Oct. 25, 1949. W. R. TUCKER 2,486,079

HYDRAULIC BOOSTER

Filed May 18, 1945 3 Sheets-Sheet 1

FIG. 1.

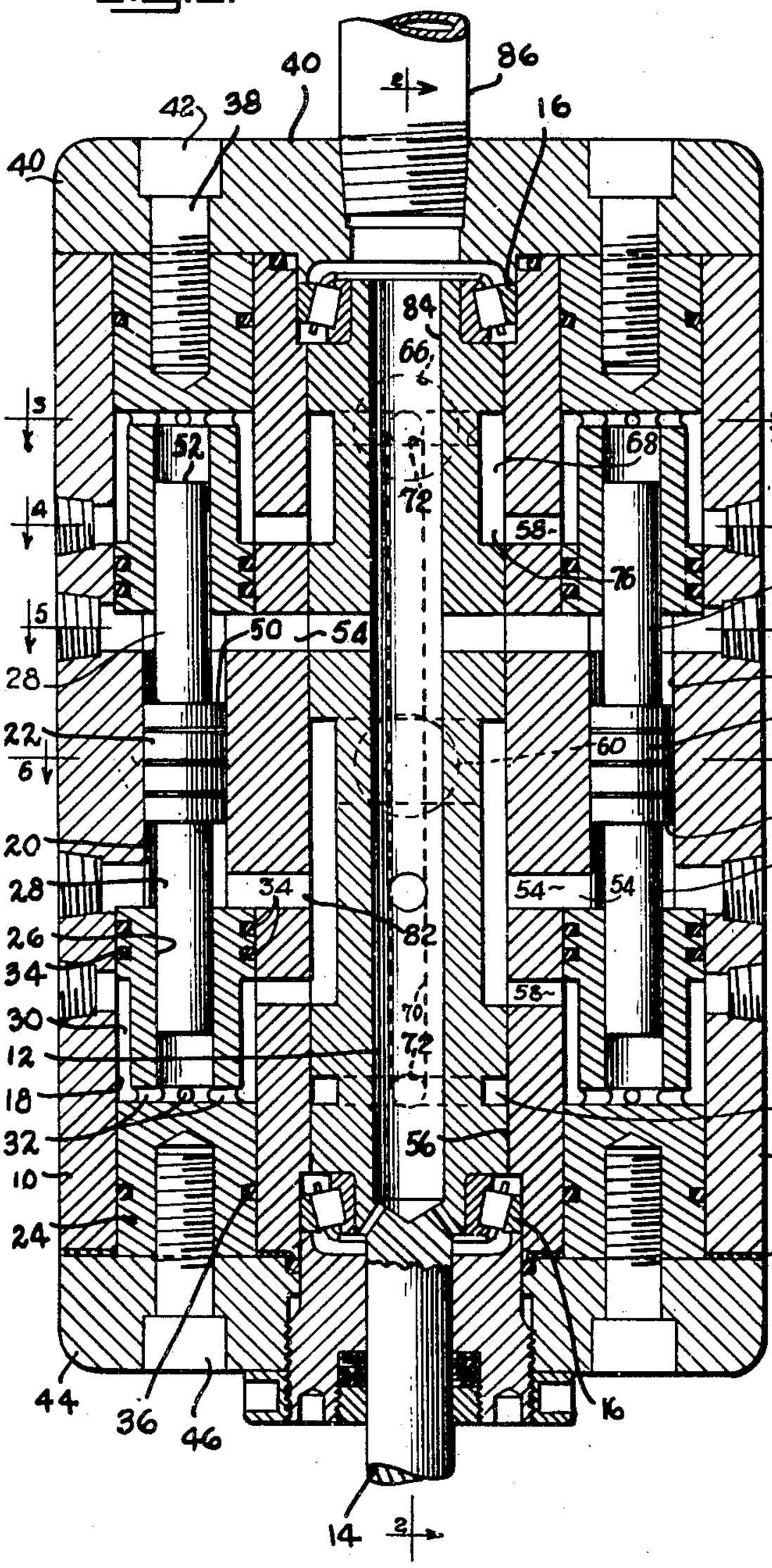

FIG. 2.

