Aug. 24, 1965 G. GROTNESS 3,202,060

FLUID POWER CYLINDER

Original Filed Nov. 20, 1961 3 Sheets-Sheet 1

Fig. 1.

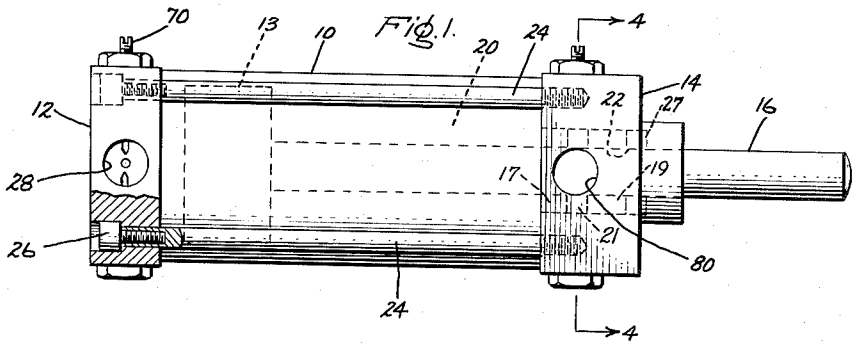

Fig. 2.

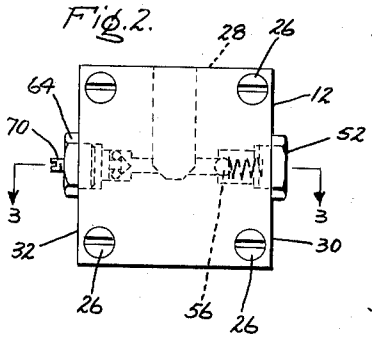

Fig. 3.

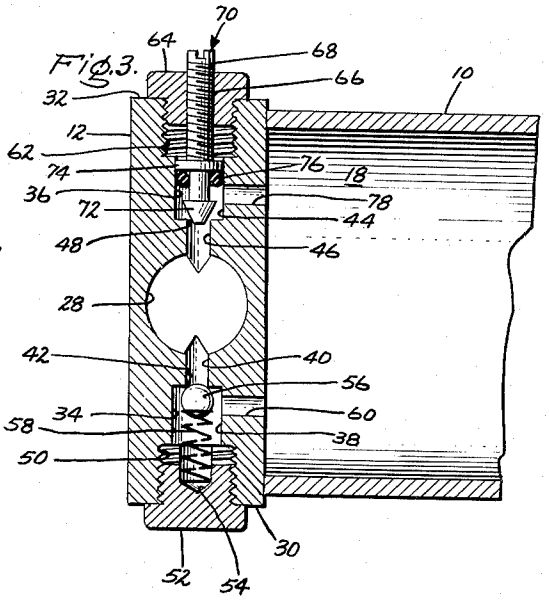

Fig. 4.

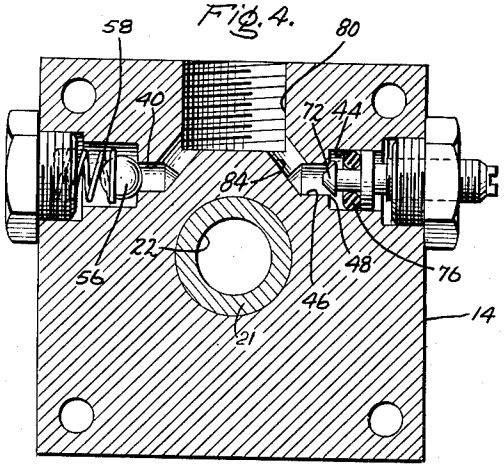

Fig. 5.

