July 28, 1942. C. W. BROWN 2,290,858

COMPRESSOR

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Fig. 1.

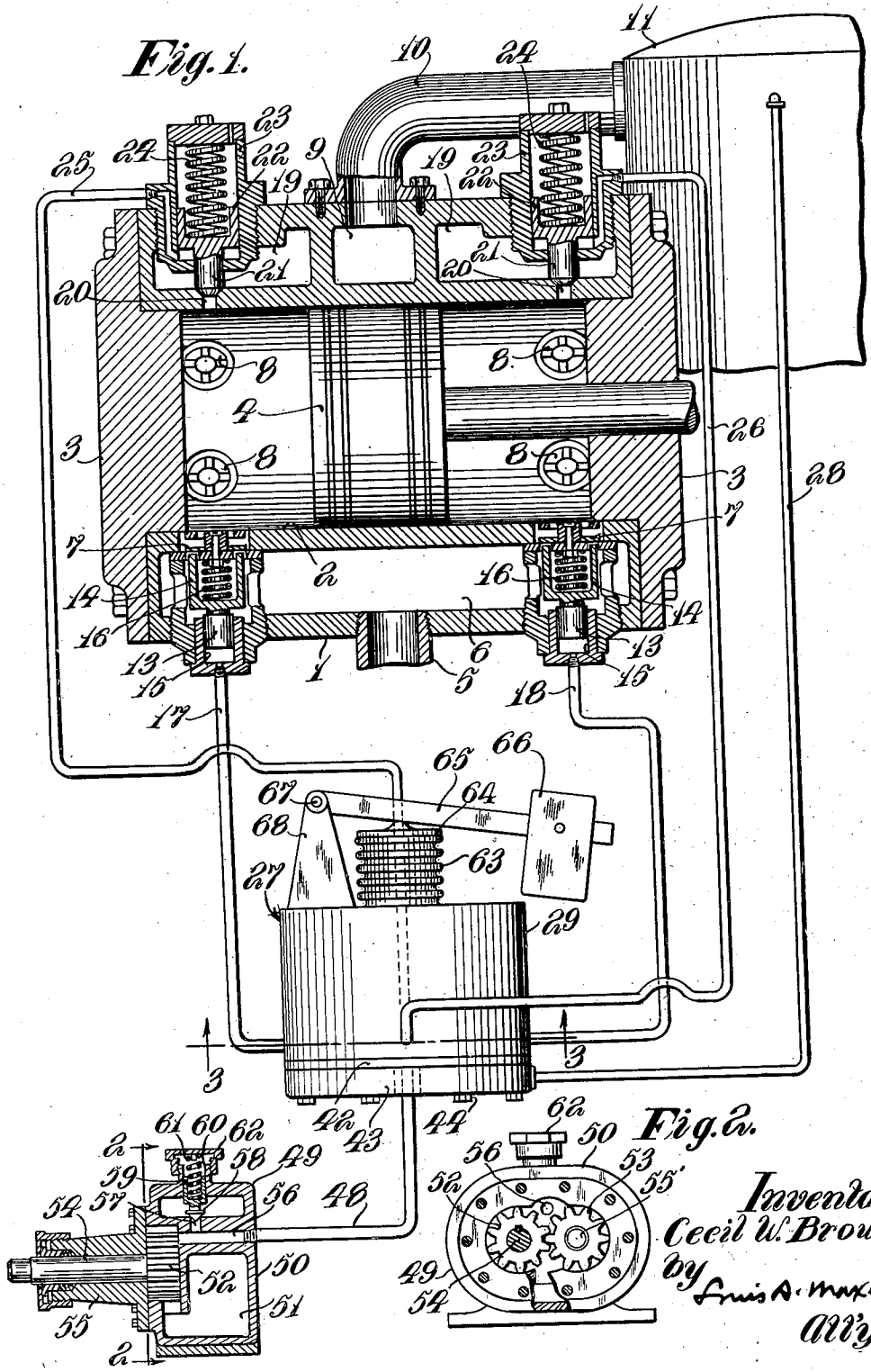


Fig. 2.

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Fig. 3.

