Oct. 26, 1965 R. J. KNABLE 3,213,765

FLUID PRESSURE MOTOR

Filed Sept. 20, 1963 2 Sheets-Sheet 1

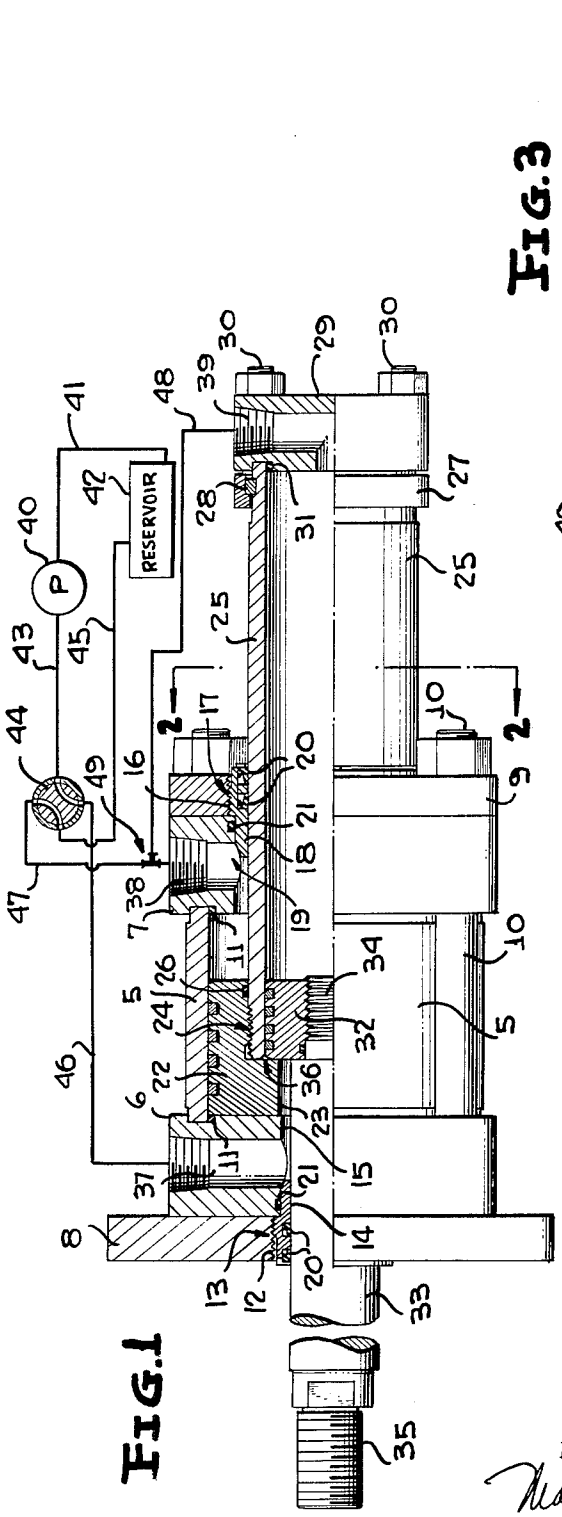


FIG. 1

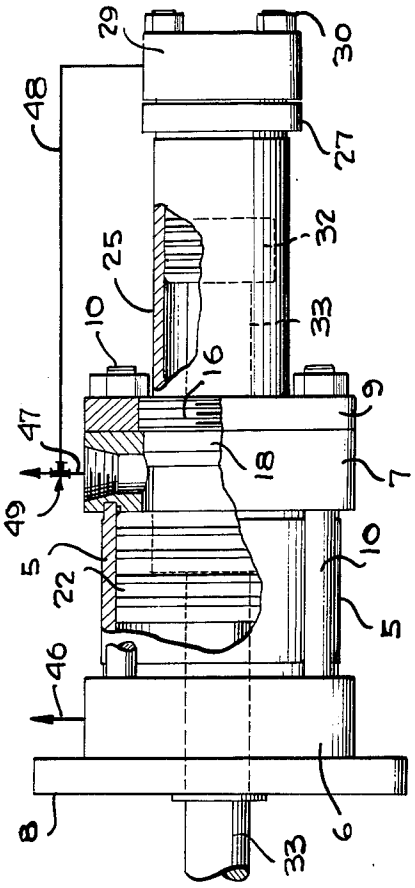


FIG. 3

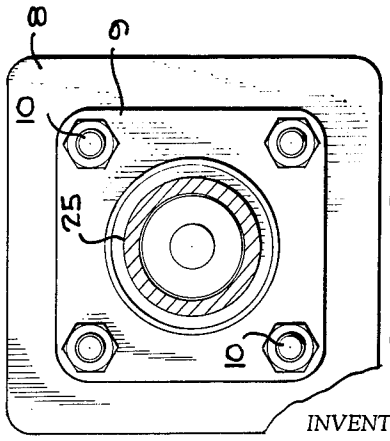


FIG. 2

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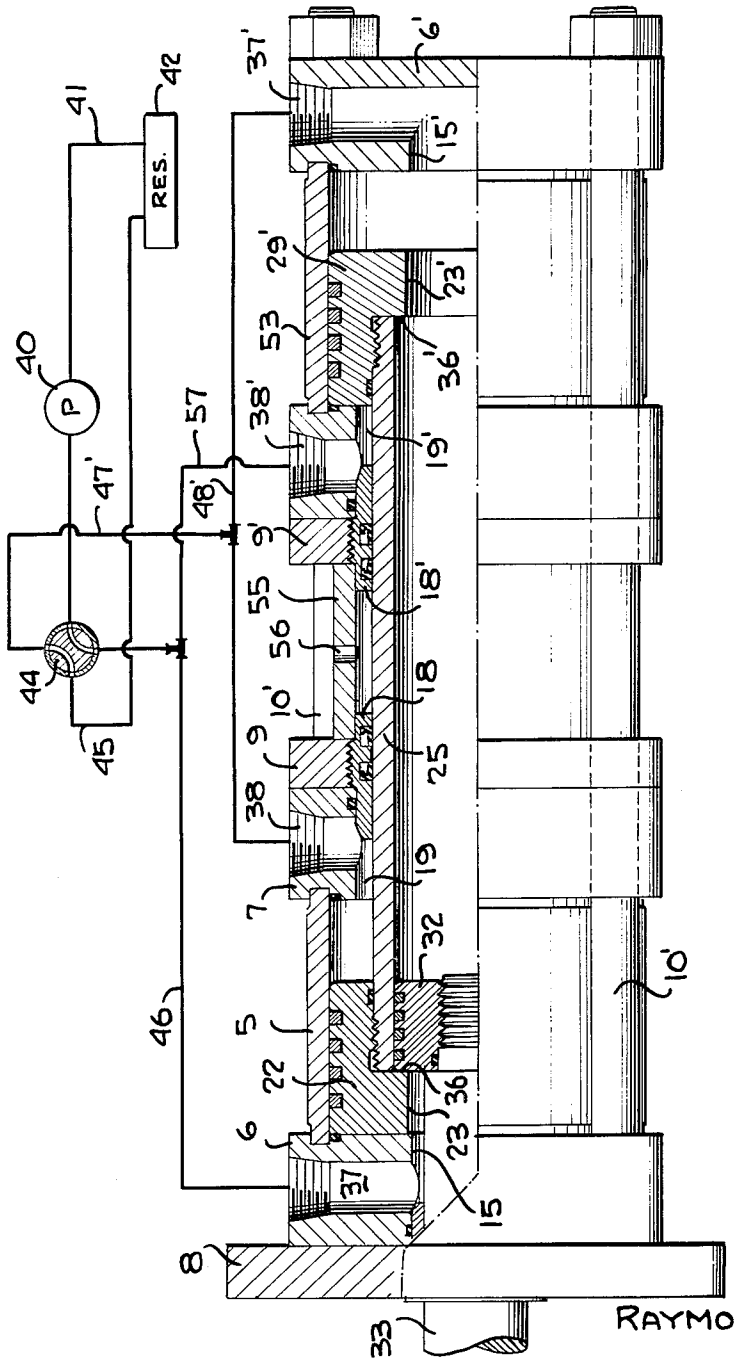


FIG. 4

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3,213,765

FLUID PRESSURE MOTOR

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The invention relates generally to fluid pressure actuators and seeks to provide a novel cylinder and piston arrangement wherein a piston operated actuator movement is initiated by a large force application and is then sustained or continued by a smaller force application.

