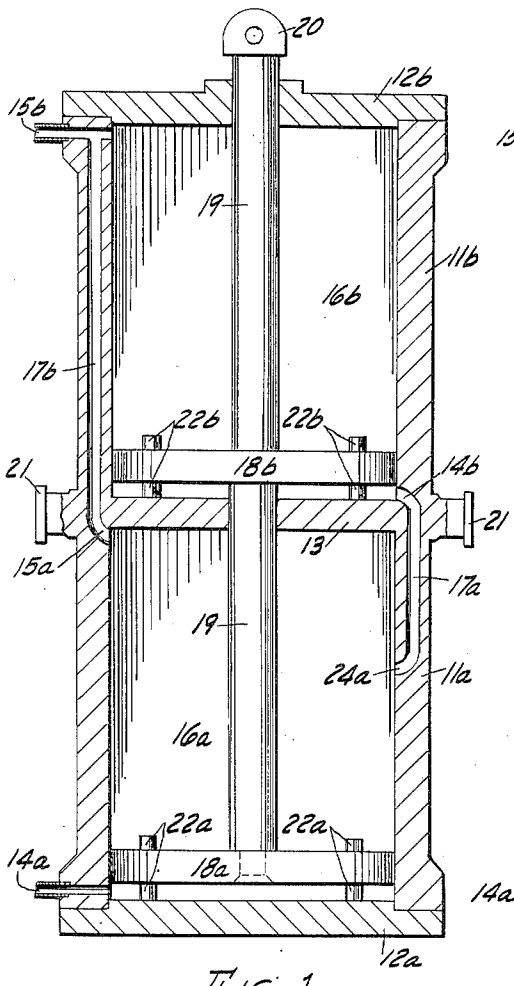


FIG. 1

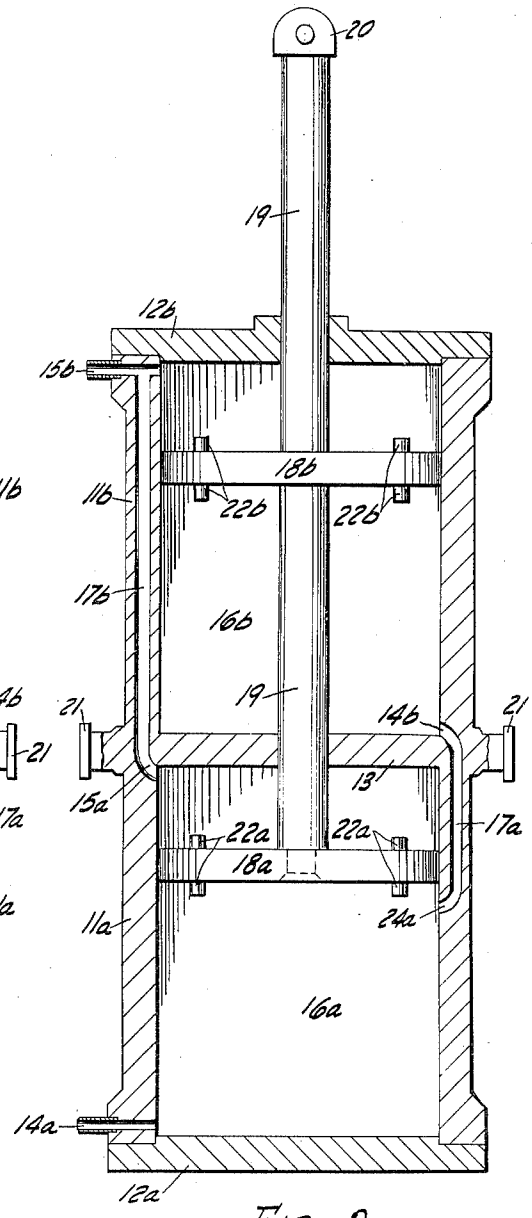


FIG. 2

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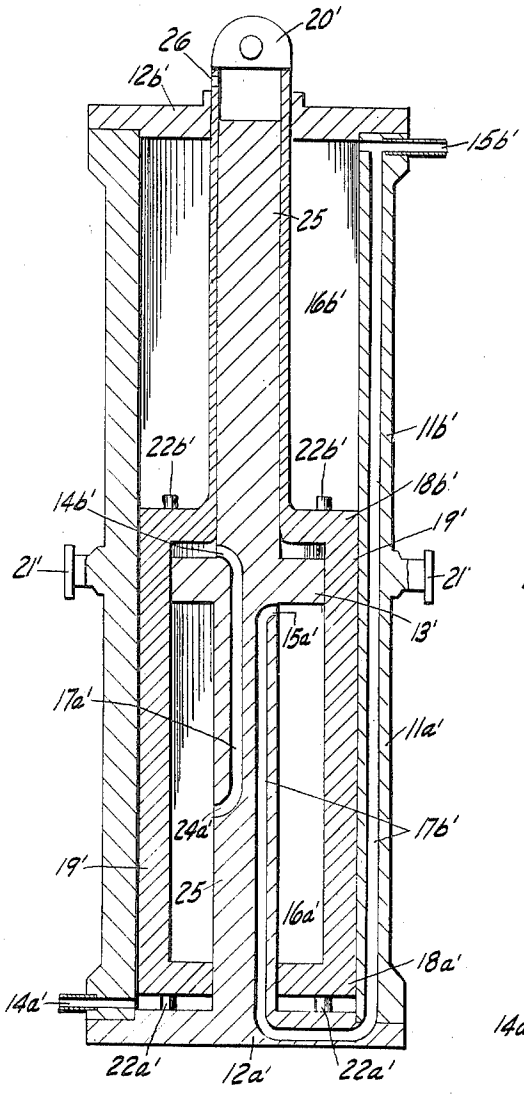


FIG. 3

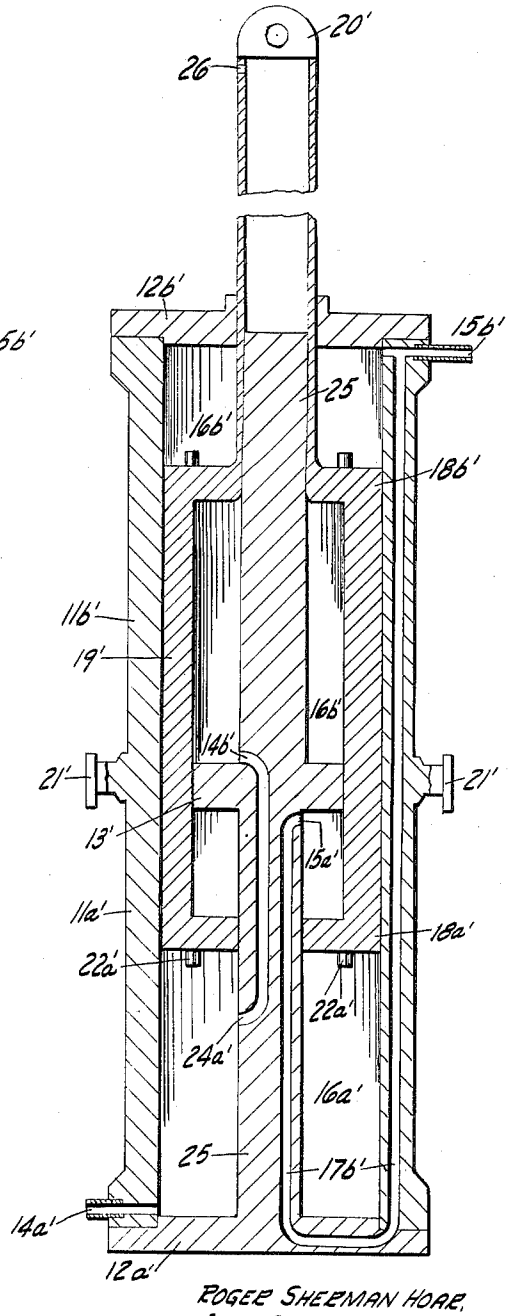


FIG 4

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DIFFERENTIAL CYLINDER-PISTON ASSEMBLY

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19 Claims. (Cl. 60—97)

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Our invention relates to new and useful improvements in double-acting differential cylinder-piston assemblies, specifically those of the type that utilize fluid conduits to effect one or more changes in the force-speed ratio of the assembly at different stages of relative travel of the piston and cylinder in each direction.