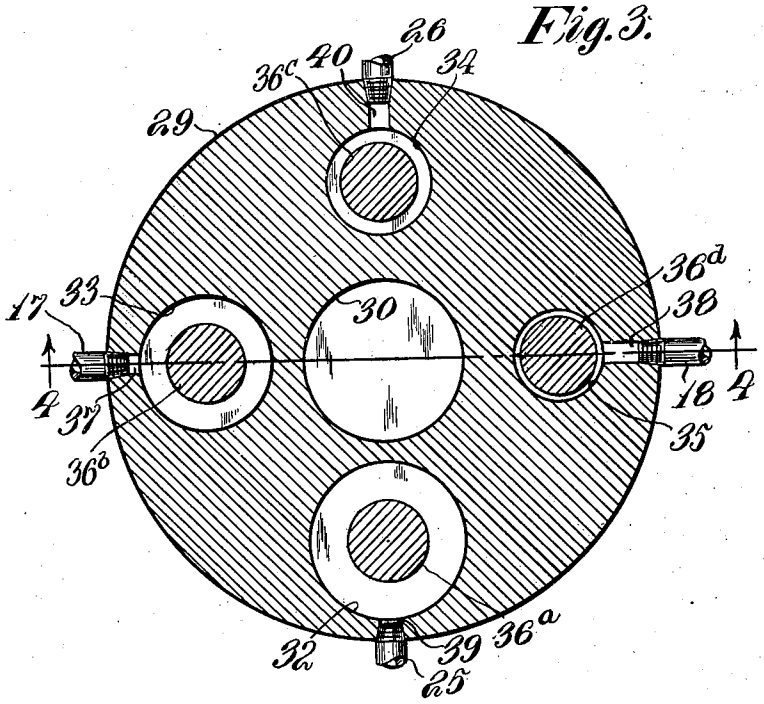
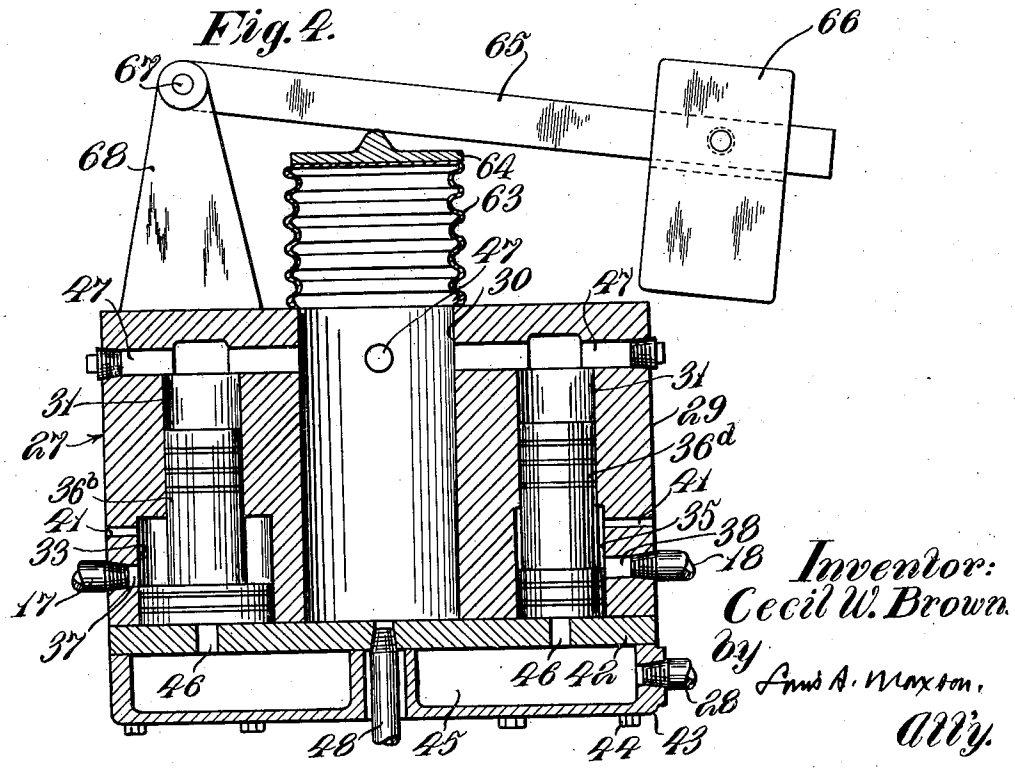


Fig. 4.