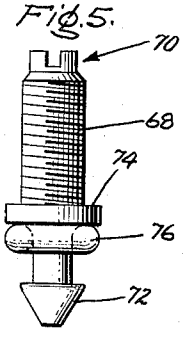

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Fig.6

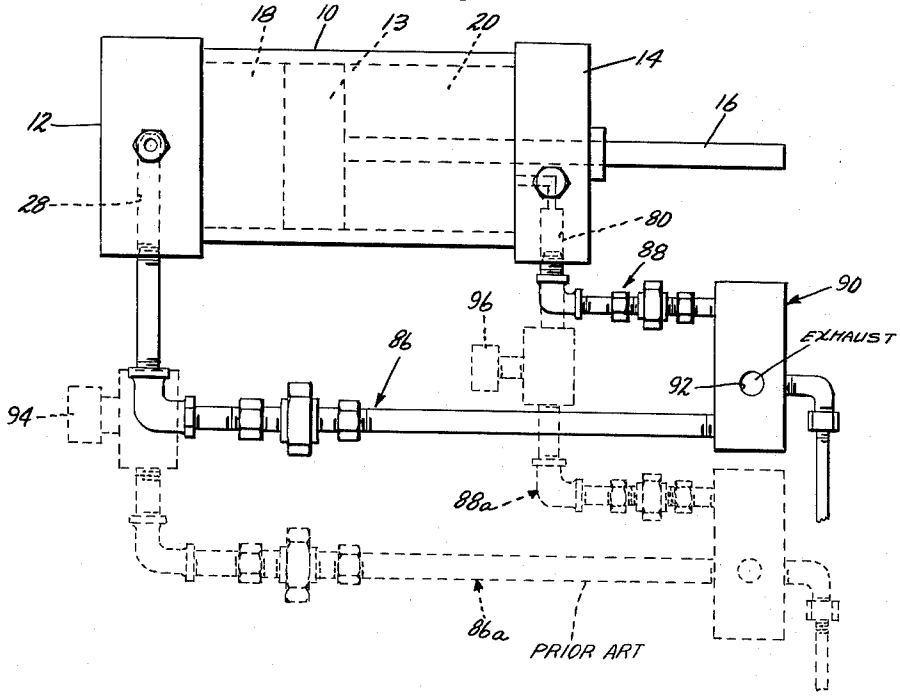


Fig.7

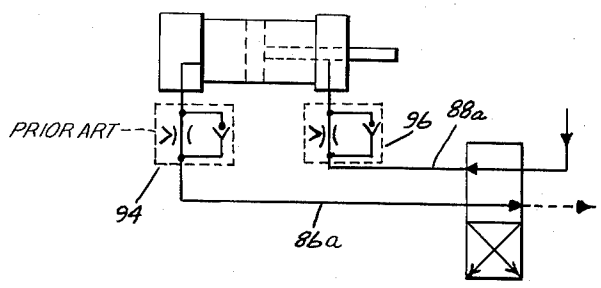
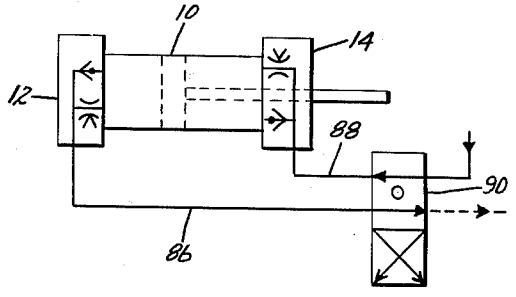


Fig.8



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FLUID POWER CYLINDER

Original Filed Nov. 20, 1961 3 Sheets-Sheet 3

Fig. 10

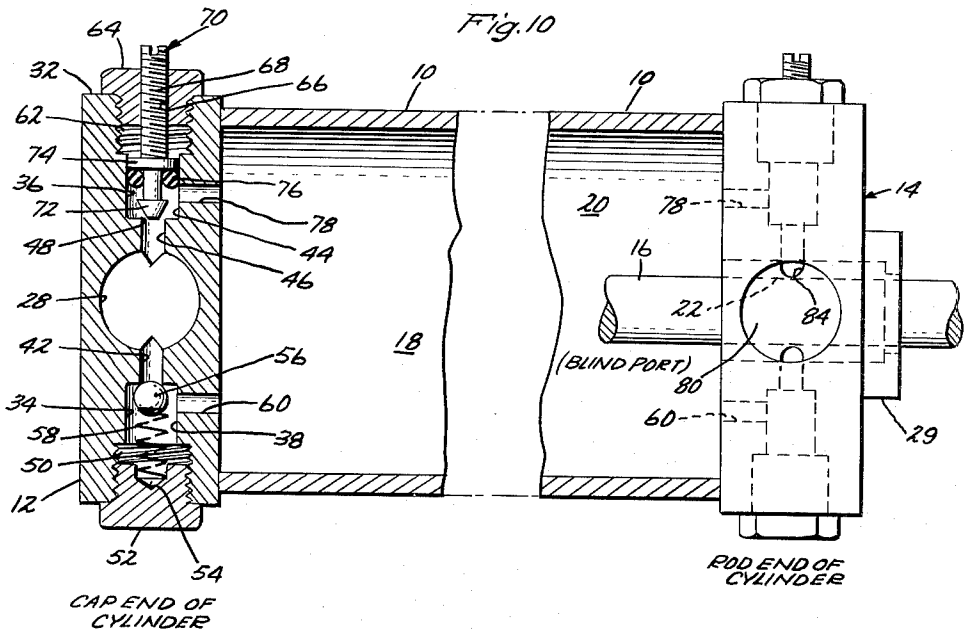
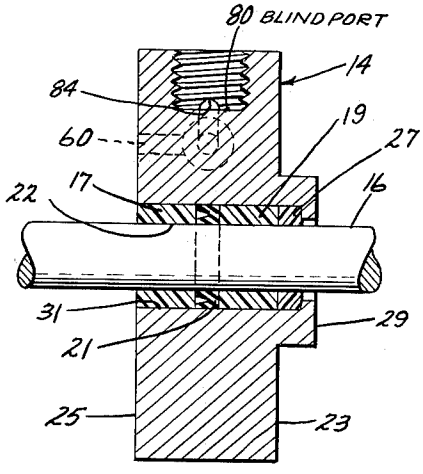


Fig. 9



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United States Patent Office 3,202,060 Patented Aug. 24, 1965

3,202,060

FLUID POWER CYLINDER

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Continuation of application Ser. No. 153,471, Nov. 20, 1961. This application Dec. 30, 1963, Ser. No. 337,699
9 Claims. (Cl. 91—443)

This is a continuation of application Serial No. 153,471, now abandoned, filed November 20, 1961.

The present invention relates to a fluid power cylinder and more particularly to a power cylinder with self-contained flow or speed control elements which are incorporated into an integrated, interchangeable and compact assembly to provide adjustable, constant control of piston velocity. This invention also relates to various fluid power cylinder designs including single rod end and double rod end types when operated either single or double acting whereby piston velocity is governed throughout the entire portion of the cylinder stroke whether it be push or pull.

Fluid power cylinders operated by gaseous or other fluid media are variously controlled in the respects of both power and velocity of operation. Such fluid power applications conventionally include the usual power cylinder in conjunction or combination with individual supply lines and controls separately connected thereto as individual accessories. Being so constructed, the space occupied by the complete system is not only that required by the power cylinder itself, but also the space required by the individual, separate controls which are usually in the form of valves of various design.