An object of the invention is to provide a cylinder, piston and actuator arrangement of the character stated wherein a double acting cylinder and piston means is included to bring about movement of the actuator in both directions, such movement in each direction being initiated by a large force application and continued or sustained by a smaller force application.

It is another object of the invention to provide a pair of large diameter cylinders and a small diameter cylinder in which the heads of the latter are also large pistons of the large cylinders, the small cylinder having a small piston with a rod attached thereto, the small piston being movable by contact with either of the large pistons for movement thereby during the first part of a stroke of the small piston, and with the small piston being movable by fluid pressure away from the contacting large piston during the remaining part of the small piston stroke.

It is another object of the invention to provide a small cylinder with a small piston therein movable by fluid pressure and with a pair of large cylinders with large pistons therein, and with means whereby fluid pressure acting on each large piston assists in moving the small piston for a part of its stroke in either direction.

Another object of the invention is to provide a novel fluid pressure actuator of the character stated wherein there are provided a tandem cylinder-piston arrangement including a large cylinder with a head at each end thereof and a smaller cylinder with an inner end telescoped in the larger cylinder through one head thereof and a large piston secured on the telescoped end of the smaller cylinder for movement in unison therewith and slidable in the large cylinder between the heads thereon, the smaller cylinder also having a head on its outer end, a small piston slidable in the small cylinder between the head on the small cylinder and an abutment portion of the large piston and to which an actuator rod is attached to project through the other large cylinder head, and means through which pressure fluid may be directed into and from the cylinders to bring about reciprocation of the pistons individually and in unison.

A further object of the invention is to provide a fluid pressure actuator of the character stated wherein an initial portion of retraction of the actuator rod is effected by pressure fluid action against the large piston followed by continued retraction effected solely by pressure fluid action against the small piston.

Yet another object of the invention is to provide a fluid pressure actuator of the character stated wherein an initial portion of retraction of the actuator rod is effected by pressure fluid action against the large piston and attendant movement of the large piston and the small cylinder followed by continued projection effected by pressure fluid action against the small piston and movement thereof independently of movement of the small cylinder.

Still another object of the invention is to provide a fluid pressure actuator of the character stated wherein the large piston is arranged to bottom in each stroke direction in the large cylinder and includes thereon means for limiting movement of the small piston in the direction of projection of the actuator rod thereby to limit the amount of movement in unison of the pistons in each direction, and there being included stop means on the small cylinder to limit movement of projection of the actuator rod and cause initial movement of retraction of said rod in unison with the small cylinder.

A further object of the invention is to provide a fluid pressure actuator of the character stated wherein the large piston bottoms directly against one or the other of the large cylinder heads at the end of each reciprocation stroke of the small cylinder, and the small piston bottoms directly against the small cylinder head to limit the retraction stroke of the actuator rod.

A still further object of the invention is to provdie a fluid pressure actuator of the character stated wherein the means through which pressure fluid may be directed into and from the cylinders comprises an inlet and exhaust passage formed in each cylinder head and communicating with an end of the cylinder on which the particular head is mounted.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more clearly understood by reference to the following detailed description, the appended claims and the several views illustrated in the accompanying drawing:

In the drawing:

FIGURE 1 is a partial longitudinal section and side elevation illustrating the invention, the actuator rod being shown in its projected position.

FIGURE 2 is a vertical cross section taken on the line 2—2 on FIGURE 1.