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Patented July 28, 1942 2,290,858

UNITED STATES PATENT OFFICE

2,290,858

COMPRESSOR

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Application January 31, 1940, Serial No. 316,568

12 Claims. (Cl. 230—21)

My invention relates to compressors, and more particularly to devices for automatically controlling the unloading of a compressor in accordance with discharge pressure.

It is an object of my invention to provide an improved device for effecting step-by-step unloading of a compressor. It is another object of my invention to provide an improved compressor discharge pressure controlled and actuated unloading system for a compressor adapted to effect step-by-step unloading of the latter. It is still another object of the invention to provide an improved pilot mechanism adapted for compressor control. It is yet a further object of my invention to provide an improved device for automatically controlling the step-by-step unloading of a compressor and having adjustable means operative to effect its responsiveness to the pressures to be controlled, whereby changes may readily be made to suit different conditions. Other objects and advantages of my invention will hereinafter more fully appear.

In the accompanying drawings, in which I have shown one form which the invention may assume in practice.

Fig. 1 is a diagrammatic view, partly in vertical section, showing the invention applied in a single cylinder compressor so as to effect four-step unloading of the latter.

Fig. 2 is a view of the fluid pump taken on the plane of the line 2—2 of Fig. 1 with a portion of the casing broken away.

Fig. 3 is an enlarged horizontal sectional view, looking up, through the automatic device for controlling the flow of pressure fluid to the compressor unloading elements, taken on the plane of the line 3—3 of Fig. 1.

Fig. 4 is a vertical sectional view through the unloading control device, taken on the line 4—4 of Fig. 3.

It will be evident that my invention from its control aspect may be utilized with single or multiple compressor cylinders and with single or multiple stage compressors. To illustrate a preferred embodiment of the invention there is shown a compressor cylinder 1 having a bore 2 closed at its ends by cylinder heads 3 and in which a piston 4 reciprocates. Air is supplied to the cylinder bore from an intake connection 5 through a chamber 6 and inlet valves 7 at the head and crank ends of the cylinder. Discharge valve mechanisms 8 are provided at the head and crank ends of the cylinder, through which compressed air is discharged to a chamber 9 in the cylinder, and through a discharge connection 10 to a receiver 11.

Suitable inlet valve opening devices are provided, and are shown here as comprising pistons 13 carrying fingers 14 and operating in cylinders 15. The fingers are normally held in a retracted position by springs 16 but are moved to unseat the inlet valves when pressure fluid is supplied to the cylinders 15 through pipes 17 and 18. Clearance chambers 19 are provided in the compressor cylinder, having communication with the head and crank ends of the cylinder bore through passages 20. Clearance valves 21 are provided in the clearance chambers, and each valve has a piston 22 operating in a cylinder 23. Springs 24 normally maintain the clearance valves in position to shut off communication between the clearance chambers and cylinder bore through passages 20. The clearance valves are opened when pressure fluid is conducted to the lower surfaces of the pistons by pipes 25 and 26. It will be appreciated that the unloading devices for the compressors or cylinders (if a plurality of cylinders are employed) may be of various kinds and that the number of steps of unloading may be varied at the will of the designer.

In my invention I have provided improved means for partially or totally unloading and for reloading the compressor cylinder described above in four steps automatically as the pressure in the receiver varies. For this purpose I use a pilot valve mechanism, generally designated 27, which is adapted to connect the receiver through a pipe 28, if desired with the interposition of a valve of the type which transmits only the pressures in excess of any selected value, to the inlet valve opening devices through pipes 17 and 18, and to the cylinders 23 through the pipes 25 and 26 for opening the clearance valves 21. The pilot valve mechanism comprises, as shown in Figs. 3 and 4, a block 29 having a central bore 30 extending through it, and bores 31, having equal diameters, formed within the block 29 surrounding the central bore 30. The bores 31 severally open into larger bores 32, 33, 34 and 35, each having a different cross sectional area and each opening through the lower surface of the block. Reciprocably mounted in the bores surrounding the central bore are pistons severally designated 36a, 36b, 36c and 36d and each having a portion fitting the bores 31 and respectively having portions fitting the larger bores 32, 33, 34 and 35. Pipes 17, 18, 25 and 26 communicate with the bores 33, 35, 32 and 34 respectively through passages 37, 38 39 and 40 in the block 29 at points overrun by the

