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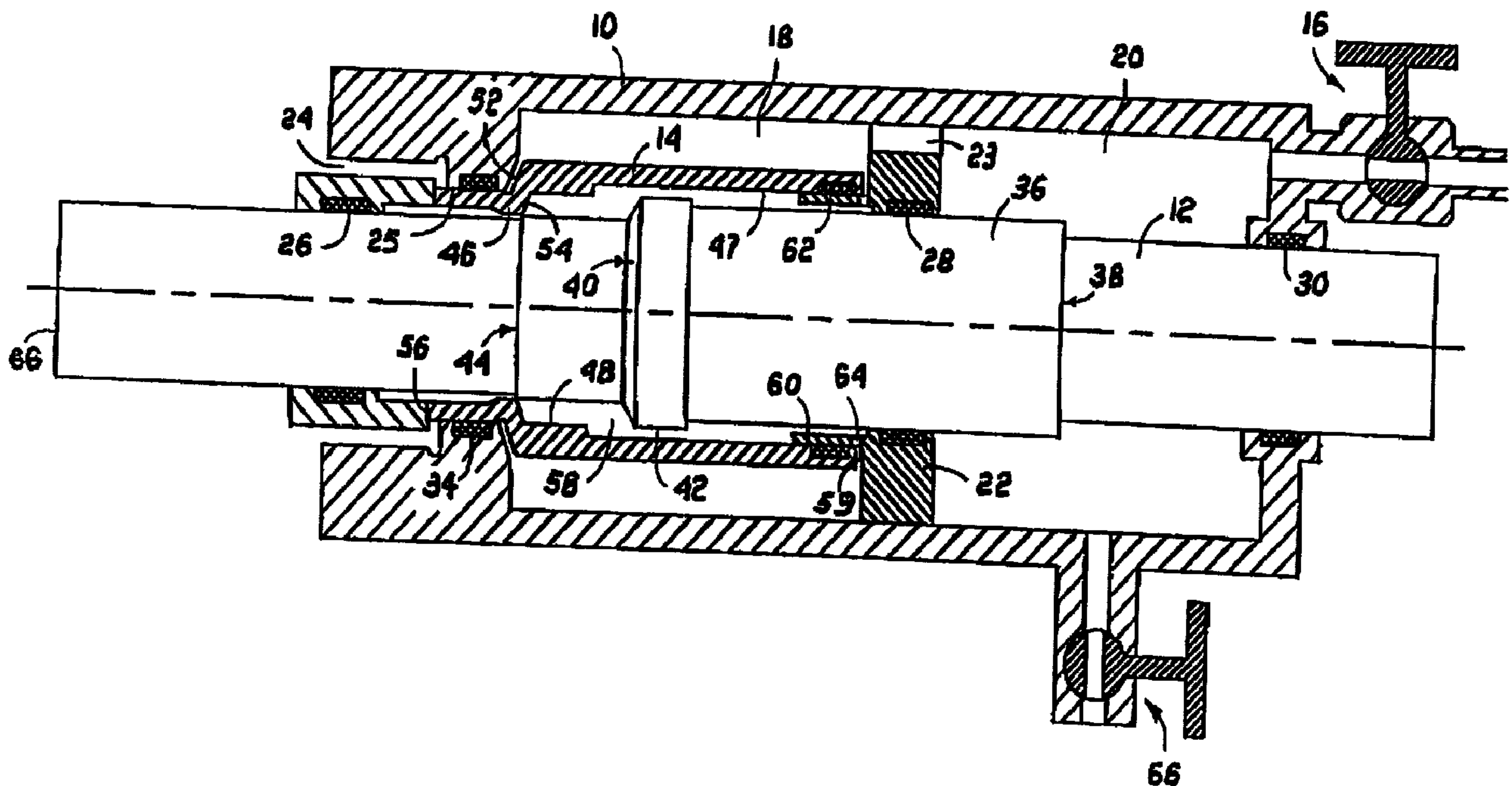
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(57) Abrégé/Abstract:

A hydraulic actuator has a housing including a drive chamber with a fluid inlet, with a piston extending from and reciprocating in the housing. A reciprocal sleeve within the drive chamber, clear of the drive chamber and piston walls, surrounds the piston to define a return chamber having an exhaust valve and inlet valve. The piston and sleeve interact to generate pressure changes in the return chamber during piston movement in the first direction, moving the sleeve to open the inlet valve and close the exhaust valve, thereby decelerating and then accelerating the piston in the second direction. Formations on the piston and the housing, downstream of the inlet valve, interact to generate pressure changes in the return chamber during piston movement in the second direction, moving the sleeve to close the inlet valve and open the exhaust valve, thereby decelerating and then accelerating the piston in the first direction.

