United States Patent [19]

Kondo

[11] **3,929,057**

[45] **Dec. 30, 1975**

[54] **HYDRAULIC BRAKE MECHANISM FOR AN AIR CYLINDER**

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[22] Filed: **Dec. 26, 1973**

[21] Appl. No.: **427,847**

[30] **Foreign Application Priority Data**

Sept. 18, 1973 Japan 48-105140
Apr. 14, 1973 Japan 48-42427

[52] **U.S. Cl.** **92/9**; 92/10; 92/12; 92/143; 188/300; 188/318

[51] **Int. Cl.**² **F15B 15/2**

[58] **Field of Search** .... 92/8, 9, 10, 11, 12, 143; 188/300 X, 318 X

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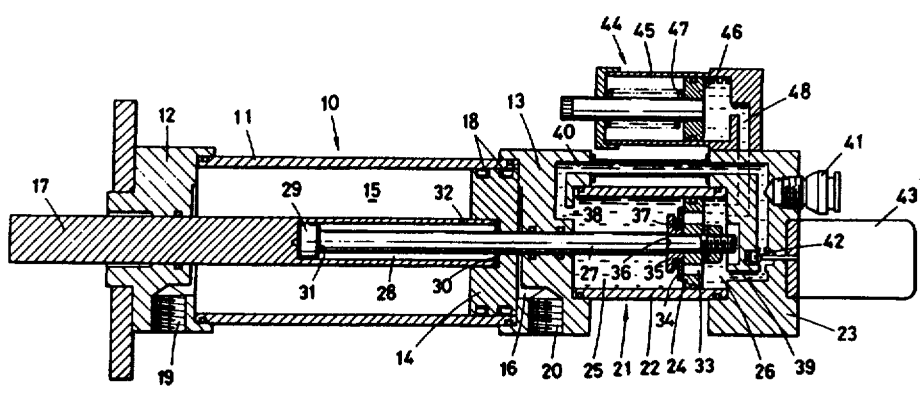
[57] **ABSTRACT**

For retarding the motion of a piston traveling on its forward stroke in an air cylinder, a hydraulic cylinder having shorter piston stroke than that of the air cylinder is mounted on its rear side in axial alignment therewith. The piston rod of the hydraulic cylinder projects into the air cylinder to be telescopically received in an axial bore formed through the rear end portion of the air cylinder piston rod. Hence, as the air cylinder piston travels forwardly in the usual manner to a predetermined point intermediate both extremities of its stroke, a larger diameter portion on the front end of the hydraulic cylinder piston rod engages the air cylinder piston at the rear end of the aforesaid axial bore. The forward motion of the air cylinder piston is thereafter retarded by the hydraulic cylinder piston also traveling forwardly against the resistance offered by hydraulic fluid in the intercommunicated chambers of the hydraulic cylinder. The passageway intercommunicating the hydraulic fluid chambers can be closed by a solenoid-operated shut-off valve whereby the air cylinder piston traveling forwardly at reduced speed as above can be stopped whenever required.