The principal object of our invention is to provide an improved double-acting differential cylinder-piston assembly, in which:

(1) The cylinder chamber is of uniform cross-section for its entire length.

(2) A minimum of fluid conduits are employed.

(3) The force-speed ratios are substantially the same for travel in either direction at any portion of the stroke.

(4) Assembly and disassembly are simple.

(5) Manufacture is inexpensive.

Our invention consists in the novel parts and in the combination and arrangement thereof, which are defined in the appended claims, and of which two embodiments are exemplified in the accompanying drawings, which are hereinafter particularly described and explained.

Throughout the description the same reference number is applied to the same member or to similar members.

Figure 1 is a side elevation, partly in section, of the first embodiment of our invention, showing the piston-assembly in its lowest position, in the low-force high-speed portion of its travel.

Figure 2 is similar to Figure 1, but shows the piston-assembly in a raised position near the upper end of its stroke, in the high-force low-speed portion of its stroke.

Figure 3 is a sectional side elevation of the second embodiment of our invention, showing the piston-assembly in its lowest position, in the low-force high-speed portion of its travel.

Figure 4 is similar to Figure 3, but shows the piston-assembly in a raised position near the upper end of its stroke, in the high-force low-speed portion of its travel.

Referring now to Figures 1 and 2, we see that our cylinder assembly comprises two coaxial cylinders 11*a* and 11*b* located end-to-end and having the same cross-sectional area. The first (i. e., lower) cylinder 11*a* is closed at its lower end by end plate 12*a* and at its upper end by plate 13. Fluid ports 14*a* and 15*a* are adjacent plates 12*a* and 13 respectively and lead into the lower and upper ends respectively of lower cylinder chamber 16*a*. Similarly, the second (i. e., upper) cylinder 11*b* is closed at its lower end by plate 13 and at its upper end by end plate 12*b*; and fluid ports 14*b* and 15*b* are adjacent plates 13 and 12*b*

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respectively and lead into the lower and upper ends respectively of upper cylinder chamber 16*b*. Intermediate the ends of cylinder 11*a* is port 24*a* which leads into chamber 16*a*. Fluid conduit 17*a* interconnects ports 24*a* and 14*b*; and fluid conduit 17*b* interconnects ports 15*a* and 15*b*.

The piston assembly consists of a first (i. e., lower) piston 18*a* which has fluid-tight sliding contact with the inside surface of cylinder 11*a*, and a second (i. e., upper) piston 18*b* which has fluid-tight sliding contact with the inside surface of cylinder 11*b*. Extending upwardly from lower piston 18*a* is piston rod 19 which passes out through a fluid-tight opening in plate 13 and is rigidly connected to upper piston 18*b*; thence piston rod 19 extends upwardly, out through another fluid-tight opening in end plate 12*b*.

Work to be actuated by the cylinder-piston assembly is attached to piston rod 19, as at lug 23, and to cylinder 11, as at trunnions 21.

Stops 22*a* and 22*b*, on each face of the pistons 18*a* and 18*b* respectively, prevent the ends of the pistons from abutting the ends of the cylinders.

The operation of the cylinder-piston assembly is as follows:

Assume the apparatus to be in the position shown in Figure 1. Pressure fluid is admitted, through port 14*a*, into the lower end of chamber 16*a*, just below piston 18*a*, and sets up a pressure against the cross-sectional area of the lower face of piston 18*a*. Under the influence of this pressure, the entire piston assembly, including piston rod 19 moves upwardly rapidly with small force.

Meanwhile exhaust from the upper end of chamber 16*a*, above piston 18*a*, passes out through port 24*a*, fluid conduit 17*a*, and port 14*b*, into the lower end of chamber 16*b* just below upper piston 18*b*, thereby equalizing the pressure in these two chambers. No fluid passes through conduit 17*b* because piston displacement in the upper and lower chambers is the same. Exhaust from the upper end of chamber 16*b*, above piston 18*b*, passes out through port 15*b* at the top of the cylinder assembly. Thus, during this lower portion of the piston stroke, the lower and upper cylinder-piston assemblies operate together in series.