Systems in which the power cylinder having the usual rod and cap ends is connected to externally located speed controls or valves have two pressure fluid lines connected to the rod and cap ends, respectively, and a reversing control valve is connected to the distal ends of the pressure lines. A suitable source of pressure fluid may be connected to this valve. In this prior art arrangement, each line is provided with a speed control valve assembly connected in series therewith. Each assembly has physical size which not only requires a certain amount of space but can add to the length of the pressure lines. Additionally, these valve assemblies, being external to the power cylinder, are necessarily spaced therefrom, such that the length of the pressure lines providing for the connections between the power cylinder and the valve assemblies present an enclosed volume which is in series with the power cylinder itself. In other words, the volume of fluid to which the piston is subjected and in which it must work is not only that enclosed by the power cylinder itself, but also that existing in the pressure lines between the power cylinder and the speed control valve assemblies.

As will appear from the following discussion, this prior art system presents problems which are intolerable in certain situations. The present invention overcomes these problems.

In power cylinders of the character contemplated by this invention, the features of (1) piston velocity, (2) power applied to the piston and (3) compressibility of the fluid medium against which and in which the piston operates are of direct concern. With respect to piston velocity, and keeping in mind the foregoing prior art system, control thereof is governed by resistance to fluid flow, or, in other words, pressure drop, across an orifice having a size determined by a needle valve. This orifice and needle valve combination is incorporated in the previously mentioned speed control valve assembly which is mounted externally to the power cylinder. Precise control of this piston velocity is not possible in this prior art arrangement, since the volume of the compressible, gaseous medium (such as air) against which the piston works is relatively large as previously explained. For small diameter or short stroke power cylinders, it is absolutely necessary that the compressible volume be reduced to an absolute minimum to provide efficient, reliable control of the piston velocity. The present invention provides this.

The present invention is unique for the reasons, among others, that the (1) piston velocity is precisely controlled, (2) power applied to the piston is also closely controlled and rendered uniform, (3) the problems of compressibility have been overcome, and (4) the space occupied by the total system is much smaller than that of prior art systems. In the accomplishment of these features, speed and power control elements are integrated into the power cylinder itself, and more particularly within the rod and cap ends thereof. The present invention makes this possible by using blind port construction in the cap and rod ends, respectively, whereby the volume of air or other fluid under pressure is limited to the content of the cylinder bore only and is isolated from the external pressure fluid lines.

This invention provides a self-contained unit wherein the control valve is integrated with the cylinder-piston assembly and is so arranged as not only to control the speed of operation but also to apply full power to the piston during the entire stroke thereof.

It is therefore an object of this invention to provide a power cylinder construction wherein control valve mechanism is integrated therewith and is so arranged as not only to govern the velocity of the piston through the full stroke but also to apply uniformly full power to the piston throughout every incremental portion of the stroke.

It is another object of this invention to provide a fluid power cylinder so constructed as to provide for precise control of piston velocity, the application of uniform power or pressure to the piston, the reduction of compressibility effects of the fluid in which the piston must operate, and the rendering of a total system more compact.

It is another object of this invention to provide maximum ratio of bearing length for the piston rod when the bearing is located in the rod end of the cylinder while at the same time accomplishing the features of precise control of piston velocity, uniform application of pressure to the piston, provision of minimal compressibility of the fluid in which the piston acts and the like. This permits the utilization of the entire thickness of the rod end of the power cylinder for use as the rod bearing.

It is still another object of this invention to provide a fluid power cylinder of such design that overcomes the foregoing mentioned problems, this design being the optimum in compactness.

It is an object of this invention to provide a self-contained power unit wherein the control valve is integrated into the cylinder-piston assembly.

It is another object of this invention to provide a control valve assembly integrated with its power cylinder whereby full power is applied to the piston for its entire stroke.

It is still another object of this invention to provide a uniquely constructed valve element which cannot be accidentally removed from its assembly during adjustment.

It is yet another object to provide a valve element incorporating a rubber-like seal whereby the seal performs the twofold function of not only preventing leakage but also of locking the control valve against accidental adjustment.

A further object is to provide a power cylinder of

compact design which is simple, economical and reliable in operation.

Other objects will become apparent as the description proceeds.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a top plan view of one embodiment of this invention;

FIG. 2 is an end view thereof;

FIG. 3 is a fragmentary sectional illustration showing the cap end of the cylinder taken substantially along section line 3—3 of FIG. 2;

FIG. 4 is a cross-section taken substantially along section line 4—4 of FIG. 1;

FIG. 5 is an enlarged side view of the needle valve assembly used in the arrangement of the preceding figures;

FIG. 6 is an illustration of a typical system into which the power cylinder of the preceding figures is connected;

FIGS. 7 and 8 are diagrammatic illustrations of the systems of FIG. 6;

FIG. 9 is an axial sectional view of the head block on the rod end of the cylinder taken at right angles to that of FIG. 3; and

FIG. 10 is an axial, fragmentary sectional view, similar to FIG. 3, illustrating in enlarged detail both the rod and cap ends of the cylinder.