4 Claims, 2 Drawing Figures



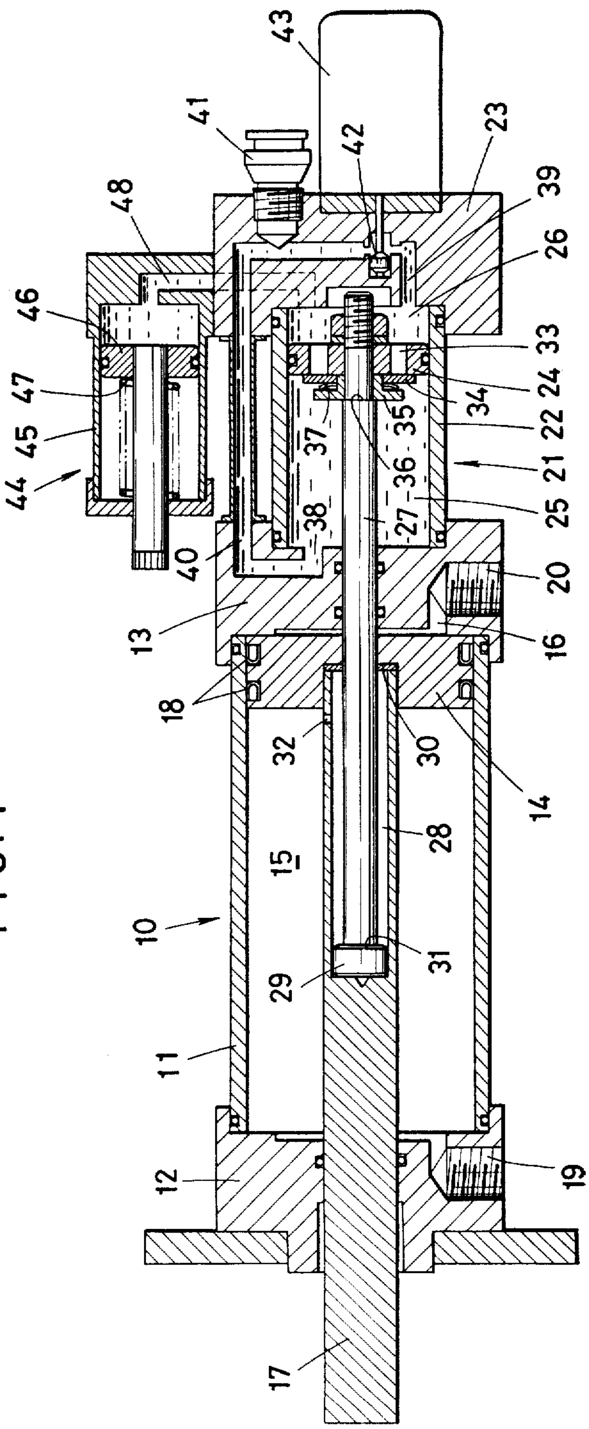

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FIG. 1

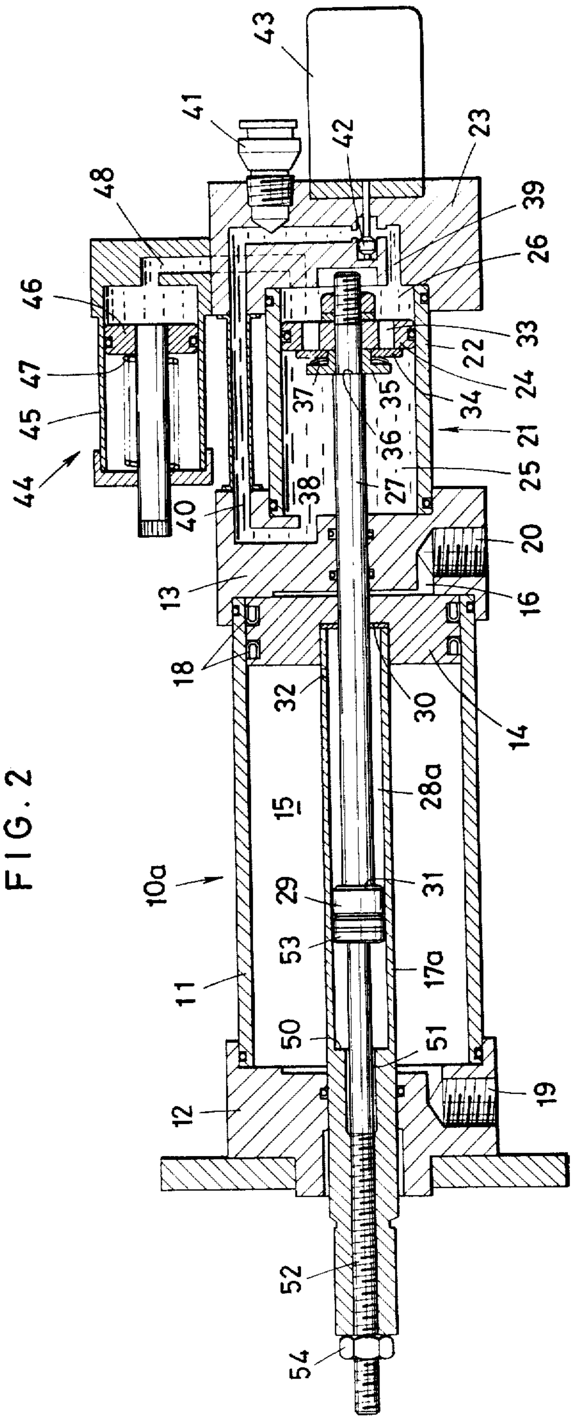
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FIG. 2

HYDRAULIC BRAKE MECHANISM FOR AN AIR CYLINDER

BACKGROUND OF THE INVENTION

This invention relates to an apparatus for hydraulically controlling the speed of a piston in an air cylinder.