ABSTRACT

A hydraulic actuator has a housing including a drive chamber with a fluid inlet, with a piston extending from and reciprocating in the housing. A reciprocal sleeve within the drive chamber, clear of the drive chamber and piston walls, surrounds the piston to define a return chamber having an exhaust valve and inlet valve. The piston and sleeve interact to generate pressure changes in the return chamber during piston movement in the first direction, moving the sleeve to open the inlet valve and close the exhaust valve, thereby decelerating and then accelerating the piston in the second direction. Formations on the piston and the housing, downstream of the inlet valve, interact to generate pressure changes in the return chamber during piston movement in the second direction, moving the sleeve to close the inlet valve and open the exhaust valve, thereby decelerating and then accelerating the piston in the first direction.

HYDRAULIC ACTUATOR

FIELD OF THE INVENTION

This invention relates to cyclic hydraulic actuators and more particularly to cyclic actuators such as those used in rock drills and other mining machinery.

5 SUMMARY OF THE INVENTION

A hydraulic actuator according to the invention includes a housing, a drive chamber in the housing, a hydraulic supply fluid inlet into the drive chamber, an elongated piston which extends from and is reciprocal in the housing, with the piston including a first diametrical step to provide a piston drive area on the
10 piston in the drive chamber, a reciprocal sleeve within the drive chamber clear of the drive chamber inner wall and which surrounds, is spaced from and extends over a length of the piston to define between its inner surface, the outer surface of the piston and first and second opposed surfaces in the housing, a piston return chamber, a second diametrical step in the piston in the return chamber to
15 provide a piston return area, the first surface of the opposed surfaces in the housing defining with a first end surface of the sleeve a fluid exhaust valve which on reciprocation of the sleeve opens and closes the return chamber to an exhaust port from the housing, a blind bore in a wall of the drive chamber in which a portion of the first end portion of the sleeve is sealingly reciprocal to seal
20 the exhaust valve in the bore from the drive chamber, the second of the opposed

surfaces in the housing defining with the second end surface of the sleeve a fluid inlet valve to the return chamber which on reciprocation of the sleeve opens and closes the return chamber to and from the drive chamber, formations on the piston and sleeve which interact during the reciprocation of the piston to generate

5 hydraulic fluid pressure changes in the return chamber which will, during travel of the piston in a first direction towards the exhaust valve, cause the sleeve to move to open the return chamber inlet valve and close the exhaust valve to result in deceleration and then acceleration of the piston in its opposite second direction towards the inlet valve, formations on the piston and the housing downstream of

10 the return chamber inlet valve which interact to generate hydraulic fluid pressure changes in the return chamber which, during travel of the piston in its second direction, cause the sleeve to be moved to close the inlet valve open the exhaust valve to result in the deceleration and then acceleration of the piston in its first direction.

15 The return chamber sleeve preferably is cylindrical with a portion of its length from its first end downwardly stepped from a first diameter in the drive chamber to a second smaller diameter which is partially located in the blind bore in the housing wall with the step in the sleeve being located in the drive chamber to

20 provide a hydraulically exposed return area for the sleeve in the drive chamber which is permanently exposed to fluid at supply pressure in use.

Preferably, the actuator includes a sleeve guide formation which surrounds the piston and projects from the second of the opposed housing surfaces into the return chamber and on which a second end portion of the sleeve is sealingly reciprocal to open and close the inlet valve to the return chamber,

- 5 The reduced diameter portion of the piston on the return area side of the piston may again be stepped, at a position spaced from the second diametrical step, from a first diameter to a further reduced second diameter portion which is sealingly reciprocal through the actuator housing wall with the reduced diameter second end portion of the sleeve including an inner rib which is spaced from the
- 10 first end of the sleeve with the radially inner surface of the rib having a diameter just greater than the outer diameter of the piston first diameter.