Referring to the drawings, and more particularly to FIG. 1 thereof, a power cylinder which may be either pneumatically or hydraulically operated comprises a cylinder 10 which receives for reciprocation a conventional piston 13. The opposite ends of the cylinder 10 are closed by means of two head blocks 12 and 14, respectively, and a piston rod 16 is secured coaxially to the piston 13 and reciprocally projects through the head block 14. The piston 13 divides the cylinder into two chambers 18 and 20 such that fluid pressure admitted to chamber 18 will force the piston 13 toward the right while fluid pressure admitted to the chamber 20 will force the piston 13 toward the left.

The two head blocks 12 and 14 are substantially identically constructed except for the fact that the block 14 is provided with centrally disposed aperture 22 for reciprocally receiving the piston rod 16. Blocks 12, 14 can be made having a variety of thicknesses; this fact is illustrated in FIGS. 1, 6 and 10 by showing block 14 thicker than block 12, block 12 thicker than block 14, and blocks 12, 14 of equal thickness, respectively. Thus, a description of one block 12, 14 with respect to the control valves and the like will suffice for both.

The head blocks 12 and 14 are securely clamped to the opposite ends, respectively, of the cylinder 10 by means of four elongated rods 24 which are threaded into the rectangular block 14 adjacent the corners thereof as shown and entered into apertures in the corners of the head block 14 to receive ordinary screws 26 for drawing the two head blocks 12 and 14 toward each other and into sealing engagement with the opposite ends of the cylinder 10.

The head block 12 will now be described. It is first of all provided with a bore or blind port 28 through one side as shown which extends about half-way through the block 12. Then extending inwardly from the opposite sides 30 and 32, respectively, of the block 12, are two bores 34 and 36 which in one embodiment of the invention are substantially identical in size and shape. As a matter of fact, as shown in FIGS. 2 and 3, these bores 34 and 36 are formed about a common axis and extend inwardly toward each other until they intersect the lower end of the first bore 28.

The bores 34 and 36 are of stepped diameter configuration, the bore 34 having a larger diameter portion 38 which joins a smaller diameter portion 40 in a valve seat 42. Similarly, the bore 36 is provided with a larger diameter portion 44 and a smaller diameter portion 46 which are joined together to provide a valve seat at 48. As already explained, these two bores 34 and 36 are substantially identical in size and shape for reasons which will become apparent from the following description.

In the bore 34 the outer end is threaded at 50 to receive a retaining nut 52 provided with a socket 54 in its inner end. A ball check valve 56 is yieldably urged into seating engagement with the valve seat 42 by means of a helical compression spring 58 which enters and is retained by the socket 54. A passage 60 connects the larger diameter bore portion 38 with the cylinder chamber 18 as shown. The valve 56 is therefore interposed between the passage 60 and the bore 28.

The outer end of the bore 36 is threaded at 62 and receives a retaining nut 64. This retaining nut is provided with a coaxial, threaded opening 66 which receives the threaded end 68 of a needle valve 70. This needle valve 70 is provided at its inner end with an enlarged, frusto-conically shaped valve tip 72 which is enterable into the smaller diameter bore portion 46 and engageable with the valve seat 48 to seal off any flow of fluid through the valve portion 46.

As shown more clearly in FIG. 5, the needle valve 70 is provided with an integral annular collar 74 intermediate the valve tip 72 and threaded end 68, the diameter of this collar 74 being substantially equal to the diameter of the bore portion 44.

Mounted on the needle valve 70 between the valve tip 72 and the collar 74 is a rubber O-ring seal 76, this seal frictionally engaging the shank of the needle valve 70 itself and also being of such outer diameter as to frictionally engage the inner wall of the bore portion 44. Thus, as viewed in FIG. 3, the needle valve 70 is restrained against rotation by virtue of the frictional grip afforded by the O-ring seal 76, this preventing the needle valve from being accidentally loosened or adjusted in the retaining nut 64.

Through the use of the O-ring seal in this manner, it is not necessary to use a locknut on the outer end of the thread 68 which would normally bear against the retaining nut 64.

A passage 78 connects the bore portion 44 to the cylinder chamber 18. Thus, the bore portion 46 is interposed between the cylinder chamber 18 and the first bore 28.

As will now be clearly understood, the needle valve 70 may be adjusted by virtue of its threaded connection with the retaining nut 64 to vary the size of the opening of the bore portion 46 into the larger diameter bore portion 44. By this means, the fluid which passes from the cylinder chamber 18, through the passage 78, and eventually into the blind port 28 is metered. The O-ring seal 76 prevents leakage outwardly around the threads of either the nut 64 or the needle valve 70.

Thus, far, the head block 12 has been described. As previously mentioned, the head block 14 is similarly constructed, and in this connection like numerals will indicate like parts (FIG. 4). With particular reference to FIG. 4, it will be noted that the bore or blind port 80 which corresponds to the blind port 28 in block 12 is not quite as deep, such that two angular bore extensions 84 connect the bore 80 with the respective bore portions 40 and 46. In all other respects, except for reciprocally receiving the piston rod 16, the construction of head block 14 is the same as that of head block 12.

With reference to the two bores 28 and 80, they are alike to the extent that they extend into the respective blocks 12 and 14 from the sides thereof and are therefore closed at the inner ends. This particular bore con-

struction being closed at the inner end and open at the outer end may be conveniently referred to as a "blind port." Neither of the blind ports 28 and 80 directly open into the cylinder chambers 18, 20 but communicate therewith by way of the passages 60, 78 only.

Fluid lines 86 and 88 (FIG. 6) are connected to the two blind ports 28 and 80, respectively, through the intermediary of a conventional reversing valve 90 whereby during one period of time fluid pressure is admitted to blind port 28 and during another period of time fluid pressure will be admitted to the blind port 80. By alternating the admission of fluid pressure to these two blind ports, the piston 13 may be caused to reciprocate.