PRIOR ART

As is well known, the air cylinder of prior art construction is used extensively as a feed mechanism in some machine tools or other classes of manufacturing equipment. It is often desired, however, that a cutting tool or the like be fed toward the work, or vice versa, at relatively high speed and then at appropriately reduced speed as the tool starts actually machining the work. To this end the air cylinder has been used in combination with a hydraulic cylinder of equal piston stroke either in serial or tandem arrangement.

It will be apparent that such prior art arrangement results in large space requirement and high manufacturing costs as the hydraulic cylinder is required to have as long piston stroke as the air cylinder. As a further disadvantage, the hydraulic circuit of the prior art arrangement must be equipped with highly involved valving to effect the desired change in the feed speed of the cutting tool or the like.

SUMMARY OF THE INVENTION

In view of the noted deficiencies of the prior art, it is an object of this invention to provide a novel and advanced apparatus for controlling the speed of a piston in an air cylinder, in such a manner that the forward motion of the piston becomes retarded at a predetermined point intermediate both extremities of its stroke.

Another object of the invention is to provide an apparatus of the above described character, wherein a hydraulic cylinder of considerably shorter piston stroke than that of the air cylinder is coupled directly thereto in serial arrangement, with the front end portion of the hydraulic cylinder piston rod telescopically received in an axial bore formed through the rear end portion of the air cylinder piston rod, so that the overall system is rendered highly compact in size and inexpensive in construction.

A further object of the invention is to provide an apparatus of the character described, including a regulating valve whereby the degree of reduction in the speed of the air cylinder piston is regulatable as desired.

A further object of the invention is to provide an apparatus of the character described, including a shut-off valve typically operated by a solenoid to arrest the motion of the air cylinder piston as it travels forwardly at reduced speed.

A still further object of the invention is to provide an apparatus of the character described, wherein the depth or axial length of the axial bore formed through the rear end portion of the air cylinder piston rod is variable to adjustably change the distances the air cylinder piston is driven at high and reduced speeds, respectively, on its forward stroke.

In order to control the speed of a piston in an air cylinder assembly of well known construction in accordance with the concepts of this invention, there is employed a hydraulic cylinder assembly of shorter piston stroke than that of the air cylinder assembly. The hydraulic cylinder assembly comprises a sleeve or cylin-

der fixedly supported on the rear side of that of the air cylinder assembly in coaxial relationship thereto, a piston slidably mounted within the cylinder to pressure-tightly divide its interior into front and rear hydraulic fluid chambers which are intercommunicated through a passageway, and a piston rod securely coupled at its rear end to the piston and slidably extending into the air cylinder assembly to have its front end portion telescopically received in an axial bore formed through the rear end portion of the air cylinder pistion rod. The hydraulic cylinder piston rod carries a flange or larger diameter portion on its front end which is adapted to engage the air cylinder piston at the rear end of the said axial bore.

Hence, as the air cylinder piston travels forwardly in the usual manner to a predetermined point intermediate both extremities of its stroke, its motion becomes retarded by the hydraulic cylinder piston as the latter is then caused to start traveling forwardly in step with the air cylinder piston against the resistance offered by hydraulic fluid flowing from the front to the rear hydraulic fluid chamber through the passageway. Typically, this passageway is equipped with a regulating valve adapted to regulate the rate of flow of the hydraulic fluid therethrough and hence to adjust the degree of reduction in the speed of the air cylinder piston. The passageway can be further equipped with a shut-off valve capable of completely closing the same to arrest the forward motion of the air cylinder piston. Thus, if the passageway is alternately opened and closed by the shut-off valve during the forward stroke of the hydraulic cylinder piston, the air cylinder piston can be caused to travel forwardly at reduced speed in an intermittent manner. Such intermittent piston motion is highly useful in some machining operations.

The features which are believed to be novel and characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its configuration and mode of operation, together with the further objects and advantages thereof, will be best understood from the following description taken in conjunction with the accompanying drawings which illustrate, by way of example only, some preferred embodiments of the invention and in both of which like reference characters denote like parts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal or axial sectional view of an arrangement formed in accordance with the principles of this invention; and

FIG. 2 is a similar view showing another preferred embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIG. 1, the reference numeral **10** generally designates an air cylinder assembly the piston speed of which is to be controlled in accordance with the inventive concepts. The air cylinder assembly **10** includes a sleeve or cylinder **11** pressure-tightly closed at its left hand end, as seen in the drawing, by a front end cap **12** and at its right hand end by a rear end cap **13**. A piston **14** is slidably but pressure-tightly mounted within the cylinder **11** thereby dividing its interior into a pair of opposed air chambers **15** and **16**, and a piston rod **17** securely coupled at its right hand end to the piston **14** slidably but pressure-tightly extends through the front end cap 12 in axial alignment with the cylinder 11.