FIGURE 3 is a side elevation, parts being broken away and the actuator rod being shown in a partially retracted position.

FIGURE 4 is a partial longitudinal section and side elevation of a second form of the invention.

In the example of embodiment of the invention disclosed in FIGURES 1 to 3 herein, the novel fluid pressure actuator includes a large cylinder **5** having heads **6** and **7** secured on the ends thereof and in assembly between head plates **8** and **9** by securing bolt means **10**, suitable sealing means **11** being provided at each cylinder end and head juncture.

A sealing bearing ring **12** is threadably mounted at **13** in the plate **8** and has an extension **14** projecting into the center bore **15** of the large cylinder head **6**. A similar seal bearing ring **16** is threadably mounted at **17** in the plate **9** and has an extension **18** projecting into the center bore **19** of the large cylinder head **7**. In addition to the sealing means **20** provided in each seal bearing ring **12** and **16** a sealing means **21** surrounds each ring extension **14** and **18** within the respective cylinder head **6** or **7**.

A large piston **22** is reciprocable within the large cylinder **5** between the heads **6** and **7**, and said piston has a bore **23** therein, together with a threaded counterbore **24** into which one end of a small cylinder **25** is threadably attached in the manner clearly illustrated in FIGURE 1. The attached small cylinder end is surrounded by a seal **26** within the threaded counterbore **24**.

At its outer end the small cylinder **25** has an anchor ring **27** secured thereon by conventional slot and ring means **28**, and a head **29** is secured to the small cylinder end and to the ring **27** by bolt means **30**, a suitable seal being provided at the head and cylinder juncture as at **31**.

It will be observed that the small cylinder **25** is slidable through the seal bearing ring **16** and its extension **18**, and a small piston **32** is reciprocable in the cylinder and has an actuator rod **33** secured thereto as at **34**. The rod

33 extends through the large piston 22, the large cylinder head 6 and the plate 8, being slidable through the seal bearing ring 12 and its extension 14 as clearly shown in FIGURE 1. The rod 33 has provision at 35 for attachment with any device to be moved or actuated by reciprocation of the rod.

The large piston bore 23 and the counterbore 24 result in the provision of an abutment shoulder 36 on the large piston 22, said shoulder projecting inwardly with respect to the inner diameter of the small cylinder 25 so as to be engageable by the small piston 32, as shown in FIGURE 1. It will be apparent by reference to FIGURE 1 that when the large piston 22 is bottomed against the large cylinder head 6 and the small piston 32 is bottomed or stopped against the large piston shoulder 36 a limit will be provided for the outward projection of the actuator rod 33. It will also be apparent that when the large piston 22 is bottomed against the large cylinder head 7 as shown in FIGURE 3 and the small piston 32 is stopped against the small cylinder head 29 a limit will be placed upon the in stroke or retraction of the actuator rod 33.

While various installations of the fluid pressure actuator may be made, an example is disclosed schematically herein. In this schematic showing, in FIGURE 1, there is included a fluid pressure circulating pump 40 connected by a receiving line 41 with a supply reservoir 42 and by a delivery line 43 with a four-way control valve 44 which is also connected by a return line 45 with the supply reservoir 42. The valve 44 also is connected by a flow and return line 46 with the port 37 of the large cylinder head 6, and by a flow and return line 47 with the port 38 of the large cylinder head 7. The small cylinder port 39 also has a flow and return line 48 connected therewith and through the T-connection 49 and the previously mentioned flow and return line 47 with the valve 44. Since head 29 to which line 48 is connected is movable relative to cylinder 5, line 48 should be in the form of a flexible hose or otherwise adapted to permit such movement.