lower ends of plungers or pistons 36a, 36b, 36c and 36d when in their raised positions and below which the tops of the enlarged piston portions pass when in their lower positions. Vent passages 41 connect the upper ends of the bores 32, 33, 34 and 35 to atmosphere. Plates 42 and 43, attached to the block as by bolts 44, provide a chamber 45 communicating with each of the larger bores 32, 33, 34 and 35 through passages 46 in the plate 42. The chamber 45 is connected to the receiver by the pipe 28. The central bore 30 communicates with the bores 31 through passages 47 extending radially from the central bore and formed in the block 29. A pipe 48 connects the central bore 30 to a fluid pump 49. The fluid pump may be of any suitable constant pressure type, and is shown here as comprising a casing 50 enclosing a fluid reservoir 51 and meshing pinions 52 and 53, one of which is fixed on a shaft 54 mounted in a suitable bearing 55 attached to the pump casing, while the other pinion is rotatable on a stud 55' carried by the pump casing. Any suitable means may be attached to the shaft 54 for driving the pinions 52 and 53. A passage 56 in the pump casing connects the pipe 48 to a point adjacent the pinions 52, 53. A passage 57 in the pump casing is adapted to connect the passage 56 to the reservoir 51, and a relief valve 58 having a guide element 59 operating in a cylinder 60 is normally pressed by a spring 61 to close off communication between the reservoir 51 and passage 57. The compression of the spring is adjusted by a threaded cap 62. Attached in fluid-tight relationship to the block 29 at one end of the central bore 30 is a flexible diaphragm or bellows element 63 carrying a plate 64 at its upper end. An arm 65 carrying a slidably adjustable weight 66 at one end is pivoted at its other end 67 to a support 68 attached to the block 29. The arm presses against the plate 64 attached to the upper end of the flexible diaphragm 63.

The mode of operation is as follows:

The fluid pump 49 is started to pump fluid from the reservoir 51 through the pipe 48 to the central bore 30. As a pressure builds up in the bore 30 the flexible diaphragm 63 expands, lifting the arm 65 and weight 66. When the pressure attains a value sufficient to lift the relief valve 58 against the pressure of the spring 61, fluid will be pumped through the passage 57 back into the reservoir. By adjusting the weight 66 on the arm 65 and the compression of the spring 61 by the threaded cap 62, any desired constant pressure may be maintained in the central bore 30. The fluid under pressure will be conducted from the bore 30 through the radial passages 47 to the bores 31, where it will act against the upper ends of the pistons 36a, 36b, 36c and 36d and continuously urge them toward their lower positions.

Pressure fluid is conducted from the receiver through pipe 28 to the chamber 45 and flows through passages 46 to the cylinder bores 32, 33, 34 and 35, where it acts on the lower ends of the pistons 36a, 36b, 36c and 36d and urges them toward their raised position. Assuming that the pressure in the chamber 45 is insufficient to raise any of the pistons against the pressure in the bores 31, the pipes 17, 18, 25 and 26 will be vented through the bores 33, 35, 32 and 34, and vent passages 41; the inlet valve opening devices will be retracted by the springs 16 to permit the inlet valves to operate in their normal manner, and the clearance valves will be held closed by springs 24. The compressor cylinder then operates fully loaded until the pressure in the receiver increases to a value sufficient to force the piston 36a, having its lower end fitting the large bore 32, to its upper position. Pressure fluid then flows from the receiver through pipe 28, chamber 45, passage 46, bore 32 and pipe 25 to open the clearance valve 21 at the head end of the compressor cylinder against the spring 24. The compressor cylinder then operates at three-quarters load, and if the demand for air is low and the receiver pressure continues to increase, it will, at a higher pressure, move the piston 36b having its large end fitting the bore 33, to its upper position. Pressure fluid will then flow from the chamber 45 through bore 33 and pipe 17 to the cylinder 15, where it moves the fingers to open the inlet valve at the head end of the cylinder and completely unload that end of the cylinder. If the receiver pressure still continues to increase, it will ultimately move the piston 36c having its large end fitting the bore 34, to its upper position and pressure fluid will flow from chamber 45 through the bore 34 and pipe 26 to open the clearance valve in the crank end of the compressor cylinder. The compressor cylinder then operates three-quarters unloaded, and if the receiver pressure increases to a value sufficient to move the piston 36d, having its large end fitting the bore 35, to its upper position, pressure fluid will flow from the chamber 45 through bore 35 and pipe 18 to open the inlet valve in the crank end of the compressor cylinder and completely unload the cylinder.