A pair of U-type sealing rings 18 are fitted in an opposed manner in annular recesses formed in spaced parallel relationship on the circumference of the piston 14. Air inlet/outlet ports 19 and 20 are formed through the front and rear end caps 12 and 13, respectively, to communicate the respective air chambers 15 and 16 with a source of compressed air, not shown, through pressure conduits having suitable valving such that air under pressure will be introduced alternately into the two opposed air chambers in the operation of this air cylinder. It is to be noted, however, that the construction of the air cylinder assembly 10 as so far described is well known and, by itself, does not constitute a part of this invention.

In order to control the speed of the piston 14 of this air cylinder assembly 10 in the manner previously set forth, a hydraulic cylinder assembly generally designated by the numeral 21 is mounted in serial realtionship to the air cylinder assembly. The hydraulic cylinder assembly 21 also includes a sleeve or cylinder 22 pressure-tightly closed at its front or left hand end by the rear end cap 13 of the first mentioned cylinder 11 and at its rear or right hand end by its own rear end cap 23. A piston 24 is slidably but pressure-tightly mounted within the cylinder 22 to divide its interior into a pair of opposed hydraulic fluid chambers 25 and 26. It will be noted from the drawing that the stroke of this piston 24 within the cylinder 22 is considerably shorter than the piston stroke within the cylinder 11.

A piston rod 27 securely coupled at its rear or right hand end to the hydraulic cylinder piston 24 slidably but pressure-tightly extends through the end cap 13 and further through the air cylinder piston 14 to have its front or left hand end portion telescopically received in an axial bore 28 of the air cylinder piston rod 17. This axial bore 28 has a diameter sufficient to slidably accommodate a flange or larger diameter portion 29 formed on the left hand end of the hydraulic cylinder piston rod 27 and extends from the right hand end of the air cylinder piston rod 17 to a prescribed point intermediate both ends thereof. The right hand extremity of the axial bore 28 is closed by the air cylinder piston 14, and a shock absorber such for example as a sheet of suitably elastic material is provided at 30 to minimize the impact energy that may be produced as the larger diameter portion 29 on the hydraulic cylinder piston rod 27 engages the air cylinder piston 14 by its shoulder 31. Preferably, an air vent should be formed as at 32, and a groove or aperture should be formed longitudinally on or through the larger diameter portion 29 of the hydraulic cylinder piston rod 27, in order to assure its smooth sliding motion within the axial bore 28 of the air cylinder piston rod 17.

A plurality of bores 33 are formed eccentrically through the hydraulic cylinder piston 24 substantially in annular arrangement, and these bores 33 are normally closed by a flap 34 of annular shape on the side of the left hand hydraulic fluid chamber 25. The flap 34 is somewhat loosely fitted over a flanged sleeve 35 fixedly supported on the hydraulic cylinder piston rod 27 between its shoulder 36 and the hydraulic cylinder piston 24 and is yieldably urged toward the bores 33 by spring means 37 supported by the flanged sleeve 35. The flap 34 in combination with the spring means 37 is adapted to perform the function of a check valve, permitting the flow of hydraulic fluid such as oil through

the bores 33 only from the right to the left hand hydraulic fluid chamber during the rightward or return stroke of the hydraulic cylinder piston 24.

The left and right hand hydraulic fluid chambers 25 and 26 have hydraulic fluid inlet/outlet ports 38 and 39 formed in the end caps 13 and 23, respectively, and these ports 38 and 39 are intercommunicated through a passageway 40 which is equipped with a regulating valve 41 of the type operated manually to regulate the flow rate of the hydraulic fluid therethrough and with a shut-off valve 42 of the type operated by a solenoid mechanism 43 of well known construction to completely close the passageway 40 as required, as hereinafter set forth in more detail.