When the actuator rod 33 is in its projected position as illustrated in FIGURE 1, and it is desired to retract the rod, the valve 44 will be conditioned as illustrated in FIG URE 1 to direct pressure fluid through the large cylinder port 37 into the interior of the large cylinder and against the left hand ends of the large piston 22 and the small piston 32. This applied fluid pressure will serve to move the large piston 22 and the attached small cylinder 25 toward the right as viewed in FIGURE 1, and with them the small piston 32 and the connected actuator rod 33, the large piston abutment or stop shoulder 36 being in contact with the small piston 32 as long as the external load on rod 33 exceeds the fluid pressure force being applied to the left side of small piston 32. When the external load exceeds this force, piston 32 will move away from shoulder 36 and continue to move until it contacts head 29. Meanwhile, piston 22 bottoms against head 7 to limit its stroke. At this time fluid is expelled from behind the large piston 22 out through the head port 38 and line 47, the valve 44 and the return line 45 to the reservoir 43 and fluid will be expelled from the right side of piston 32 through the small cylinder head port 39, the lines 48 and 47, the valve 44 and the return line 45 to the reservoir 42. It will be apparent that in the retraction of the actuator rod 33 the movement initially is imparted by force applied to the large piston 22 and later the movement of retraction of the piston 32 and the rod 33 will be sustained or continued by the smaller force applied to the small piston 32.

As in the case of the retraction of the actuator rod, projection of the rod also is initiated by a large force applied to the large piston 22, and then is continued or sustained by a smaller force applied to the small piston 32. It is to be understood that when the rod is to be projected the small piston 32 may be at the limit of its in stroke, in the present illustration, bottomed against the small cylinder head 29. This time pressure fluid will be directed from the reservoir 42, through the line 41, pump 40, line 43, the now reversed valve 44 and the lines 47 and 48 into the large cylinder 5 through the head port 38 and into the small cylinder 25 through the head port 39. The pressure fluid thus introduced will, of course, be initially active against the large piston 22 and will cause said piston and the attached small cylinder 25 to move to the left from the FIGURE 3 position. The small piston 32 having been stopped against or bottomed on the small cylinder head 29 will, of course, move with the small cylinder 25 and the large piston 22 to which it is attached. After the external load on rod 33 becomes less than the fluid pressure force acting directly on piston 32, piston 32 moves away from head 29 and continues its stroke while piston 22 bottoms against head 6 and with piston 32 ultimately bottoming against shoulder 36.

In the FIGURE 4 form of the invention there is a second large cylinder 53 for assisting movement of small piston 32 during part of its stroke in either direction. Second large cylinder 53 is attached to a first large cylinder 5, the latter being identical with cylinder 5 of FIGURE 1 and therefore described with like reference numerals. Small cylinder 25 in FIGURE 4 is likewise identical with small cylinder 25 of FIGURE 1, except that head 29 of FIGURE 1 is replaced by a head 29^1 which is formed to serve as a piston for cylinder 53. Cylinder 53 is identical to cylinder 5 except that head 6^1 does not have its opening 15^1 extending completely therethrough, nor is there a head plate 8 attached thereto. Reference numerals for parts of cylinder 53 are the same as the numerals of the corresponding parts of cylinder 5 except with the prime designation, and therefore further description of cylinder 53 is unnecessary.

The ends of a cylindrical tube 55 have a close guiding fit over the unthreaded ends of glands 18, 18^1 and butts against head plates 9, 9^1 to locate the two cylinders 5, 53 in a fixed axially spaced relationship. A vent opening 56 is provided in tube 55 for draining off any hydraulic fluid which may leak into tube 55 past packing glands 18, 18^1. Heads 6, 7, 9^1 and 6^1 are held in position on their respective cylinders and with reference to tube 55 by suitable tie rod bolts 10^1 which extend from one end to the other of the assembly and pass through the heads at their four corners, the heads being square in end view outline.

The piping from four-way valve 44 to cylinder 5 is the same as in FIGURE 1 but branch line 48^1 from line 47^1 connects to port 37^1 of head 6^1 and branch line 57 from line 46 is added to connect with port 38^1.