If the demand for air increases and the receiver pressure drops, the pressure acting on the upper ends of the pistons 36d, 36c, 36b and 36a will move them to their lower positions in an order reverse to that of unloading, and vent the pipes 18, 26, 17 and 25 through bores 35, 34, 33 and 32, and vent passages 41, thereby permitting the inlet valves to operate in their normal manner and the clearance valves to close, reloading the compressor in steps.

It will be appreciated that the expansible bellows will enable the several plungers to move upwardly without the amount of retardation that would be present if the fluid displaced had all to be pushed through the passage 57 in order for the plungers to move. It will be understood, moreover, that the pressure differentials may be made quite small, and by suitably proportioning and selecting the areas wide ranges of pressures may easily be provided for with minor changes in design. The device is strong and simple and does not depend on small pressure areas or passages for operativeness.

While I have in this application specifically described one form which my invention may assume in practice, it will be understood that this form is shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a control device, a cylinder block, a plurality of bores in said cylinder block each having the same diameter, a plurality of bores in said cylinder block having different diameters and each opening into a different one of said first mentioned plurality of bores, pistons reciprocable in said bores and having heads fitting the bores opening into each other, means for subjecting said pistons at one end to a constant pressure, and

means for subjecting the opposite ends of said pistons to a pressure to be controlled.

2. In a control device, a cylinder block, a plurality of bores in said cylinder block each having the same diameter, a plurality of bores in said cylinder block having different diameters and each in axial alinement with and opening into a different one of said first mentioned plurality of bores, pistons reciprocable in said bores and having heads fitting the bores opening into each other, means for subjecting the ends of said pistons fitting the bores having the same diameter to a constant pressure, and means for subjecting the opposite ends of said pistons to a pressure to be controlled.

3. In a control device, a cylinder block, a pressure chamber in said cylinder block, a plurality of bores in said cylinder block each having the same diameter, passage means connecting said pressure chamber with said plurality of bores, a plurality of bores in said cylinder block having different diameters and each in axial alinement with and opening into a different one of said first mentioned plurality of bores, pistons reciprocable in said bores and having heads fitting the bores opening into each other, means for subjecting the ends of said pistons fitting the bores having different diameters to a pressure to be controlled, and means for creating in said pressure chamber a constant control pressure.

4. In a control device, a cylinder block, a pressure chamber in said cylinder block, a plurality of bores in said cylinder block each having the same diameter, passage means connecting said pressure chamber with said plurality of bores, a plurality of bores in said cylinder block having different diameters and each in axial alinement with and opening into a different one of said first mentioned plurality of bores, pistons reciprocable in said bores and having heads fitting the bores opening into each other, means for subjecting the ends of said pistons fitting the bores having different diameters to a pressure to be controlled, means for supplying pressure fluid to said pressure chamber, and means for controlling the pressure in said chamber including an expansible element attached in fluid-tight relationship to one end of said chamber.