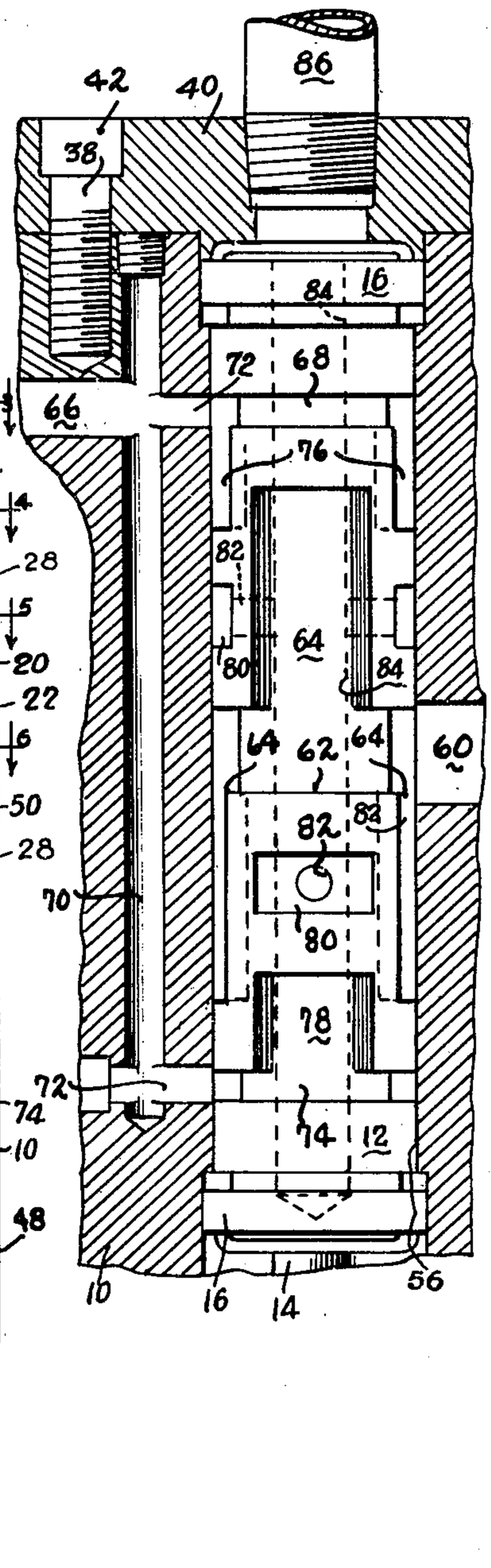

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FIG. 3.

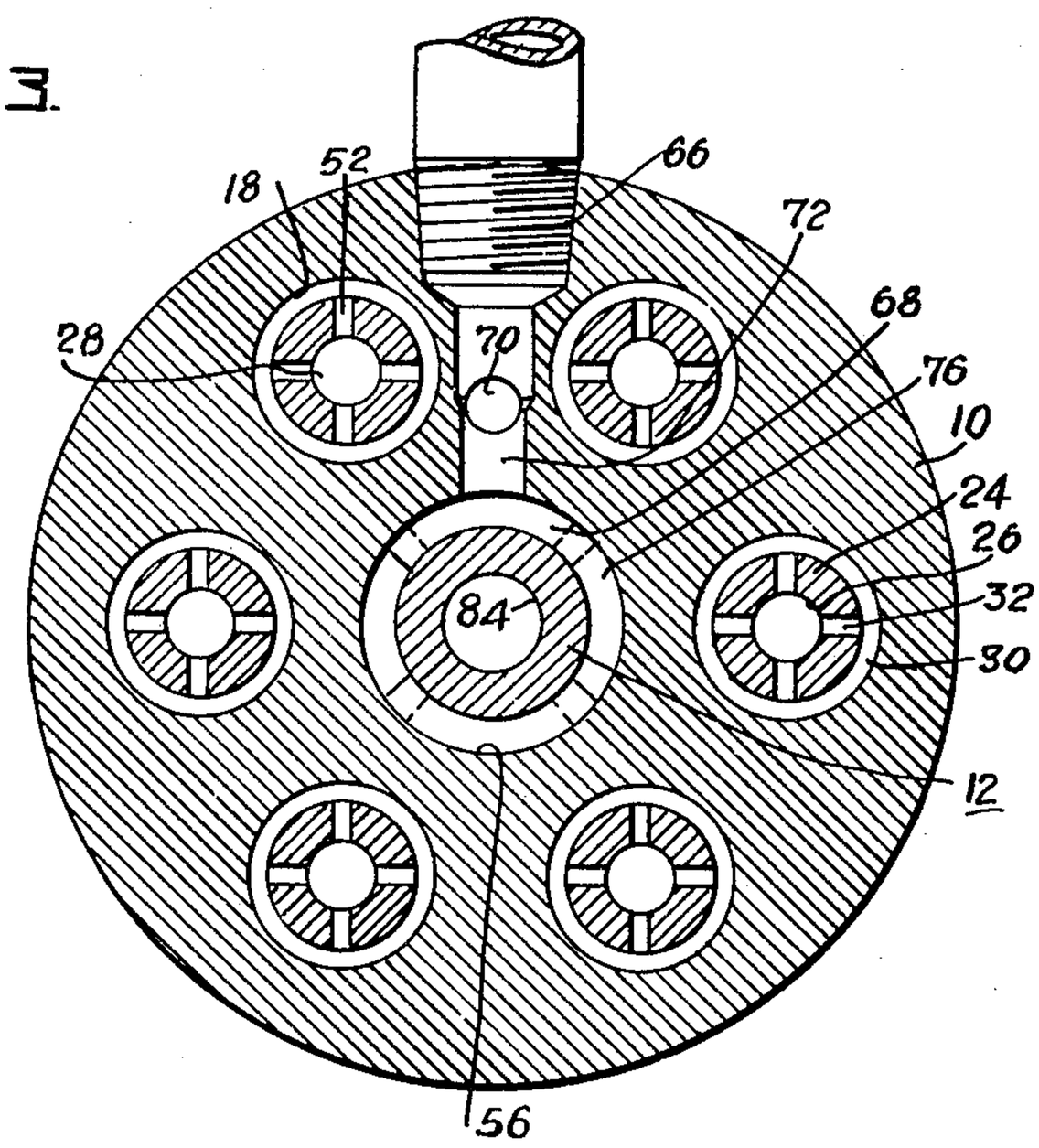

FIG. 5.