In the operation of the FIGURE 4 form, and with the parts in the position illustrated, fluid under pressure from pump 40 will pass through lines 46, 57 and ports 37, 38^1 to the left side of large pistons 22, 29^1 and through bore 23 to the left side of small piston 32. As long as the external load on rod 33 is greater than the fluid pressure force exerted on the left side of small piston 32, the latter will remain in contact with shoulder 36 on piston 22 and be moved by the latter in right hand direction for retracting rod 33. It will be noted that at this time fluid pressure acting on the left side of piston 29^1 is transmitted to piston 22 through cylinder tube 25 so that piston 32 is moved by the force acting on both of the large pistons 22, 29^1.

As soon as the external load on rod 33 becomes less than the fluid pressure force being applied to the left side of small piston 32, the latter will move away from shoulder 36 and will continue to move until it bottoms on shoulder 36^1 of piston 29^1. Meanwhile, piston 22 will have reached the end of its stroke by bottoming on head 7 and piston 29^1 will likewise be at the end of its stroke adjacent head 6^1.

During the retraction stroke of rod 33, fluid will be expelled from the right hand sides of pistons 22, 29^1 and

32 through line 47[1] to reservoir 42, the fluid from the right hand side of piston 32 first passing through opening 23[1] in piston 29[1].

To extend rod 33 of FIGURE 4, valve 44 is turned to connect pump 40 to line 47[1] and reservoir 42 with lines 46, 57. Fluid under pressure is then admitted to ports 38, 37[1] to move pistons 22, 29[1] to the left and through port 23[1] to act against the right hand side of piston 32. As long as the load on rod 33 exceeds the force applied to the right hand side of piston 32 by fluid pressure, the latter remains in contact with shoulder 36[1] and is moved by the combined effect of fluid pressure acting on pistons 22, 29[1]. When the load on rod 33 becomes less than the fluid pressure force applied to the right hand side of piston 32, the latter moves away from shoulder 36[1] to complete its stroke.

While two examples embodying the invention are disclosed herein, together with schematic examples of installation, it is to be understood that other variations may be made without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. In a fluid pressure actuator the combination of a large cylinder having a head at each end thereof, a small cylinder having an inner end telescoped in the large cylinder through one head thereof, a large piston secured on the telescoped end of the small cylinder for movement in unison therewith and slidable in the large cylinder between the heads thereon, said small cylinder also having a head on its outer end, a small piston slidable in the small cylinder, between the head on the small cylinder and an abutment movable with the large piston, an actuator rod attached to and moveable with the small piston and projecting through the other head on the large cylinder, and means through which pressure fluid may be directed into and from the cylinders to bring about reciprocation of the pistons individually and in unison in said cylinders.

2. Fluid pressure actuator structure as defined in claim 1 wherein the large piston is provided with a center bore through which the actuator rod extends from the small piston and through which pressure fluid is directed against and from the small piston.

3. Fluid pressure actuator structure as defined in claim 1 wherein the large piston is provided with a center bore through which the actuator rod extends from the small piston and through which pressure fluid is directed against and from the small piston, said large piston also having a counterbore in which the inner end of the small cylinder is secured and which provides for a radial inward extension of the large piston constituting an abutment engageable by the small piston whereby said pistons move in unison.

4. In a fluid pressure actuator the combination of a large cylinder having a head at each end thereof, a small cylinder having an inner end telescoped in the large cylinder through one head thereof, a large piston secured on the telescoped end of the small cylinder for movement in unison therewith and slidable in the large cylinder between the heads thereon, a small piston slidable in the small cylinder, an actuator rod attached to and movable with the small piston and projecting through the other head on the large cylinder, and means through which pressure fluid may be directed into and from the cylinders simultaneously to bring about reciprocation of the pistons individually and in unison in said cylinders in at least one direction of movement of the actuator rod.

5. In a fluid pressure actuator the combination of a large cylinder having a head at each end thereof, a small cylinder having an inner end telescoped in the large cylinder through one head thereof, a large piston secured on the telescoped end of the small cylinder for movement in unison therewith and slidable in the large cylinder between the heads thereon, said small cylinder also having a head on its outer end, a small piston slidable in the small cylinder between the head on the small cylinder and an abutment movable with the large piston, an actuator rod attached to and movable with the small piston and projecting through the other head on the large cylinder, and means through which pressure fluid may be directed into and from the cylinders to bring about reciprocation of the pistons individually and in unison in said cylinders in each direction of movement of the actuator rod.