5. In a control device, a cylinder block, a pressure chamber in said cylinder block, a plurality of bores in said cylinder block each having the same diameter, passage means connecting said pressure chamber with said plurality of bores, a plurality of bores in said cylinder block having different diameters and each in axial alinement with and opening into a different one of said first mentioned plurality of bores, pistons reciprocable in said bores and having heads fitting the bores opening into each other, means for subjecting the ends of said pistons fitting the bores having different diameters to a pressure to be controlled, means for supplying pressure fluid to said pressure chamber, and means for controlling the pressure in said chamber including an expansible element attached in fluid-tight relationship to one end of said chamber and adjustable means for opposing the expansion of said expansible element.

6. In combination, in a controlling apparatus, means forming a plurality of differential bores of which the smaller portions are of like cross sectional area and the larger portions of different cross sectional area, plungers in each of said differential bores each having a portion fitting each portion of its respective differential bore, means for subjecting the larger ends of said plungers to a pressure to be controlled, means for subjecting the smaller ends of said plungers to a relatively constant pressure and adapted to maintain substantial uniformity of pressure regardless of plunger movements, and fluid delivery and exhaust lines communicating with each of the larger bores.

7. In a valve device for controlling the distribution of a pressure fluid, in combination, a plurality of movable valve members having oppositely directed unequal pressure areas, means supporting said valve members for movement relative to each other, a pressure chamber, means for creating in said pressure chamber a constant control pressure, means for subjecting the pressure areas on said valve members directed in one direction to the pressure in said pressure chamber, means for supplying pressure fluid to the pressure areas on said valve members that are directed oppositely from the areas subjected to the pressure in said pressure chamber, and fluid delivery lines communicable with said pressure fluid supply means on predetermined movement of said valve members.

8. In a valve device for controlling the distribution of a pressure fluid, in combination, a plurality of movable valve members having oppositely directed pressure areas, the pressure areas directed in one direction being equal to each other and those directed in the opposite direction being different from each other, means supporting said valve members for movement relative to each other, a pressure chamber, means for creating in said pressure chamber a constant pressure, means for subjecting the equal pressure areas on said valve members to the pressure in said chamber, means for supplying pressure fluid to the pressure areas on said valve members that are different from each other, and fluid delivery lines communicable with said pressure fluid supply means on predetermined movement of said valve members.

9. In a valve device for controlling the distribution of a pressure fluid, in combination, a plurality of movable valve members having unequal pressure areas, means supporting said valve members for movement relative to each other, means for subjecting said valve members to a constant force opposing movement of said members in one direction, means for supplying pressure fluid to the unequal pressure areas on said valve members, and fluid delivery lines communicable with said pressure fluid supply means on predetermined movement of said valve members.

10. In a device for controlling the distribution of a fluid under pressure to a pressure responsive control mechanism, a plurality of movable valve members each having oppositely directed unequal pressure areas, means for subjecting the pressure areas directed in one direction to a constant pressure, means for subjecting the pressure areas directed in the opposite direction to a pressure to be controlled, and means operative on predetermined movement of said valve members in opposition to said constant pressure for supplying pressure fluid to the pressure responsive control mechanism.

11. In a device for controlling the distribution of a fluid under pressure to a pressure responsive control mechanism, a plurality of movable valve members each having oppositely directed unequal pressure areas, means for subjecting the pressure areas directed in one direc-

tion to a constant pressure, means for subjecting the pressure areas directed in the opposite direction to a pressure to be controlled, and means for supplying pressure fluid to said control mechanism and for venting pressure fluid from said control mechanism, said supply and venting means including passage means controlled by said valve members.

12. In a device for controlling the distribution of a fluid under pressure to a pressure responsive control mechanism, a cylinder block, a plurality of bores formed in said cylinder block and each having the same diameter, a plurality of bores of different diameters formed in said cylinder block and each in axial alinement with and opening into a different one of said first mentioned plurality of bores, pistons reciprocable in said bores and having heads fitting the bores opening into each other in which they are respectively received, means for subjecting the ends of said piston heads fitting said bores of equal diameter to a constant pressure, means for supplying pressure fluid to the outer ends of said bores of different diameters, means for venting the inner ends of said bores of different diameters, and fluid distribution lines communicating with said last mentioned bores at points between their ends and communicable with said pressure fluid supply means or said venting means on predetermined movements of said pistons.

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