The inner surface of the larger diameter portion of the wall of the sleeve may be recessed radially outwardly from a position spaced from the step in the sleeve, to a larger diameter which extends over the remainder of its length, with an

15 intermediate zone of the piston between its drive and return areas in the return chamber including an outwardly stepped portion having a diameter just less than the non-recessed portion of the sleeve wall inner surface.

In a preferred form of the invention the drive chamber in the actuator body is divided into first and second chamber sections by a partition wall which includes

20 at least one aperture through which the chamber sections are continually open to each other with the first drive chamber section housing the portion of the piston

which includes its drive area; the second chamber section housing the larger diameter portion of the sleeve which projects from the blind bore in the drive chamber wall and, on the partition wall, the second of the two opposed housing surfaces and the sleeve guide formation.

- 5 The sleeve guide formation is conveniently a guide sleeve having an internal diameter just greater than the outwardly stepped portion of the piston and which projects from the partition wall to be in sliding engagement with the recessed inner surface of the second end portion of the reciprocal sleeve with the guide sleeve including a fluid inlet port which passes through its wall at or adjacent the
- 10 second opposed housing surface on the partition wall for hydraulically connecting the return chamber to the second drive chamber section as the reciprocal sleeve opens the return chamber inlet valve, in use.

The actuator may include a start/stop valve arrangement which is located in the hydraulic fluid supply inlet to the first drive chamber section.

- 15 In this specification the term "hydraulic fluid" is intended to include water, oil and emulsions of water and oil.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now described by way of example only with reference to the drawings in which:

FIGURE 1 is a diagrammatic sectioned side elevation of an embodiment of the actuator of the invention as used in a rock drill, and

FIGURE 2 is an enlarged fragmentary view of the return chamber inlet valve arrangement of the Figure 1 actuator.

5 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The drill actuator of the invention is shown in Figure 1 to include a housing 10, a piston 12, a sleeve 14 and a start/stop valve 16.

The actuator housing includes a composite piston drive chamber which is composed of two drive chamber sections 18 and 20 which are separated from each other by a divider wall 22 through which at least one open fluid passage 23 passes. The start/stop valve 16 is connected to a hydraulic fluid inlet which is open into the drive chamber section 20. The forward end wall of the drive chamber 18 is recessed to provide a blind bore 25 from which a plurality of exhaust ports 24 lead to the outside of the housing. The body additionally includes three seal bearings 26, 28 and 30 which support the piston 12 and in which the piston is sealingly reciprocal. A further seal bearing 34 is located in the bore 25 and sealingly supports the sleeve 14 for reciprocal movement.

The piston 12 is downwardly stepped on either side of a central zone 36 to provide a hydraulically exposed piston drive area 38 in the drive chamber section

20 and a piston return area which is a combination of a portion of piston area 40 and a further stepped area 44. The piston further includes an outwardly stepped portion 42. The net return area of the piston is larger than the piston drive area.

5 The sleeve 14 is in the form of a stepped cylindrical sleeve with its forward smaller diameter portion located in the bore 25 for reciprocatory movement on the seal bearing 34. The step in the sleeve extends beyond the inner surface of the small diameter portion of the sleeve to provide an inner rib 46 in the sleeve cavity. The inner surface of the rib is just larger in diameter than the diameter of the piston portion between the piston steps 42 and 44. (The term "just" in this
10 specification is to be taken to mean a separation distance between components which is optimally less than 0,15mm).

The rear portion of the inner surface 47 of the large diameter portion of the sleeve is recessed from a position rearward of the sleeve step, as shown in the drawing, to provide a fluid flow restrictor surface 48 in the forward portion of the
15 sleeve cavity. The diameter of the restrictor surface 48 is just greater than the outer diameter of the piston step 42. The step in the sleeve wall provides, on the outside of the sleeve, a hydraulically exposed return area 52 which is, during operation of the actuator, continually exposed to fluid under pressure in the drive chamber section 18. The net return area of the sleeve is the diametrical
20 difference between the inner sleeve surface 47 and the outer diameter of the reduced diameter forward portion of the sleeve. The annular surface at the front

end of the sleeve seats on a valve seat 56, which is a transverse surface portion of the end wall of the bore 25, with the two surfaces defining an exhaust valve for the actuator.