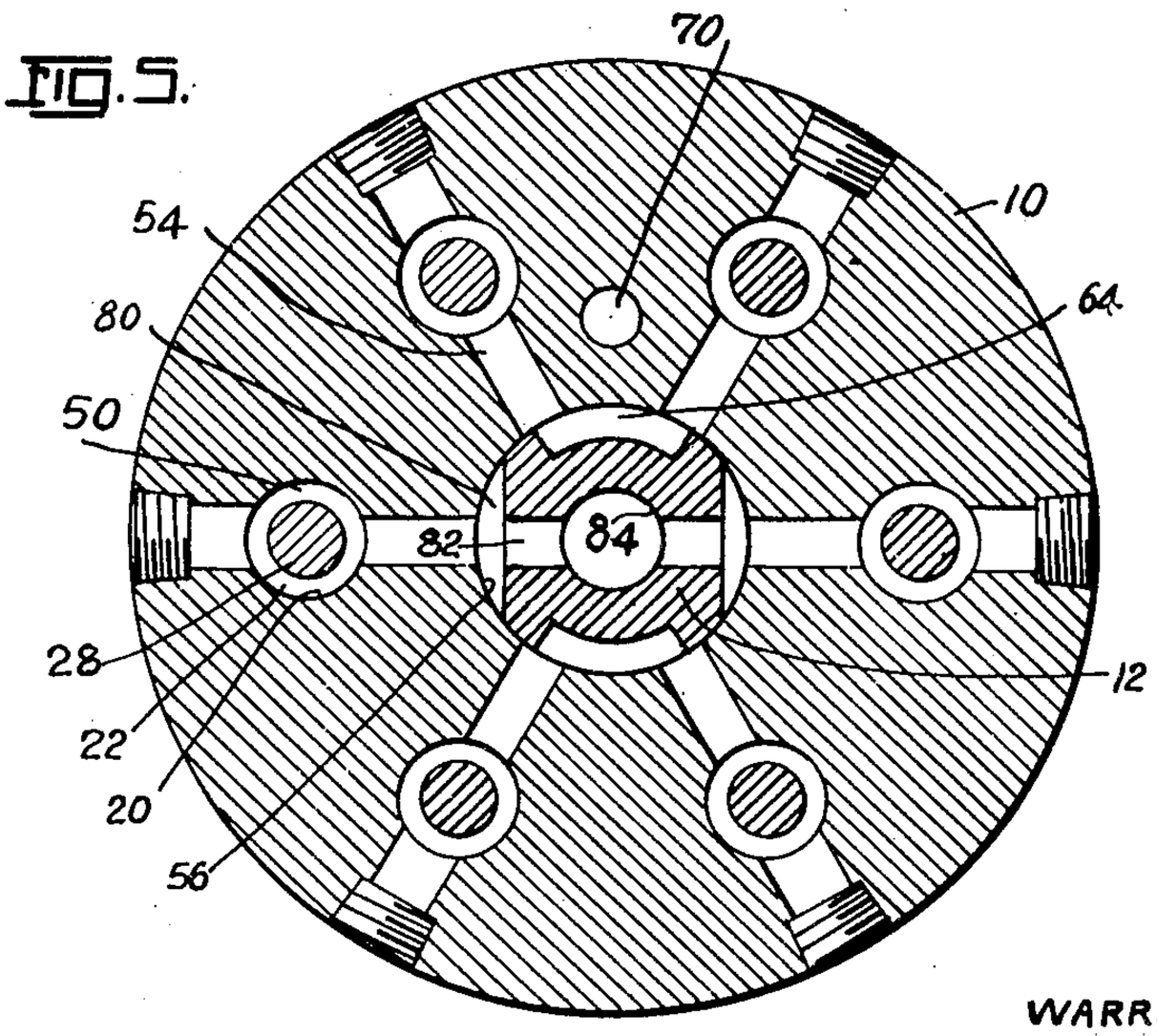

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FIG. 4.