The lines 86 and 88 are composed of conventional pipe, elbows and couplings, and the valve 90 is of conventional design and preferably is manually operable to control the admission and exhausting fluid to the chambers 18 and 20. For one direction of valve 90 operation, air, for example, under pressure is admitted to chamber 18 via line 86 for forcing piston 13 toward the right as viewed in FIG. 6. Simultaneously, air is exhausted from chamber 20 via line 88 and the exhaust port 92 of valve 90. For the opposite direction of valve 90 operation, the reverse flow of air is effected, air under pressure passing through line 88 into chamber 20 for moving piston 16 leftwardly, and exhausted air flowing from chamber 18 through line 86 and out of exhaust port 92. The valve 90 may conventionally have a vertical position in which no air is admitted to or exhausted from the chambers 18 and 20.

FIG. 8 is the diagrammatic equivalent of the system shown in FIG. 6.

In operation, the needle valve 70 is retracted from the valve seat 48 so as to provide communication between the bore 28 and the cylinder chamber 18. The same is true of the needle valve 70 in the head block 14 (FIG. 4). As a first cycle of operation, let it be assumed that fluid pressure is admitted to the bore 28, and that fluid in chamber 20 is exhausted from the bore 80. This fluid pressure flows past the valve tip 72, the passage 78 and into the cylinder chamber 18. Also, this same fluid pressure also flows past the check valve 56 through the passage 60 and into the cylinder chamber 18. This drives the piston 13 toward the right as viewed in FIG. 1, causing the air in the chamber 20 to compress. As a consequence, and now considering FIG. 4, the compressed air will attempt to pass out of the passages in block 14 which correspond to passages 60 and 78 of the end block 12. Since the ball check 56 is seated, the fluid, of course, cannot pass out of the bore portion 40. However, by reason of the fact that the valve tip 72 (FIG. 4) is retracted from the seat 48, the air can exhaust through the passage 78, the bore portion 44, bore portion 46, bore extension 84 and outwardly of the bore 80. The speed at which the piston 13 approaches the head block 14 can be governed by the size of the opening provided between the valve tip 72 (FIG. 4) and the seat 48, and it may now be stated that this is the means for controlling the speed of operation of the power cylinder.

Once the piston 13 has fully protracted and abuts against the head block 14, the admission of pressure fluid is reversed such that pressure fluid is applied through the bore 80 and fluid is permitted to exhaust from the bore 28. The exact reverse performance results in the piston 12 retracting to its illustrated position up against the head block 12, the valve tip 72 of FIG. 3 determining the speed at which the piston retracts.

It will now be apparent that the speed or protraction and retraction, respectively, of the piston 12 may be varied to suit operational requirements.

The speed of the power cylinder is normally adjusted while the power cylinder is in operation and is connected to its associated equipment. This, as explained previously, is accomplished by adjustment of the needle valves 70. With fluid power applied to the cylinder and the piston 12 reciprocating, each needle valve 70 is adjusted to the desired position. As the needle valve is backed farther outwardly, the piston will operate faster until the port or valve seat 48 is fully opened (FIG. 3). However, should the needle valve be backed outwardly to its full extent, the collar 74 will be abutted against the inner end of the retaining nut 64, thereby preventing the needle valve from being fully withdrawn from the retaining nut 64. This is important for the reason that if the collar 74 were not present, the needle valve 70 could be withdrawn completely from the retaining nut 64, thereby allowing the escape of pressure fluid which is introduced at the bore 28. This has been one difficulty experienced in the past with prior art needle valves, and it has been found that the escape of pressure fluid from the opening 66 in the retaining nut 64 is so violent that it is impossible to reinsert the needle valve into the opening unless the entire system has been first shut down. Also, when the prior art needle valves without the collar 74 have been backed out to the point where the threads thereof lose engagement with the retaining nut 64, the fluid pressure blows the needle valve outwardly and away, whereby the needle valve usually becomes lost. This requires a complete shutdown of the system and replacement of the lost needle valve by a different one. By using the collar 74, the accidental removal of the needle valve is obviously prevented.

As will be noted by viewing FIG. 5, the fluid pressure acts against the O-ring seal in such a manner as to force it against the collar 76 and to distend it against the shank of the needle valve as well as against the wall of the bore portion 44. This tends to tighten the needle valve against rotation, thereby locking it in position. Since equipment with which the power cylinder is conventionally used vibrates considerably, it will be seen that this locking action prevents accidental adjustment of the needle valve.

Inasmuch as the bores 34 and 36 are, in one embodiment, of identical size and shape, it is possible to reverse the ball valve 56 and needle valve 70 without altering the performance or operation of the power cylinder. Reversal of these parts may be occasioned because of installation peculiarities wherein it may be desirable to have the needle valve 70 on one side instead of on the other.

As shown in FIG. 1, the diameter of the aperture 22 is uniform throughout the length thereof, this length being substantially equal to the thickness of the block 14. Thus, the entire thickness of this block is available and is used to provide the necessary bearing support. This constitutes an advantage over prior art arrangements wherein communication with the cylinder chamber has been provided by means of enlarged bores coaxial with the piston rod, because this prior art arrangement requires the addition of bearing length whereby the total cylinder construction becomes longer. This invention provides both adequate bearing support as well as full and complete speed control in a construction smaller than the prior art permitted.