The reference numeral 44 generally indicates a compensating mechanism adapted to compensate for the undersupply of hydraulic fluid which will take place in the right hand hydraulic fluid chamber 26 as the hydraulic cylinder piston 24 moves on its leftward or forward stroke, due largely to the presence of the hydraulic cylinder piston rod 27 in the left hand hydraulic fluid chamber 25. The compensating mechanism 44 includes a cylinder 45 closed at both ends thereof, and a piston 46 slidably mounted therein. The right hand one of the two opposed chambers defined within the cylinder 45 by the piston 46 is pressure tight. The piston 46 is yieldably urged, as by a helical compression spring 47, toward that one pressure-tight chamber of the cylinder 45 to constantly force hydraulic fluid into the right hand hydraulic fluid chamber 26 of the hydraulic cylinder assembly 21 through a passageway 48 at a prescribed pressure. The right hand hydraulic fluid chamber 26 can thus be held filled with hydraulic fluid regardless of the position of the hydraulic cylinder piston 24 within the cylinder 22.

In the operation of this first preferred embodiment of the invention, it is assumed that air under pressure is first delivered into the right hand air chamber 16 of the air cylinder assembly 10 through the air inlet/outlet port 20, thereby causing the air cylinder piston 14 to travel toward the front end cap 12 at relatively high speed while the air which has been trapped within the left hand air chamber 15 is caused to escape through the other air inlet/outlet port 19. Forward thrust is thus imparted to the air cylinder piston rod 17. However, as the air cylinder piston 14 reaches the prescribed point within the cylinder 11 at which the air cylinder piston 14 closing the right hand extremity of the axial bore 28 becomes engaged by the shoulder 31 on the hydraulic cylinder piston rod 27 through the shock absorber 30, the hydraulic cylinder piston 24 becomes operative to retard the forward motion of the air cylinder piston 14 and hence of the air cylinder piston rod 17.

Thereafter, as the air under pressure is further introduced into the right hand air chamber 16, the air cylinder piston 14 continues traveling to the left on its forward stroke at reduced speed since now its motion is retarded by the hydraulic cylinder piston 24 traveling in the same direction against the resistance offered by the hydraulic fluid within the left hand hydraulic fluid chamber 25. During this forward stroke of the hydraulic cylinder piston 24, its bores 33 are held closed by the aforesaid check valve means comprising the flap 34 and the spring means 37, so that the hydraulic fluid within the left hand hydraulic fluid chamber 25 is forced out into the hydraulic fluid inlet/outlet port 38 and flows into the right hand hydraulic fluid chamber 26 through the passageway 40 at a rate determined by the regulating valve **41**.

If the solenoid mechanism **43** is energized while the air cylinder piston **14** is thus traveling on its forward stroke at reduced speed, its plunger retracts to cause the shut-off valve **42** to completely close the passageway **40** intercommunicating the hydraulic fluid chambers **25** and **26**. The forward motion of the hydraulic cylinder piston **24** is then arrested, and the air cylinder piston **14** is also caused to stop rapidly through the hydraulic cylinder piston rod **27**. As the solenoid mechanism **43** is succeedingly de-energized, the shut-off valve **42** reopens the passageway **40** thereby permitting the flow of the hydraulic fluid from the left hand chamber **25** to the right hand chamber **26**, so that the air cylinder piston **14** resumes traveling on its forward stroke at reduced speed. Thus, by alternately energizing and de-energizing the solenoid mechanism **43** while the hydraulic cylinder piston **24** is traveling on its forward stroke, the air cylinder piston **14** can be caused to travel forwardly at reduced speed in an intermittent manner.

Upon completion of the forward stroke of the air cylinder piston **14**, air under pressure is to be introduced into the left hand air chamber **15** through the air inlet/outlet port **19**. The air cylinder piston **14** starts traveling to the right on its return stroke at relatively high speed causing the air within the right hand air chamber **16** to escape through the air inlet/outlet port **20**. As the left hand extremity of the axial bore **28** in the air cylinder piston rod **17** comes into contact with the larger diameter portion **29** on the left hand end of the hydraulic cylinder piston rod **27**, the hydraulic cylinder piston **24** also is caused to start traveling to the right on its return stroke through the hydraulic cylinder piston rod **27**. Since then the hydraulic fluid within the right hand hydraulic fluid chamber **26** is permitted to flow into the left hand hydraulic fluid chamber **25** through the bores **33** as aforesaid, the hydraulic cylinder piston **24** is capable of traveling back to the position of FIG. **1** without any substantial resistance. Thus the air cylinder piston **14** is allowed to complete its return stroke with hardly any appreciable reduction in speed.

Illustrated in FIG. **2** is another preferred embodiment of the invention, in which the working length of the axial bore **28** formed in the air cylinder piston rod **17** is made adjustable to change the position in which the speed of the air cylinder piston **14** traveling on its forward stroke is reduced from high to low level. In the succeeding description of this second embodiment of the invention, parts corresponding to those of the preceding embodiment are indicated by like reference characters and are not explained in any detail.