The space between the inner surface of the larger diameter portion of the sleeve 14 and the outer surface of the piston defines a piston return chamber 58. The rear annular surface of the sleeve defines with a seat 59 on the partition wall 22 an inlet valve to the return chamber 58.

The divider wall 22 carries a guide formation which, in this embodiment of the invention, is a short circular sleeve 60 which is made integral with the wall 22. The inner surface of the guide sleeve 60 is spaced from the piston zone 36 by a distance to be just clear of the piston step 42 on the return stroke of the piston. The inner surface 47 of the sleeve 14, adjacent its free end, carries a seal bearing 62 which is slidably engaged with the outer surface of the guide sleeve 60 to hold the sleeve centralised about the piston. The sleeve 60 carries a plurality of circumferentially spaced fluid inlet ports 64 which pass through it at the inlet valve seat 59, as is more clearly seen in Figure 2.

The start/stop valve 16 is, in this embodiment of the invention, a ball valve which is operable between a first position, which is shown in the drawing, to open the composite drive chamber to hydraulic fluid under pressure and a second transverse position in which the drive chamber sections are closed to fluid at supply pressure.

The actuator additionally includes a vent valve 66 for venting fluid at supply pressure from the drive chamber section 20 for starting as will be explained below.

5 The actuator, in a typical application might include a conventional pressurised gas accumulator, not shown in the drawing, which ensures that the hydraulic fluid supply pressure in the machine remains constant within acceptable limits.

Prior to use, the valve 16 is closed, and the vent valve 66 is opened to drop any fluid pressure in both the drive chamber sections 18 and 20 and the return chamber 58. In use the valve 66 is closed and the valve 16 is connected to a
10 hydraulic hose through which the drive chamber sections 18 and 20 are, on opening of the valve 16, charged with hydraulic fluid at supply pressure. Pressure fluid in the drive chamber 20 acting on the piston drive area 38 drives the piston to the left in the drawing with substantially the return area 40 of the piston driving hydraulic fluid in the return chamber 58 through the open exhaust ports 24 until
15 the return area 40 on the piston engages the step area 54 on the inner surface of the sleeve to entrain the sleeve to the left in the drawing until its leading edge abuts the seat 56 to close the exhaust valve leading to the exhaust port 24.

The fluid enters the return chamber 58 through the inlet valve and the open inlet ports 64 to the return chamber. The fluid pressure acting on the sleeve drive area
20 54 hydraulically locks the sleeve to the exhaust seat 56 and the hydraulic pressures acting on the piston drive and return areas 38, 40 and 44 returns the

piston to the right in the drawing. As the piston moves to the right and its outwardly stepped portion 42 enters the guide sleeve 60 the fluid pressure in the return chamber 58 drops and the force acting on the net return area of the sleeve 14 breaks the hydraulic lock of the sleeve 14 on the exhaust valve seat 56 to
5 force the sleeve rearwardly until the rear edge of the sleeve closes the inlet valve 59 on the divider wall 22. The return chamber 58 is vented to atmosphere through the exhaust ports 24 to cause the pressure acting on the sleeve 14 return area hydraulically to lock the sleeve onto its inlet seat 59 to prevent fluid flow from the drive chamber section 18 into the return chamber 58. With the fluid
10 pressure in the return chamber dropped the high fluid pressure acting on the piston drive area 38 in the drive chamber section 20, stops and reverses the direction of piston travel into its drive stroke. It is to be noted that the outwardly directed step 42 on the piston 12 enters and leaves the underside of the guide sleeve 60 downstream of the return chamber inlet valve. This causes the drive
15 chamber fluid at supply pressure to be isolated from the interaction space between the underside of the guide sleeve 60 and the piston step 42 while the piston is driven into its drive stroke thereby minimising cavitation.

As the piston commences its drive stroke the rapid acceleration of the piston to
20 the left in the drawing causes the piston return areas 40 and 44 to expel hydraulic fluid in the return chamber 58 from the open exhaust ports 24 until the outward step 44 on the piston reaches the restriction surface on the rib 46 in the

sleeve to restrict exhaust fluid flow from the machine and to cause a fluid pressure build up in the return chamber 58 ahead of the piston return area 40. The pressure build up acting on the sleeve drive area 54 breaks the hydraulic lock between the sleeve and its inlet valve seat 59 and the net fluid force now
5 acting on the sleeve drives the sleeve onto its exhaust valve seat 56. The high speed piston is now decelerated by fluid force acting on its return areas 40 and 44 until the free end 66 of the piston strikes the drill steel or until the hydraulic cushion formed between the drive area 54 of the sleeve and the return area 40 of the piston, by the hydraulic interaction of the flow restrictor surface 48 with the
10 step 42 on the piston, rapidly decelerates the piston.