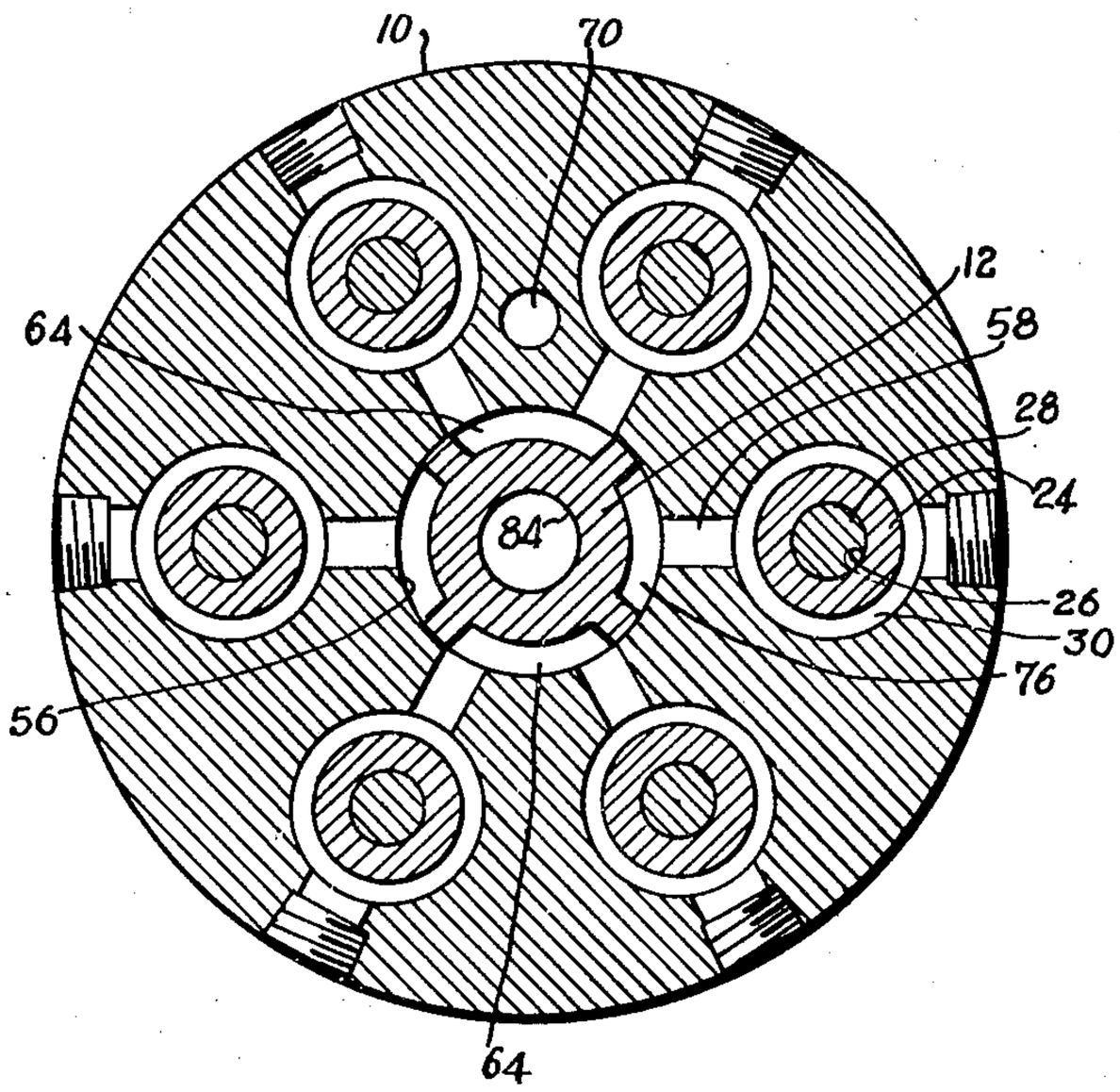
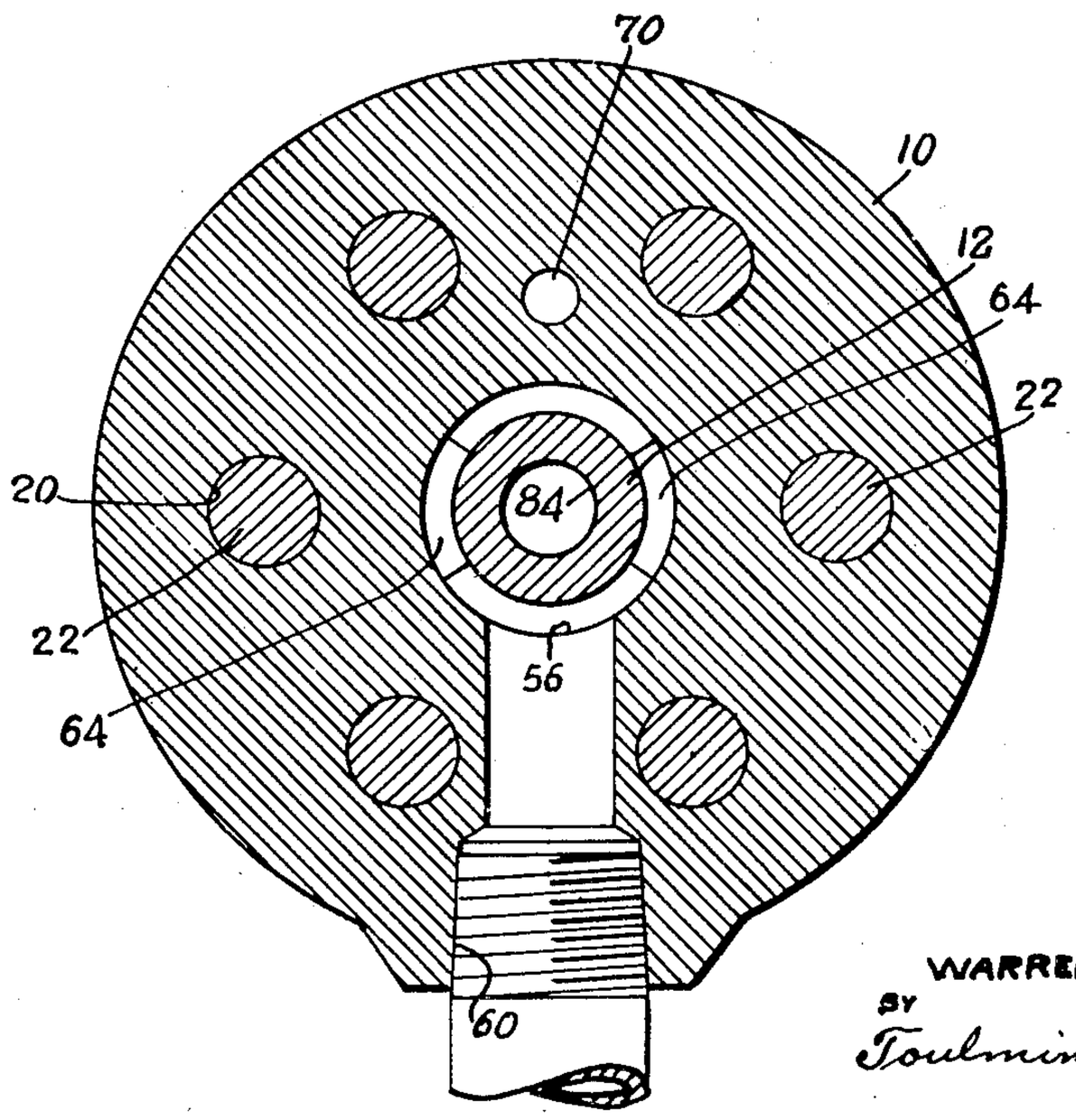


FIG. 6.