Turning now to Figure 2, when piston 18*a* has passed port 24*a*, as shown in this figure, pressure fluid is now free to pass through that port into the lower end of upper chamber 16*b*, setting up pressure against the lower face of upper piston 18*b*, and the effective pressure area now becomes the area of lower piston 18*a* plus the area of upper piston 18*b*. Accordingly these pistons and piston rod 19 now move upwardly slowly with greater

force than in the first portion of the stroke. Exhaust from the upper end of upper and lower chambers 16*a* and 16*b* passes out through ports 15*a* and 15*b* respectively. This continues for the remainder of the upward stroke. During this upper portion of the piston stroke, the two cylinder-piston assemblies operate together in parallel.

The reverse motion (downward) is similar, pressure being against the upper instead of the lower faces of the pistons. Initially (Figure 2) fluid under pressure is admitted, through ports 15*a* and 15*b*, into the upper end of lower and upper chambers 16*a* and 16*b* respectively; and exhaust from the lower end of chambers 16*a* and 16*b* passes out through ports 14*a* and 14*b* respectively, these chambers being interconnected through fluid conduit 17*a* and port 24*a*. Accordingly, during the first (upper) portion of the downward stroke (Figure 2), the cylinder-piston assembles operate in parallel, and the effective pressure area is the effective area of upper piston 18*b* plus the effective area of lower piston 18*a*. When lower piston 18*a* passes port 24*a*, however, pressure fluid is introduced, through fluid conduit 17*a*, into the lower end of upper chamber 16*b*, thereby equalizing the pressure on the upper face of lower piston 18*a* and the lower face of upper piston 18*b*. Accordingly, for the remainder of the downward stroke (Figure 1), the cylinder-piston assemblies operate in series, and the effective pressure area is the area of upper piston 18*b* alone. Both speeds for the downward stroke are slightly higher and less forceful than the corresponding speeds of the upward stroke, due to piston rod 19 which reduces slightly the effective pressure area of the pistons.

Turning now to Figures 3 and 4, showing a second embodiment of our invention, we see that it differs from the first embodiment shown in Figures 1 and 2 in that:

(1) Lower and upper cylinders 11*a'* and 11*b'* contain a fixed axial rod 25 which is rigidly connected to lower end plate 12*a'* and intermediate plate 13', and contains fluid conduit 17*a'* and ports 24*a'* and 14*b'*, as well as port 15*a'* and a portion of fluid conduit 17*b'* leading thereto.

(2) Piston rod 19' and pistons 18*a'* and 18*b'* are annular in form (instead of in the form of a solid rod) to permit them to embrace fixed rod 25. That portion of annular rod 19' between the pistons 18*a'* and 18*b'* is preferably connected to the outer periphery of the pistons and has sliding contact with the cylinder walls in order to avoid the necessity of additional ports either in the annular rod 19' itself or in the walls of the cylinder. The upper portion of the annular rod 19' above piston 18*b'* has sliding contact with the outer surface of fixed rod 25. At the top of fixed rod 25 there is an opening 26 to the atmosphere, to prevent the building up of pressure or vacuum in the upper end of the hollow interior of the fixed rod 25.

Other parts of the cylinder-piston assembly of our second embodiment are similar to corresponding parts of the first embodiment, and bear the same reference numbers with the addition of a prime.

The operation of the second embodiment is the same as the first.

Having now described and illustrated two forms of our invention, we wish it to be understood that our invention is not to be limited to the specific form or arrangement of parts herein described and shown.