While the invention has been described with reference to a specific embodiment it is to be appreciated that modifications and variations of the invention are possible without departing from the scope of the invention which is defined in the following claims.

CLAIMS

1. A hydraulic actuator including:

a housing;

a drive chamber in the housing;

a hydraulic supply fluid inlet into the drive chamber;

an elongated piston which extends from and is reciprocal in the housing, with the piston including a first diametrical step to provide a piston drive area on the piston in the drive chamber;

a reciprocal sleeve within the drive chamber clear of the drive chamber inner wall and which surrounds the piston, is spaced from the piston and extends over a length of the piston to define between its inner surface, the outer surface of the piston and first and second opposed surfaces in the housing, a piston return chamber;

a second diametrical step in the piston in the return chamber to provide a piston return area;

the first surface of the opposed surfaces in the housing defining with a first end surface of the reciprocal sleeve a fluid exhaust valve which on reciprocation of the sleeve opens and closes the return chamber to an exhaust port from the housing;

a blind bore in a wall of the drive chamber in which a portion of the first end portion of the sleeve is sealingly reciprocal to seal the exhaust valve in the bore from the drive chamber;

the second of the opposed surfaces in the housing defining with the second end surface of the sleeve a fluid inlet valve to the return chamber which on reciprocation of the sleeve opens and closes the return chamber to and from the drive chamber;

a guide formation which surrounds the piston and projects from the second of the opposed housing surfaces into the return chamber and on which a second end portion of the reciprocal sleeve is sealingly reciprocal to open and close the inlet valve to the return chamber;

formations on the piston and sleeve which interact during the reciprocation of the piston to generate hydraulic fluid pressure changes in the return chamber which will, during travel of the piston in a first direction towards the exhaust valve, cause the sleeve to move to open the return chamber inlet valve and close the exhaust valve to result in deceleration and then acceleration of the piston in its opposite second direction towards the inlet valve;

formations on the piston and the housing downstream of the return chamber inlet valve which interact to generate hydraulic fluid pressure changes in the return chamber which, during travel of the piston in its second direction, cause the sleeve to be moved to close the inlet valve and open the exhaust valve to result in the deceleration and then acceleration of the piston in its first direction.

2. An actuator as claimed in claim 1 in which the sleeve is cylindrical with a portion of its length from its first end downwardly stepped from a first diameter in the drive chamber to a second smaller diameter which is partially located in the blind bore in the housing wall with the step in the sleeve being located in the drive chamber to provide a hydraulically exposed return area for the sleeve in the drive chamber which is permanently exposed to fluid at supply pressure in use.

3. An actuator as claimed in claim 2 in which the reduced diameter portion of the piston on the return area side of the piston is again stepped at a position spaced from the second diametrical step from a first diameter to a further reduced second diameter portion which is sealingly reciprocal through the actuator housing wall with the reduced diameter second end portion of the reciprocal sleeve including an inner rib which is spaced from the first end of the reciprocal sleeve with the radially inner surface of the rib having a diameter just greater than the outer diameter of the piston first diameter.

4. An actuator as claimed in claim 3 in which the inner surface of the larger diameter portion of the wall of the sleeve is recessed radially outwardly from a position

spaced from the step in the sleeve, to a larger diameter which extends over the remainder of its length, with an intermediate zone of the piston between its drive and return areas in the return chamber including an outwardly stepped portion having a diameter just less than the non-recessed portion of the reciprocal sleeve wall inner surface.

5. An actuator as claimed in claim 4 in which the drive chamber in the actuator body is divided into first and second chamber sections by a partition wall which includes at least one aperture through which the chamber sections are continually open to each other with the first drive chamber section housing the portion of the piston which includes its drive area; the second chamber section housing the larger diameter portion of the reciprocal sleeve which projects from the blind bore in the drive chamber wall and, on the partition wall, the second of the two opposed housing surfaces and the sleeve guide formation.