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UNITED STATES PATENT OFFICE

2,486,079

HYDRAULIC BOOSTER

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17 Claims. (Cl. 103—49)

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This invention relates to method and apparatus for modifying fluid pressures.

In many classes of work such as coining, forging and some types of drawing, it is desired that the working member perform the final portion of its work stroke with substantially greater thrust than the average thrust during a cycle. In a hydraulic press this is most easily accomplished by increasing the working pressure on the working member or ram during this portion of its stroke. This is often accomplished by having a double ram area which is valved to the pressure source for single or multiple operation. In other instances a plurality of pumps are employed, the one having the highest pressure being used for the final portion of the working stroke.

In other types of work, it is of advantage to move a ram under low pressure to working position and thereafter to advance it under pump pressure to complete a stroke. Also, there are often low pressure auxiliaries which are operable by pressure fluid at pressures substantially below pump pressure. This reduced pressure fluid is usually obtained from a low pressure pump or from a pressure reducing valve.

It is a primary object of the present invention to provide an apparatus operable to intensify hydraulic pressures for effecting high pressure working stroke in fluid motors.

It is another object to provide an apparatus for intensifying hydraulic pressures which produces a substantially constant flow of fluid.

It is still another object to provide for a hydraulic intensifier or booster which is relatively simple to construct and assemble.

It is another object to provide a hydraulic intensifier or booster in which there is substantially no hydraulic power lost.

It is still another object to provide an apparatus operable to reduce fluid pressures with substantially no loss of power.

Another object is to provide an apparatus operable either to intensify or to reduce fluid pressures.

Another object is to provide for an efficient method of modifying fluid pressures.

These and other objects and advantages will become more apparent upon reference to the accompanying drawings, in which:

Figure 1 is a vertical section through a hydraulic intensifier or booster constructed according to this invention;

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Figure 2 is a partial section taken on the line 2—2 of Figure 1 showing the inlet and outlet connections and also showing the valve member in elevation; and

Figures 3, 4, 5 and 6 are transverse sections taken on the lines 3—3, 4—4, 5—5 and 6—6 of Figure 1.

Referring to the drawings, 10 indicates a casing which is centrally bored to receive a valve member 12 which is adapted for being driven in rotation by any suitable means which may be connected with the shaft 14. The valve member 12 is supported on the antifriction bearings 16 so as to operate with a minimum of friction in the central bore of the casing 10 within which it fits with a very small clearance.

The casing 10 also comprises a plurality of circumferentially arranged axial bores 18 which have a reduced diameter central portion as at 20 for receiving the reciprocating pistons 22. As shown in the drawings, there are six of the bores 18 but it will be understood that there could be any number without in any way affecting the operation of the device.

The opposite end portions of the bores 18 are adapted for receiving cylindrical members 24 which comprise the inwardly extending bores 26 for receiving the pistons 28 which may be integral with the pistons 22. The cylindrical members 24 also comprise a groove 30 which communicates by means of the radial bores 32 with the bores 26. The inner ends of the members 24 are grooved and fitted with the piston rings 34 for effecting a seal between the bores 20 and the grooves 30. The outer ends of the members 24 are grooved for receiving the resilient rings 36. The members 24 at the upper end of the unit, as viewed in Figure 1, are secured by the cap screws 38 to a cover plate 40 which is, in turn, secured to the casing 10 by the cap screws 42. The members 24 at the lower end of the unit are secured to the cover plate 44 by the cap screws 46, the said cover plate being in turn secured to the casing 10 by cap screws, not shown. A gasket 48 between the casing 10 and the cover plate 44 provides for sealing the assembly together in precise adjustment.

The pistons 22 together with the pistons 28

form the opposed annular surfaces 50 within the bores 20 while the pistons 28 have the working surfaces 52 within the cylinders 26. In operation in order to provide for a flow of fluid at intensified pressure, fluid at a predetermined pressure is directed to one of the areas 52 and the adjacent area 50 while the opposite area 50 is connected with exhaust, and the opposite area 52 is connected with the intensified pressure outlet. After the pistons have made a stroke in one direction, the fluid connections thereto are reversed and a stroke is made in the opposite direction so that each piston has two working strokes per cycle.

In order to establish the aforementioned fluid connections the valve member 12 is divided into a plurality of zones which communicate with the various piston areas and with the inlet and outlet ports of the device. The bores 20 have the radial passages 54 at opposite ends thereof which communicate with the central bore 56 of the casing 10 within which is rotatable the valve member 12. The cylinders 26 communicate with the bore 56 through the grooves 30 which connect with the radial passages 58.

The pressure inlet of the casing 10 is indicated by the port 60 in Figure 2 wherein it will be seen to communicate with an annular groove 62 in the valve member 12. The groove 62 is connected by diametrically opposite notches 64 with the level of the ports 58. The notches 64 above the groove 62 are 90° displaced from the notches 64 below the said groove. Each of the notches 64, as will be seen in Figures 4 and 6, span slightly less than 90° of the circumference of the valve member.

The discharge port of the casing 10 is indicated at 66 in Figure 2 wherein it will be seen to communicate with the groove 68 in the valve member 12. A vertical bore 70 communicates the port 66 with the transverse passage 72 which is connected with the groove 74 at the lower end of the member 12. The groove 68 is connected by the downwardly extending diametrically opposite notches 76 with the level of the upper ports 58, the notches 76 being 90° displaced from the notches 64 at the upper end of the member 12. The groove 74 is connected by the upwardly extending diametrically opposite notches 78 with the level of the lower ports 58, the notches 78 being 90° displaced from the adjacent notches 64.