6. Fluid pressure actuator structure as defined in claim 5 wherein stop means is provided on the small cylinder for limiting movement of the small piston away from the abutment and stop means is provided on the large cylinder for limiting movement of the large piston in each direction, said stop means and the means through which pressure fluid may be directed into and from the cylinders being so cooperatively arranged that in the effecting of each actuator rod stroke movement the movement will initially be caused by pressure fluid force application against the large piston to move the same and the small cylinder and small piston in unison and then be continued by pressure fluid force application to the small piston to move the same and the actuator rod independent of the movement of the large piston and the small cylinder secured thereto.

7. Fluid pressure actuator structure as defined in claim 6 wherein the large piston is provided with a center bore through which the actuator rod extends from the small piston and through which pressure fluid is directed against and from the small piston, said large piston also having a counterbore in which the inner end of the small cylinder is secured and which provides for a radial inward extension of the large piston constituting the small piston engageable abutment movable with the large piston.

8. Fluid pressure actuator structure as defined in claim 5 wherein the means through which pressure fluid may be directed into and from the cylinders includes a port opening through one large cylinder head into one end of the large cylinder to direct pressure fluid against and away from one end of the large piston and one end of the small piston, a port opening through the other large cylinder head into the other end of the large cylinder to direct pressure fluid about the small cylinder and against and away from the other end of the large piston, and a port opening through the small cylinder head to direct pressure fluid into and from the small cylinder at the other end of the small piston.

9. Fluid pressure actuator structure as defined in claim 5 wherein the means through which pressure fluid may be directed into and from the cylinders includes a port opening through one large cylinder head into one end of the large cylinder to direct pressure fluid against and away from one end of the large piston and one end of the small piston, a port opening through the other large cylinder head into the other end of the large cylinder to direct pressure fluid about the small cylinder and against and away from the other end of the large piston, and a port opening through the small cylinder head to direct pressure fluid into and from the small cylinder at the other end of the small piston, the large piston being provided with a center bore through which the actuator rod extends from the small piston and through which pressure fluid is directed against the small piston, said large piston also having a counterbore in which the inner end of the small cylinder is secured and which provides for a radial inward extension of the large piston constituting the small piston engageable abutment movable with the large piston.

10. Fluid pressure actuator structure as defined in claim 5 wherein the means through which pressure fluid may be directed into and from the cylinders includes a port opening through one large cylinder head into one end of the large cylinder to direct pressure fluid against and away from one end of the large piston and one end of the small piston, a port opening through the other large cyl-

inder head into the other end of the large cylinder to direct pressure fluid about the small cylinder and against and away from the other end of the large piston, and a port opening through the small cylinder head to direct pressure fluid into and from the small cylinder at the other end of the small piston, the large piston being provided with a center bore through which the actuator rod extends from the small piston and cooperating with a center bore in said one large cylinder head and its port in directing pressure fluid into and from said one end of the large cylinder, said large piston also having a counterbore in which the inner end of the small cylinder is secured and which provides for a radial inward extension of the large piston constituting the small piston engageable abutment movable with the large piston, the other large cylinder head including a center bore cooperating with its port in directing pressure fluid into and from the other end of the large cylinder, and there also being included a slide guide means for each of the actuator rod and the small cylinder and each including a projection into the center bore of one of the large cylinder heads.

11. Fluid pressure actuator structure as defined in claim **6** wherein the stop means for limiting movement of the large piston constitutes a direct bottoming of the large piston against the heads on the large cylinder.

12. Fluid pressure actuator structure as defined in claim **6** wherein the stop means for limiting movement of the large piston constitues a direct bottoming of the large piston against the heads on the large cylinder, and the stop means on the small cylinder constitutes a direct bottoming of the small piston against the small cylinder head.