We claim:

1. In a cylinder-piston assembly, the combination of: a first cylinder having a first chamber with a first piston therein; a second cylinder having a second chamber with a second piston therein; a piston rod; means operatively connecting the two pistons to the piston rod; means for alternatively admitting pressure fluid to one or the other end of the first cylinder, and for simultaneously permitting exhaust from the opposite end of the first cylinder; a fluid conduit between one end of the first cylinder chamber and the corresponding end of the second cylinder chamber; and a second fluid conduit between the other end of the second cylinder chamber and a point intermediate the ends of the first cylinder chamber whereby the effective pressure area of the assembly is automatically increased when the first piston travels past said point in one direction, and is automatically reduced when the first piston travels past said point in the other direction.

2. A cylinder-piston assembly according to claim 1, further characterized by the fact that the first and second pistons are connected in tandem.

3. A cylinder-piston assembly according to claim 2, further characterized by the fact that the first and second pistons have the same effective pressure area.

4. A cylinder-piston assembly according to claim 3, further characterized by the fact that the first and second pistons are axially aligned.

5. A cylinder-piston assembly according to claim 4, further characterized by the fact that the first and second cylinders abut each other end-to-end, and have a common fluid-tight wall separating their respective chambers.

6. A cylinder-piston assembly according to claim 5, further characterized by the fact that the means operatively connecting the two pistons is a piston rod centrally disposed along the longitudinal axis of the pistons and extending through and having a fluid-tight sliding contact with said wall.

7. A cylinder-piston assembly according to claim 6, further characterized by the fact that said intermediate point is located in the outer wall of said first cylinder.

8. A cylinder-piston assembly according to claim 1, further characterized by the fact that the first and second pistons have the same effective pressure area.

9. A cylinder-piston assembly according to claim 1, further characterized by the fact that the first and second cylinders abut each other end-to-end, and have a common fluid-tight wall separating their respective chambers.

10. A cylinder-piston assembly according to claim 9, further characterized by the fact that the means operatively connecting the two pistons is an annular piston rod extending through and having fluid-tight sliding contact inwardly and outwardly with said wall.

11. A cylinder-piston assembly according to claim 10, further characterized by the fact that the annular piston rod has fluid-tight outwardly sliding contact with the inner surface of the first cylinder.

12. A cylinder-piston assembly according to claim 1, further characterized by the fact that said first and second cylinders have an interior longitudinal fixed rod rigidly connected to the ends of said cylinders.

13. A cylinder-piston assembly according to claim 12, further characterized by the fact that the means operatively connecting the two pistons is an annular piston rod extending through and having fluid-tight sliding contact inwardly and outwardly with said wall.

14. A cylinder-piston assembly according to claim 13, further characterized by the fact that one of said fluid conduits extends within said longitudinal fixed rod.

15. In a cylinder-piston assembly, the combination of a pair of double-acting cylinder-piston assemblies; a first work attachment; a second work attachment; a piston in each assembly operatively connected to the first work attachment; a cylinder in each assembly operatively connected to the second work attachment and having a chamber for said piston of its respective assembly; a pair of interconnected fluid ports, one for one end of each of said chambers; a second pair of fluid ports, one for the other end of each of said chambers; a fifth port intermediate the ends of one of said chambers; and means connecting said fifth port with one of said second pair of ports.

16. A cylinder-piston assembly according to claim 15, further characterized by the fact that the chambers are axially aligned and have a uniform transverse cross-sectional area.

17. In a cylinder-piston assembly, the combination of: a pair of double-acting cylinder-piston assemblies; each including a piston and a cylinder providing a pressure chamber for the piston; means operatively connecting each piston to a common work attachment; means operatively connecting each cylinder to a second common work attachment; and fluid conduits connecting in parallel a portion of said chambers corresponding to a portion of the piston stroke, and connecting in series another portion of said chambers corresponding to another portion of the piston stroke.

18. A cylinder-piston assembly according to claim 17, further characterized by the fact that said fluid conduits include a first fluid conduit interconnecting one end of said chambers; and a second fluid conduit connecting the other end of one of said chambers and a point intermediate the ends of the other of said chambers.

19. A cylinder-piston assembly according to claim 18, further characterized by having a first fluid port for the first fluid conduit; a second fluid port at the other end of said other of said chambers; and means for alternatively admitting pressure fluid to the first or the second of said fluid ports; and for simultaneously permitting exhaust from the other of said fluid ports.

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No references cited.