At the level of the ports 54 there are diametrically opposite flats or grooves 80 which communicate through the bores 82 with the central passage 84 in the valve member 12, the passage 84 being connected with the exhaust conduit 86 in the cover plate 40. The notches 80 in the upper end of the member 12 are in alignment with the notches 76 while the notches 80 in the lower end of the valve member are in alignment with the notches 78.

In operation, fluid at a predetermined pressure is delivered to the unit through the port 60 while the valve member 12 is rotated by a separate source of power as, for example, a small electric motor. The fluid is conducted from the groove 62 through the lower notches 64 to the lower ports 54 and 58 of the reciprocating pistons shown in Figure 1. The upper areas 50 are connected through the upper ports 54 and the bores 82 with the exhaust passage 84 of the member 12 while the upper areas 52 are connected through the upper bores 58 with the notches 76 and thence through the groove 68 with the pressure outlet port 66. Thus, the pistons shown in Figure 1 move upwardly expelling fluid through

the port 66 at a pressure which is intensified over the incoming pressure at a ratio which is the sum of the areas 50 and 52 divided by the area 52. The quantity of the discharge is reduced from the quantity of the incoming fluid by a ratio which is equal to the area 52 divided by the sum of the areas 50 and 52.

While the pistons which are in communication with the lower notches 64 are moving upwardly, the pistons which are in communication with the upper notches 64 are moving downwardly so that the pistons first move in one direction and then the other as the valve member rotates.

It will be apparent that the extent of movement of the pistons in either direction is dependent upon the quantity of fluid being discharged through the pressure port 66 and the speed of rotation of the valve member. Preferably, the speed of rotation of the valve member is adjusted so that the pistons perform less than a complete stroke in either direction. It will be apparent that the quantity and pressure characteristics of the load connected with the discharge port 66 are reflected to the fluid source which is supplying fluid to the inlet port 60. Thus, a fluid source connected to the port 60 could be made to hold pressure, or to reverse in response to a predetermined pressure at the inlet of the booster and would respond as though it were connected directly to the load. That is, the pressure at the inlet of the booster always bears a fixed ratio to the booster discharge pressure and thus exactly reflects the pressure condition at the driven load and can, accordingly, be utilized to control the rate and direction of fluid flow in the circuit.

The construction of the intensifier or pressure booster is such that high operating efficiency is obtained with ordinarily closely machined fits. The members 24 being provided with the piston rings 34 and the sealing rings 36 eliminate the necessity of machining the bores 20 and 26 to a high degree of concentricity. Also, the pistons 22 and 28 may be separate without materially effecting the operation of the device. Thus, an intensifier constructed according to this invention is relatively simple to machine and assemble, operates with good efficiency and provides for a substantially continuous flow of fluid at intensified pressure.

It will be apparent that by introducing pressure fluid at the port 66 and connecting a load to the port 60, a flow of fluid will obtain which is augmented in volume and reduced in pressure, the added volume being supplied by the connection to exhaust at 86. This is due to the fact that pressure fluid is introduced into the port 60 and the piston moves under the influence of the said pressure acting on only one of the piston areas. Thus, during the movement of the piston due to this pressure the other area on the same end of the piston is connected with exhaust and is filled with fluid therefrom. Thus when the valve member has moved into position to reverse the connections to the piston ends, the reverse movement of the said pston discharges both of the chambers to the port 66. The supply of pressure fluid in the port 60 is thus augmented by an additional supply of fluid from exhaust because the said fluid is delivered to the port 66.

In either case the discharge of fluid from the device occurs in overlapping increments of volume so that the flow is uniform and continuous.

In operation, let it be assumed that the device is operating as a pressure intensifier and that a

fluid source of suitable pressure and capacity is connected with the port 60, the supply of pressure fluid to the port 60 is conducted around the groove 62 in the valve member 12 to the axially extending grooves 64. With the pump in operation, and the valve member 12 being driven in rotation by suitable power means connected to the shaft 14 thereof, the grooves 64 successively supply fluid to the channels 54 and 58 leading to the two areas on the ends of the pistons. It will be observed that the two lower grooves 64 is displaced 90° from the two upper grooves 64, so that each set of grooves is supplying fluid to a different set of pistons. Since the valve member 12 rotates it will be apparent that the pistons will be alternately connected with one of one set of the grooves 64 and then with the other thereof at its oher end.

Referring to Figure 1, it will be observed that the piston at the right side of the view has the working areas on the lower end thereof connected with the groove 64 of the lower set of grooves by means of the channels 54 and 58 so that pressure fluid is being simultaneously supplied to both of the said working areas. At the same time the working area at the uppermost end of the said piston is connected via the channel 58 and the groove 76 with the annular groove 68 in the valve member 12. This annular groove is connected, as seen in Figure 2, with the outlet port 66.

Referring again to Figure 1 it will be observed that the second working area on the upper end of the piston is connected through the channel 54 with the exhaust channel 84 extending through the valve member. Thus, the piston is being acted on on both of the areas on its lower end by pressure fluid from the source while movement of the valve member is resisted only by the pressure acting on the single area at the extreme upper end thereof.

The ratio of pressures between the ports 60 and 66 is therefore equal to the ratio of the sum of the working areas on the lower end of the piston to a single area at the extreme upper end thereof.

As will be seen in Figures 3 through 6, the valve member is so arranged that each of the grooves 64 thereof always communicates with at least one piston. Since there are four of these grooves it follows that there is always at least four of the pistons of the device moving on a working stroke. This provides for a perfectly smooth and uniform rate of fluid flow from the discharge port of the converter.