Preferably, as shown in FIG. 9, the bearing aperture 22 is provided by a bearing assembly composed of two elongated, cylindrical bushings 17 and 19 arranged end-to-end as shown and spaced apart axially to receive a hermetic sealing ring 21 of conventional design. The bushings 17 and 19 may be fabricated of any suitable conventional bearing material such as sintered nylon. The sealing ring 21, which surrounds the rod 16 in hermetic sealing engagement therewith, conventionally seals the bearing assembly and prevents leakage between the cylinder interior and the outside via the bearing assembly. This sealing ring 21 may be of any suitable conventional material such as rubber. The ring 21 is engageably interposed between the two bushings 17 and 19 and is situated about midway between the opposite surfaces 23 and 25, respectively, of the block 14. An annular Teflon wiper 27, which surrounds the rod 16, abuts against the right-hand end (FIG. 9) of the bushing 19 and in turn is held in place by the inturned annular flange 29 which is inte-

gral with the block 14. Thus, the bearing assembly 17, 19, 21 is retained against accidental dislodgement in a rightward direction from the block 14. Further than this, the bushings 17 and 19 are press fitted and hermetically sealed into an enlarged opening 31 in the block 14. The piston rod 16 can thereby conventionally reciprocate in the bearing aperture 22 as previously explained. As FIG. 9 shows, the two bushings 17 and 19 aggregatively are of a length substantially equal to the distance between the two surfaces 23 and 25.

The blind port 80 (FIG. 9), which is relatively shallow as previously described, terminates short of the enlarged opening 31 and bearing aperture 22 thereby preventing any direct communication between this blind port 80 and the aperture 22. The sole communication between this port 80 and the interior of the cylinder 10 is provided by the passages 60, 78 in the block 14.

Referring to FIGS. 6, 7 and 8, typical air systems incorporating this invention and a comparable prior art arrangement are shown. In FIG. 6, the dashed line portion is the prior art alternative to the full line piping hook-up leading from the power cylinder 10 to the reversing valve 90. FIG. 7 diagrammatically illustrates the equivalent of this prior art alternative wherein the speed control valve assemblies are not incorporated into the end blocks but instead are connected in series with the external lines. In this prior art arrangement, the power cylinder end blocks are bored out in a conventional manner to provide full communication between the cylinder chambers 18, 20 and the lines 86 and 88. Speed control valve assemblies 94 and 96 are connected in series with the lines which are indicated by the numerals 86*a* and 88*a*, respectively. It will immediately be obvious that the volume enclosed by the piping between these valves 94 and 96 must be added to the volumes of the cylinder chambers 18 and 20 to determine accurately the total volume of air against which the piston must work. The larger the volume, the more air there is to be compressed, such that a piston of given size will necessarily have to move a correspondingly large distance before it will encounter sufficient back pressure to control the movement thereof. Conversely, the smaller the volume, the same stroke of the piston will produce greater back pressure sooner thereby developing more resistance to movement. Thus, it is desirable to locate the control valve assemblies as closely as possible to the cylinder chambers 18 and 20, and the present invention provides the optimum for accomplishing this.

If it is assumed that piston 13 is moved from its position of FIG. 1 toward the right, a given full pressure will immediately be applied to the left-hand side of the piston 13 and will remain so applied uniformly through the entire stroke. This pressure is uniform from start to finish. At the exhaust end, the air in chamber 20 immediately encounters the needle valve. The exhaust rate past this needle valve directly and instantly governs piston velocity such that this velocity is substantially uniform regardless of whether the piston stroke is short or long. Location of the valve assemblies directly adjacent to the cylinder chambers 18, 20 provides for this precise and uniform control: to-wit, uniform application of power to the piston coupled with efficacious control of speed.

While there has been described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

What is claimed is:

1. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod disposed coaxially of said hollow cylinder secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having two parallel surfaces which are spaced apart in a direction axially of said cylinder thereby providing thickness dimensions for said blocks, said blocks having orthogonally intersecting sides, piston rod-bearing means which includes an axially extending bearing aperture through said one block, said bearing aperture coaxially slidably receiving said piston rod, said bearing aperture extending between the surfaces of said one block and being of uniform diameter throughout the length thereof, the diameter of said aperture being substantially coextensive with the diameter of said rod, each said block having first and second identically shaped bores extending inwardly from two opposite sides respectively, a third bore in each block having inner and outer opposite ends, the outer end of said third bore opening through a third side of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores being divided into two different diameter lengths with the innermost length being the smaller, each said first and second bores having a valve seat provided at the joinder of the two different diameter lengths, the outermost ends of the larger diameter lengths being threaded, one of said first and second bores receiving a ball valve engageable with the respective valve seat, a closure nut threaded into the outer end of said first bore, a spring interposed between said ball valve and said nut for urging said ball valve into sealing engagement with its valve seat, a retaining nut threaded into the outer end of the other of said first and second bores, a needle valve threadedly received by an opening in said retaining nut, said needle valve having a valve tip on its inner end which cooperatively engages the respective valve seat, an integral annular collar on said needle valve and movably disposed in the respective larger bore portion, said collar being of a diameter substantially coextensive with that of said larger bore portion, said collar having a diameter larger than the opening in said retaining nut and abuttable with said retaining nut as a stop, a rubber O-ring frictionally fitted onto said needle valve intermediate said collar and said valve tip, said O-ring frictionally engaging said larger bore portion thereby restraining said needle valve against rotation and sealing said larger bore portion, said blind ports extending in a direction normal to the axis of said cylinder, the blind port in said one block extending inwardly toward said bearing aperture but terminating short thereof, and two passages in each head block extending in directions parallel to said cylinder axis, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder, said valve seats of each block being disposed between said blind port and the respective passages.

2. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod disposed coaxially of said hollow cylinder secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having two surfaces which are spaced apart in a direction axially of said cylinder thereby providing thickness dimensions for said blocks, said blocks having sides, piston rod-bearing means which includes an axially extending bearing aperture through said one block, said bearing aperture coaxially receiving said piston rod, said bearing aperture extending between the surfaces of said one block and having an axially extending piston rod-engaging area of cylindrical shape which is of uniform cross-sectional size and shape throughout the axial extent thereof; each said block having first and second identically shaped bores extending inwardly from two opposite sides respectively, a third bore in each block having

inner and outer opposite ends, the outer end of said third bore opening through a side of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores being divided into two different diameter lengths with the innermost length being the smaller, each said first and second bores having a valve seat provided at the joinder of the two different diameter lengths, the outermost ends of the larger diameter lengths being threaded, one of said first and second bores receiving a ball valve engageable with the respective valve seat, a closure nut threaded into the outer end of said first bore, a spring interposed between said ball valve and said nut for urging said ball valve into sealing engagement with its valve seat, a retaining nut threaded into the outer end of the other of said first and second bores, a needle valve threadedly received by an opening in said retaining nut, said needle valve having a valve tip on its inner end which cooperatively engages the respective valve seat, an integral annular collar on said needle valve and movably disposed in the respective larger bore portion, said collar being of a diameter substantially coextensive with that of said larger bore portion, said collar having a diameter larger than the opening in said retaining nut and abuttable with said retaining nut as a stop, a rubber O-ring frictionally fitted onto said needle valve intermediate said collar and said valve tip, said O-ring frictionally engaging said larger bore portion thereby restraining said needle valve against rotation and sealing said larger bore portion, said blind ports extending in a direction normal to the axis of said cylinder, the blind port in said one block extending inwardly toward said bearing aperture but terminating short thereof, the first and second bores in said one block also terminating short of said bearing aperture so as not to have any direct communication therewith, and two passages in each head block, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder, said valve seats of each block being disposed between said blind port and the respective passages.

3. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod disposed coaxially of said hollow cylinder secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having two parallel surfaces which are spaced apart in a direction axially of said cylinder thereby providing thickness dimensions for said blocks, said blocks having a plurality of intersecting sides, piston rod-bearing means which includes an axially extending bearing aperture through said one block, said bearing aperture coaxially receiving said piston rod, said bearing aperture extending between the surfaces of said one block and having an axially extending piston rod-engaging area of cylindrical shape which is of uniform cross-sectional size and shape throughout the axial extent thereof; each said block having first and second identically shaped bores extending inwardly from two opposite sides respectively, a third bore in each block and having inner and outer opposite ends, the outer end of said third bore opening through a third side of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores being divided into two different diameter lengths with the innermost length being the smaller, each said first and second bores having a valve seat provided at the joinder of the two different diameter lengths, the outermost ends of the larger diameter lengths being threaded, one of said first and second bores receiving a ball valve engageable with the respective valve seat, a closure nut threaded into the outer end of said first bore, a spring interposed between said ball valve and said nut for urging said ball valve into sealing engagement with its valve seat, a retaining nut threaded into the outer end of the other of said first and second bores, a needle valve threadedly received by an opening in said retaining nut, said needle valve having a valve tip on its inner end which cooperatively engages the respective valve seat, said blind ports extending in a direction normal to the axis of said cylinder, the blind port in said one block extending inwardly toward said bearing aperture but terminating short thereof, and two passages in each head block extending in directions parallel to said cylinder axis, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder, said valve seats of each block being disposed between said blind port and the respective passages.

4. For use in a fluid power cylinder, a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having a thickness which extends in a direction axially of said cylinder, one of said blocks having piston rod-bearing means which includes an axially extending bearing aperture through the entire thickness of said one block, said bearing aperture coaxially slidably receiving said piston rod, said bearing aperture having an axially extending piston rod-engaging area which is of uniform cross-sectional size and shape throughout the axial extent thereof, said rod-engaging area extending substantially coextensively with the thickness of said one block; each said block having first and second bores extending inwardly from two opposite sides respectively, a third bore in each block and having inner and outer opposite ends, the outer end of said third bore opening through a third side of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores being divided into two different diameter lengths with the innermost length being the smaller, each said first and second bores having a valve seat provided at the joinder of the two different diameter lengths, said blind ports extending in a direction normal to the axis of said cylinder, the blind port in said one block extending inwardly toward said bearing aperture but terminating short thereof, and two passages in each head block extending in directions parallel to said cylinder axis, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder, said valve seats of each block being disposed between said blind port and the respective passages.

5. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having a thickness which extends in a direction axially of said cylinder, said one block having piston rod-bearing means which includes an axially extending bearing aperture through the entire thickness of said one block, said bearing aperture coaxially sealingly receiving said piston rod, said bearing aperture having an axially extending piston rod-engaging area which is slidably engageable with said piston rod throughout the axial extent of said rod-engaging area, said rod-engaging area extending substantially coextensively with the thickness of said one block, each said block having first and second bores, a third bore in each block and having inner and outer op-

posite ends, the outer end of said third bore opening through a side portion of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores having a valve seat, first valve means provided in one of said first and second bores in operative association with the valve seat thereof for shutting off flow in a direction from said one bore toward the respective blind port and for opening flow in the opposite direction, second valve means provided in the other of said first and second bores in operative association with the valve seat thereof for controlling flow between said other bore and the respective blind port, said blind ports extending in a direction normal to the axis of said cylinder, the blind port in said one block extending inwardly toward said bearing aperture but terminating short thereof, and two passages in each head block extending in directions parallel to said cylinder axis, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder, said valve seats of each block being disposed between said blind port and the respective passages.

6. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having a thickness which extends in a direction axially of said cylinder, said blocks having a plurality of side portions, piston rod-bearing means which includes an axially extending bearing aperture through the entire thickness of said one block, said bearing aperture coaxially sealingly receiving said piston rod, said bearing aperture having an axially extending piston rod-engaging area which is slidably engageable with said piston rod throughout the axial extent of said rod-engaging area, said rod-engaging area extending substantially coextensively with the thickness of said one block, each said block having first and second bores, a third bore in each block and having inner and outer opposite ends, the outer end of said third bore opening through a side portion of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores having a valve seat, first valve means provided in one of said first and second bores in operative association with the valve seat thereof for shutting off flow in a direction from said one bore toward the respective blind port and for opening flow in the opposite direction, second valve means provided in the other of said first and second bores in operative association with the valve seat thereof for controlling flow between said other bore and the respective blind port, the blind port in said one block having no direct communication with said bearing aperture, and two passages in each headblock, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder.

7. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having a thickness which extends in a direction axially of said cylinder, said blocks having a plurality of side portions, piston rod-bearing means which includes an axially extending bearing aperture through the entire thickness of said one block, said bearing aperture coaxially sealingly receiving said piston rod, said bearing aperture having an axially extending piston rod-engaging area which is slidably engageable with said piston rod throughout the axial extent of said rod-engaging area, said rod-engaging area extending substantially coextensively with the thickness of said one block, each said block having first and second bores, a third bore in each block and having inner and outer opposite ends, the outer end of said third bore opening through a side portion of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, means providing communication between said first and second bores of each block and the interior of said cylinder, means in the first bore of each block for limiting flow of fluid in only the direction from the blind port to the cylinder interior, and means in the second bore of each block for restricting the flow of fluid from said cylinder interior to the blind port thereof.

8. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod disposed coaxially of said hollow cylinder secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having two surfaces which are spaced apart in a direction axially of said cylinder thereby providing thickness dimensions for said blocks, said blocks having sides, piston rod-bearing means which includes an axially extending bearing aperture through said one block, said bearing aperture coaxially receiving said piston rod, said bearing aperture extending between the surfaces of said one block and having an axially extending piston rod-engaging area of cylindrical shape which is of uniform cross-sectional size and shape throughout the axial extent thereof; each said block having first and second bores extending inwardly from two opposite sides respectively, a third bore in each block having inner and outer opposite ends, the outer end of said third bore opening through a side of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores being divided into two different diameter lengths with the innermost length being the smaller, each said first and second bores having a valve seat provided at the joinder of the two different diameter lengths, the outermost ends of the larger diameter lengths being threaded, one of said first and second bores receiving a ball valve engageable with the respective valve seat, a closure nut threaded into the outer end of said first bore, a spring interposed between said ball valve and said nut for urging said ball valve into sealing engagement with its valve seat, a retaining nut threaded into the outer end of the other of said first and second bores, a needle valve threadedly recieved by an opening in said retaining nut, said needle valve having a valve tip on its inner end which cooperatively engages the respective valve seat, said blind ports in said blocks extending in a direction normal to the axis of said cylinder, the blind port in said one block extending inwardly toward said bearing aperture but terminating short thereof, and two passages in each head block, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder, said valve seats of each block being disposed between said blind port and the respective passages.

9. A fluid power cylinder comprising a hollow cylinder having opposite ends, a piston reciprocally received by said cylinder, two head blocks mounted on and closing the opposite ends respectively of said cylinder, a piston rod disposed coaxially of said hollow cylinder secured at one end to said piston and reciprocally projecting through one of said head blocks, said head blocks each having two surfaces which are spaced apart in a direction axially of said cylinder thereby providing thickness dimensions for

said blocks, said blocks having sides, piston rod-bearing means which includes an axially extending bearing aperture through said one block, said bearing aperture coaxially receiving said piston rod, each said block having first and second bores extending inwardly from two opposite sides respectively, a third bore in each block having inner and outer opposite ends, the outer end of said third bore opening through a side of the block and the inner end being closed within said block thereby providing a blind port, said blind port at its inner end communicating with the innermost ends of said first and second bores, each said first and second bores being divided into two different diameter lengths with the innermost length being the smaller, each said first and second bores having a valve seat provided at the joinder of the two different diameter lengths, the outermost ends of the larger diameter lengths being threaded, one of said first and second bores receiving a ball valve engageable with the respective valve seat, a closure nut threaded into the outer end of said first bore, a spring interposed between said ball valve and said nut for urging said ball valve into sealng engagement with its valve seat, a retaining nut threaded into the outer end of the other of said first and second bores, a needle valve

threadedly received by an opening in said retaining nut, said needle valve having a valve tip on its inner end which cooperatively engages the respective valve seat, said blind ports in said blocks extending in a direction normal to the axis of said cylinder, the blind port in said one block extending inwardly toward said bearing aperture but terminating short thereof, and two passages in each head block, one passage being connected between said first bore and the interior of said cylinder, the other passage being connected between said second bore and the interior of said cylinder, said valve seats of each block being disposed between said blind port and the respective passages.

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