13. In a fluid pressure actuator, the combination of a first large cylinder and a second large cylinder each having a head at each end thereof, a small cylinder having one of its ends telescoped into the first large cylinder through one head thereof and havings its other end telescoped into the second large cylinder through one head thereof, said small cylinder having a first head and a second head secured thereto at each of its opposite ends, said first head being within the first large cylinder and serving as a first large piston and said second head being within the second large cylinder and serving as a second large piston, a small piston slidable in the small cylinder between said first and second heads, an actuator rod attached to and movable with the small piston and projecting through the other head on said first large cylinder, and means through which pressure fluid may be directed into and from the cylinders to bring about reciprocation of the pistons.

14. The actuator of claim **13** in which the large cylinders are rigidly connected to prevent relative movement therebetween.

15. The actuator of claim **13** in which each of the large pistons has an abutment engageable by the small piston whereby movement of the large pistons imparts movement to the small piston.

16. The actuator of claim **13** in which each of the large pistons has an abutment engageable by the small piston whereby movement of the large pistons imparts movement to the small piston, said abutments being spaced to permit movement of the small piston therebetween.

17. The actuator of claim **13** in which each of the large pistons has an opening therethrough to communicate the interior of each large cylinder with the interior of the small cylinder for directing fluid to and from the small cylinder.

18. The actuator of claim **13** in which each large cylinder is divided in first and second chambers by the respective large piston, and means for communicating said first chambers with the interior of the small cylinder for directing fluid to and from the small cylinder.

19. The actuator of claim **18** in which said second chambers are sealed from the interior of the small cylinder.

20. The actuator of claim **13** in which the large cylinders are rigidly connected to means of a tube extending therebetween and said tube has an opening therein for venting any leakage fluid entering said tube from said large cylinders.

21. In a fluid pressure actuator the combination of a small diameter cylinder having a small piston therein and first and second large diameter cylinders having respective first and second large connected pistons therein, said large pistons each being separately engageable with said small piston for moving the same, and means for simultaneously directing fluid to said large cylinders for simultaneously applying force to both said large pistons to impart movement to said small piston regardless of which large piston is in contact therewith.

22. The actuator of claim **21** in which said small piston has a stroke longer than the stroke of the large pistons and is movable by fluid pressure independently of movement of the large pistons.

23. The actuator of claim **21** in which the large pistons comprise the heads of the small cylinder.

24. In a fluid pressure actuator the combination of a small diameter cylinder having a small piston therein and first and second large diameter cylinders having respective first and second large connecting pistons therein, said large pistons each being separately engageable with said small piston for moving the same, and means for directing fluid to said large cylinders for simultaneously applying force to both said large pistons to impart movement to said small piston regardless of which large piston is in contact therewith, said small piston having a stroke longer than the stroke of the large pistons and being movable by fluid pressure independently of movement of the large pistons.

25. In a fluid pressure actuator the combination of a small diameter cylinder having a small piston therein and first and second large diameter cylinders having respective first and second large connected pistons therein, said large pistons each being separately engageable with said small piston for moving the same, and means for directing fluid to said large cylinders for simultaneously applying force to both said large pistons to impart movement to said small piston regardless of which large piston is in contact therewith, the large pistons comprising heads of the small cylinder.

26. In a fluid pressure actuator, the combination of first and second large diameter cylinders each having a head at each end thereof and each having therein a respective first large piston and a second large piston, said large pistons being operatively connected to one another, a small diameter cylinder having therein a small piston and having each of its opposite ends telescoped into one of said large diameter cylinders through one of said heads, each of said large pistons being separately engageable with said small piston for moving same, and means for simultaneously directing fluid to said large diameter cylinders for simultaneously applying force to both said large pistons to impart movement to said small piston regardless of which large piston is in contact therewith.

27. The actuator of claim **26** in which said small piston has a stroke longer than the stroke of the large pistons and is movable by fluid pressure independently of the movement of the large pistons.

28. The actuator of claim **26** in which the large pistons comprise heads of the small cylinder.

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