For operation of the device as a pressure reducer, the source of fluid is connected with the port 66 while the supply of fluid at reduced pressure is withdrawn from the port 60. During operation of the device as a pressure reducer opposite conditions obtain from those explained in connection with its operation as an intensifier. This is due to the fact that each piston is advanced on its working stroke by pressure acting on only one area thereof while both of the areas on the other end thereof are connected with the outlet port. This will be apparent upon reference to the piston on the right side of Figure 1 and which, if the device were operating as a pressure reducer, is moving downwardly.

It will be apparent that as the piston moves downwardly in Figure 1 fluid will be drawn into the upper part of the bore 20. Then, when the rotation of the valve member reverses the fluid connections to the piston ends, this fluid taken in from exhaust is discharged, together with the previous supply of fluid to the upper end of the piston to the outlet port 60.

It will be apparent that this provides for a smooth and continuous discharge of fluid from the outlet port but at a pressure substantially less than that at the inlet port 66 and at a volume substantially greater than the volume of fluid supplied to the port 66.

It will be understood that I desire to comprehend within my invention such modifications as may be considered to come within the scope of the claims.

I claim:

1. In a fluid pressure converter, a casing having a first port, a second port and an exhaust port, a plurality of cylinders in said casing, a plurality of pistons reciprocably mounted in said cylinders, each of said pistons forming with its associated cylinder two working areas on either end of said piston, a bore in said casing, a valve member movably mounted in said bore in continuous communication with said ports, each of the areas on said pistons being continuously in communication with said bore, said valve member comprising passages adapted to interconnect both of the areas on one end of each of said pistons with said first port while simultaneously connecting the areas on the other ends thereof one to said second port and one to exhaust, said valve member being movable for alternately reversing the aforementioned connections to said pistons in succession.

2. In a fluid pressure converter the combination of, a casing, a first, a second and an exhaust port in said casing, a plurality of spaced cylinders in said casing, a plurality of shouldered pistons reciprocably mounted in said cylinders and forming therewith pairs of opposed working areas, a bore in said casing, a valve member rotatably mounted in said bore in continuous communication with said ports, channel means in said casing interconnecting said working areas with said bore, said valve member having passages therein adapted alternately to connect both of said areas on one end of said pistons with said first port while simultaneously connecting one of the areas on the other end with exhaust and the other of said areas with said second port, said passages being arranged in said valve member so that as the latter is rotated said pistons successively reciprocate first in one direction and then the other for supplying a continuous flow of fluid to said first or said second port at a converted pressure.

3. In a fluid pressure intensifier, a cylindrical casing, a plurality of circumferentially spaced axial cylinders in said casing, shouldered piston means reciprocably mounted in said cylinders and forming therewith pairs of opposed working areas, a central axial bore in said casing, a valve member in said bore, anti-friction bearings rotatably supporting said valve member, inlet and outlet and exhaust means for said casing in continuous communication with said valve member, channel means in said casing continuously connecting said working areas with said bore, said valve member comprising passageways adapted as said valve member is rotated to interconnect both of the working areas on one end of said pistons with said inlet while connecting the areas on the other ends thereof one with exhaust and one with said outlet and thereafter to reverse said connections, and means for driving said valve member in rotation.

4. In a fluid pressure intensifier, a cylindrical

casing, inlet, outlet and exhaust ports in said casing, a central bore in said casing, a valve member rotatably mounted in said bore in continuous communication with said ports, a plurality of circumferentially spaced axial cylinders in said casing around said bore, each of said cylinders having reciprocably mounted therein a piston having an enlarged central portion, each of said cylinders having in the opposite ends thereof cylindrical members having inwardly opening bores for receiving the smaller ends of said pistons, end caps for said casing, means securing said cylindrical members to said end caps, said valve member comprising passageways adapted for connecting said inlet with both the large and small portions of one end of said pistons while simultaneously connecting the large portion on the other end thereof with exhaust and the small portion on the other end thereof with said outlet, said passages being arranged so that as said valve member is rotated said connections are alternately reversed, and means for driving said valve member in rotation.

5. In an apparatus for converting fluid pressures, a casing having a first, a second, and an exhaust port and comprising a plurality of cylinders, a plurality of pistons independently reciprocable in said cylinders and each comprising two areas on either end thereof, and means for successively connecting both of the areas on one end of said pistons to said first port while simultaneously connecting one of the areas on the other ends of said pistons with exhaust and the other with said second port, said means comprising a single valve member forming the sole control of the connection between said ports and said areas.

6. In an apparatus for intensifying fluid pressures, a casing comprising double ended cylinder means, a plurality of double ended piston means independently reciprocable in said cylinder means and each comprising a plurality of areas on each end, and a single valve connected with said cylinder means and operable to supply fluid at a predetermined pressure to a number of the areas on one end of some of said piston means while simultaneously connecting a smaller number of the areas on the other end thereof to a high pressure outlet, said valve also being operable simultaneously to exhaust the remaining of said areas.

7. In an apparatus for intensifying fluid pressures, a casing having a plurality of cylinders therein, a plurality of pistons reciprocable within said cylinders, each of said pistons comprising a larger central portion and smaller end portions extending either way therefrom, inlet, outlet and exhaust port means for said casing, a valve bore in said casing communicating with said port means and said cylinders, and a single valve member movable in said casing forming the entire control of the connection between said cylinders and said port means and operable successively to connect both the larger and smaller portions of one end of said pistons with said inlet while simultaneously connecting the larger and smaller portions of the other ends of said pistons with said outlet and said exhaust respectively, and to reverse the connection to the said pistons in succession.