6. An actuator as claimed in claim 5 in which the reciprocal sleeve guide formation is a guide sleeve having an internal diameter just greater than the outwardly stepped portion of the piston and which projects from the partition wall to be in sliding engagement with the recessed inner surface of the second end portion of the reciprocal sleeve with the guide sleeve including a fluid inlet port which passes through its wall at or adjacent the second opposed housing surface on the partition wall for hydraulically connecting the return chamber to the second drive chamber section as the reciprocal sleeve opens the return chamber inlet valve, in use.

7. An actuator as claimed in claim 4 including a start/stop valve arrangement which is located in the hydraulic fluid supply inlet to the first drive chamber section.

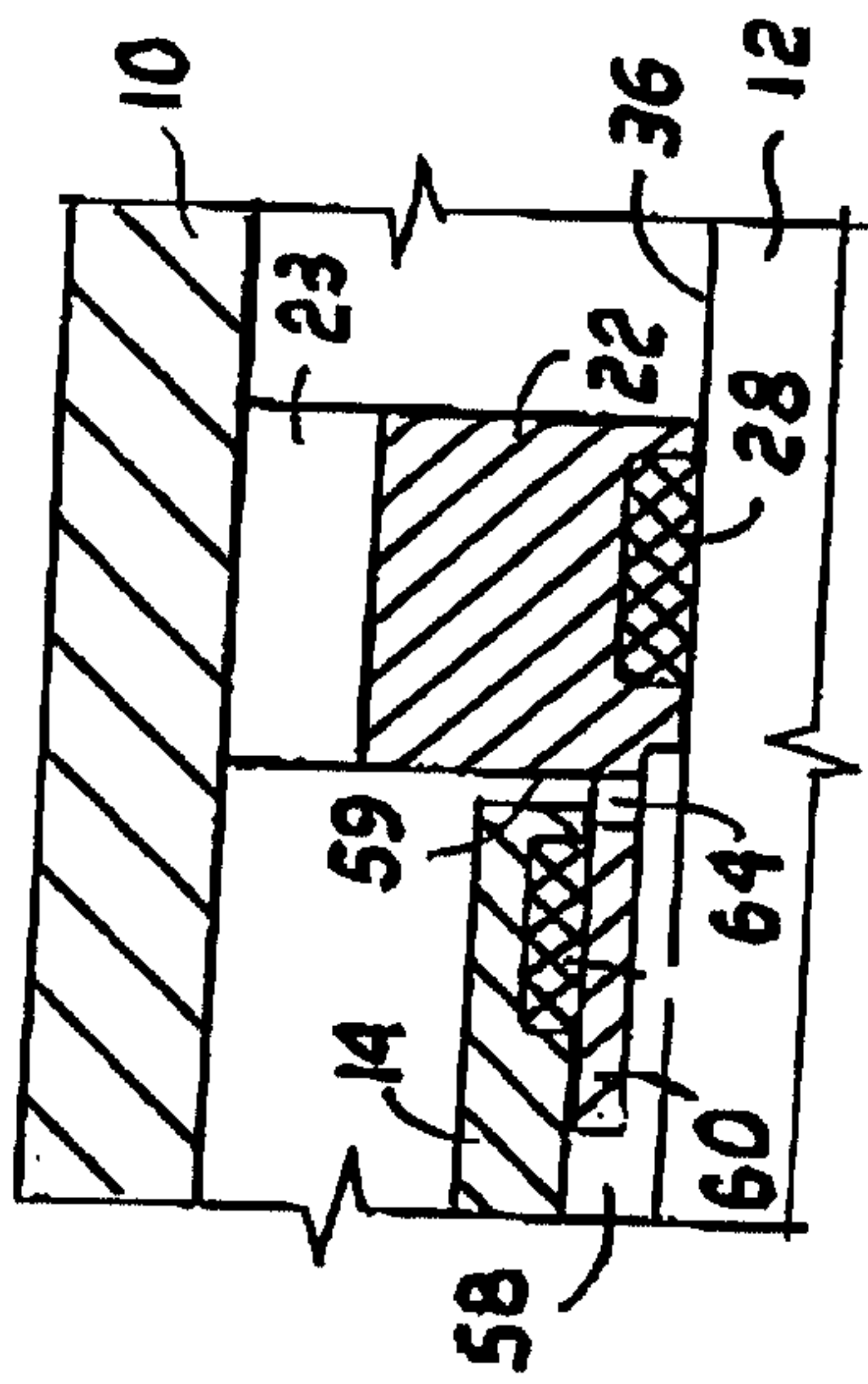


FIGURE 2

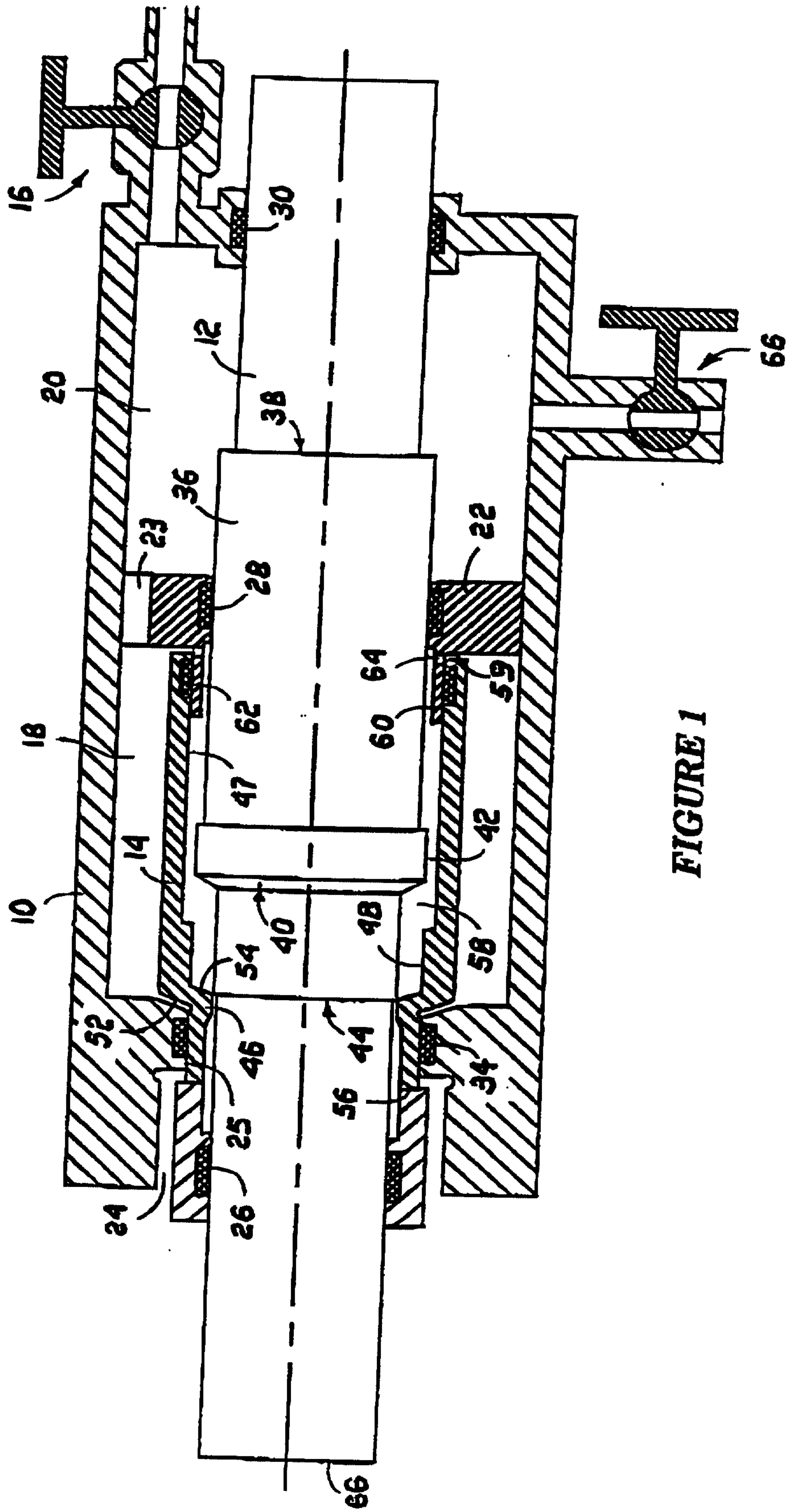


FIGURE 1