As seen in FIG. **2**, an axial bore **28*a*** extending from the right hand end of a piston rod **17*a*** of an air cylinder assembly **10*a*** toward the left may have a length appropriately greater than that of the axial bore **28** in the FIG. **1** embodiment. The left hand extremity of the axial bore **28*a*** is defined by a step **50** and is open to a second axial bore **51** of reduced diameter extending to the left hand end of the air cylinder piston rod **17*a***. The second axial bore **51** is adapted to screw-threadedly receive an adjusting rod **52** having a flange or larger diameter portion **53** on its right hand end which is slidably received in the first mentioned axial bore **28*a***. A nut **54** is fitted over the externally screw-threaded left hand end portion of the adjusting rod **52** projecting out of the second axial bore **51**. Other details of construction are as set forth previously with reference to FIG. **1**.

The operation of this second embodiment also substantially follows suit after that of the FIG. **1** embodiment. However, by turning the adjusting rod **52** relative to the air cylinder piston rod **17*a*** after loosening the nut **54**, the working length of the first axial bore **28*a*** can be varied as desired. Generally, the farther the larger diameter portion **53** of the adjusting rod **52** is located away from the right hand extremity of the first axial bore **28*a***, the greater is the distance the air cylinder piston **14** is fed at relatively high speed on its forward stroke, and the smaller is the distance the air cylinder piston is fed at reduced speed. Conversely, the closer the larger diameter portion **53** of the adjusting rod **52** is located to the right hand extremity of the first axial bore **28*a***, the smaller is the distance the air cylinder piston **14** is fed at relatively high speed on its forward stroke, and the greater is the distance the air cylinder piston is fed at reduced speed.

It is believed that the preferred embodiments shown and described herein are well calculated to accomplish the objects previously set forth. However, the general design or individual parts of the invention as explained above may be varied according to requirements in regards to manufacture and production therof, while still remaining within the spirit and scope of the invention as sought to be defined by the appended claims.

What is claimed is:

1. A feed mechanism for a machine tool comprising in combination:

a. a double-acting pneumatic cylinder assembly having a first piston and a piston rod having its inner end secured to and terminating within said piston, said rod having an axially hollow portion and an outer end for being connected to a load, said rod being subjected to compressional axial forces as it is extended during its working stroke and to tension during retraction thereof, there being means communicating the interior of said rod with that side of said first piston which is the low pressure side during the working stroke and the high pressure side during retraction;

b. a double-acting hydraulic cylinder assembly connected concentrically with said pneumatic cylinder assembly, and having a second piston, of smaller diameter and lesser stroke than said first piston, and a second piston rod having one end rigidly secured to said second piston, said second piston rod having a portion at all times projecting through and slidably guided by said first piston into said hollow portion of said piston rod;

c. the other end of said second piston rod having a flange engaging the low-pressure side of said first piston during the working stroke to tension said second piston rod for thereby pressurizing the side of said second piston which is closer to said first piston, said flange being engaged by an abutment in said axially hollow piston rod during the return stroke;

d. impact absorbing means for acting between said flange of said second piston rod and said first piston;

e. a throttling passageway interconnecting the opposite sides of said second piston during a working stroke, there being a power-actuated shut-off valve in said throttling passageway for hydraulically arresting the second portion during the working stroke;

f. a separate second hydraulic cylinder assembly including a third piston of the single-acting spring-return type and fluidly connected to the end of the first-named hydraulic cylinder which is more remote from said first piston and disposed in radially spaced relation to said first hydraulic cylinder assembly; and

g. a check valve directed to freely interconnect the opposite sides of said second piston during a return stroke.

2. A feed mechanism according to claim 1, said check valve comprising: a plurality of bores in said second piston, an annular washer of resilient material disposed against said second piston at its bores, spring means normally biasing said resilient washer in a direction away from said pneumatic cylinder assembly toward said second piston, and a flanged sleeve secured to said second piston rod against the flange of which said spring means reacts, said sleeve centering said washer and said spring means.

3. A feed mechanism according to claim 1 in which the inner end of said hollow piston rod is closed by an annular portion of said first piston through which said second rod projects.

4. A feed mechanism according to claim 1 including adjustable means in said axially hollow portion of said piston rod for positioning said abutment which initiates the return stroke of said second piston and opening of said check valve.

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