8. In an apparatus for intensifying fluid pressures, a casing having an inlet, an outlet and an exhaust port, a plurality of cylinders in said casing, a plurality of pistons reciprocably mounted in said cylinders, each of said pistons comprising an enlarged central portion, a valve bore in said casing and communicating with said ports and

with the working areas of said pistons, and valve means rotatably mounted in said casing and forming the sole control of the connections between said inlet, said outlet and said exhaust ports with the working areas of said pistons, said valve member being movable first to interconnect both working areas on one end of said pistons successively with said inlet while simultaneously connecting the working areas on the other ends of said pistons with said outlet and said exhaust respectively, and thereafter to reverse said connection.

9. In combination in a continuous pressure booster to be associated with a source of fluid pressure, a rotary distribution valve, a plurality of cylinders, a plurality of independently movable compressing pistons in said cylinders successively supplied with fluid at opposite ends thereof by said valve, said pistons being divided into a total pressure actuating area, an exhaust area and a higher compression area so arranged as to be alternately used at either end as a total pressure area or as an exhaust and compression area, the supply of fluid to and from said pistons being entirely controlled by said valve.

10. In a continuous pressure booster supplied with high pressure fluid, the combination of a booster body, a rotary distribution valve, a plurality of cylinders, a plurality of independently movable compressing pistons in said cylinders alternately supplied with pressure fluid at either end and successively supplied whereby the pistons are caused to reciprocate and alternately compress fluid delivered thereto to a higher pressure than that initially delivered, a portion of the fluid so delivered being passed back to exhaust, the flow of fluid to and from the said pistons being entirely controlled by said valve.

11. In an apparatus for intensifying fluid pressure and having an inlet and an outlet, a plurality of cylinder means each having piston means independently reciprocable therein, supply means for supplying a predetermined quantity of fluid at a lower pressure to said inlet, said piston means being movable for displacing a portion of the fluid in said cylinder means to exhaust and to compress another portion thereof to a higher pressure, and a single valve member continuously and directly hydraulically connected with said cylinder means, said inlet and said outlet and movable for controlling the flow of fluid therebetween, said valve member being so constructed and arranged that there is always at least two of said pistons active in compressing fluid at one time.

12. In combination in an intensifier system, a plurality of cylinders, a plurality of double-ended pistons in said cylinders and each having a pair of working areas on each end thereof, a first conduit adapted for supplying fluid to said pistons from a source of pressure fluid, a second conduit adapted for conducting fluid from said pistons to a load, and means operable successively to connect both areas on one end of said pistons with one of said conduits while simultaneously connecting the areas on the other ends of said pistons one with exhaust and one with the other of said conduits, and thereafter successively to reverse said connections, said means comprising a single valve member having hydraulic connections with said conduits and with both ends of said pistons.

13. In combination in an intensifier system, a plurality of double-ended pistons each having a pair of working areas on each end thereof,

cylinders in which said pistons are mounted, a first conduit adapted for supplying fluid to said pistons from a source of pressure fluid, a second conduit adapted for conducting fluid from said pistons to a load, and means operable successively to connect both areas on one end of said pistons with one of said conduits while simultaneously connecting the areas on the other ends of said pistons one with exhaust and one with the other of said conduits, and thereafter successively to reverse said connections, said means comprising a continuously operating rotary valve member.

14. In combination in an intensifier system, a plurality of double-ended pistons each having a pair of working areas on each end thereof, cylinders in which said pistons move, a first conduit adapted for supplying fluid to said pistons from a source of pressure fluid, a second conduit adapted for conducting fluid from said pistons to a load, and means operable successively to connect both areas on one end of said pistons with one of said conduits while simultaneously connecting the areas on the other ends of said pistons one with exhaust and one with the other of said conduits, and thereafter successively to reverse said connections, said means comprising a continuously operating rotary valve member continuously and directly hydraulically connected with the said conduits and said areas.

15. In an apparatus for converting fluid pressures, a casing having a first, a second, and an exhaust port, and comprising a plurality of cylinders, a plurality of pistons independently reciprocable in said cylinders and each comprising a plurality of areas on either end thereof, and means for successively connecting all of the areas on one end of said pistons to said first port while simultaneously connecting some of the areas on the other ends of said pistons with said exhaust port and the remainder thereof with said second port, said means comprising a single valve member forming the sole control of the connection between said ports and said areas.

16. In combination in an intensifier system, a plurality of double-ended pistons each having a plurality of working areas on each end thereof, cylinders in which said pistons move and which form with said areas working chambers, a first conduit adapted for supplying fluid to said chambers, a second conduit adapted for conducting fluid from said chambers, and means operable successively to connect a number of the chambers at one end of said pistons with one of said conduits while simultaneously connecting a different number of said chambers at the other ends of said pistons with said other conduit and the remaining chambers with exhaust, and thereafter successively to reverse said connections, said means comprising a valve member continuously and directly hydraulically connected with said conduits and said chambers.

17. In combination in an intensifier system, a plurality of double-ended pistons each having a plurality of working areas on each end thereof, cylinders in which said pistons move and which form with said areas working chambers, a first conduit adapted for supplying fluid to said chambers, a second conduit adapted for conducting fluid from said chambers, and means operable successively to connect a number of the chambers at one end of said pistons with one of said conduits while simultaneously connecting a different number of said chambers at the other ends of said pistons with said other conduit and the remaining chambers with exhaust, and thereafter successively to reverse said connections, said means comprising a continuously operating rotary valve member continuously and directly hydraulically connected with said conduits and said chambers.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,991,595	Creveling	Feb. 19, 1935
2,243,978	Reader	June 3, 1941
2,293,076	Ponting	Aug. 18, 1942
2,296,647	McCormick	Sept. 22, 1942
2,336,446	Tucker et al.	Dec. 7, 1943