

- [54] LOCKING CYLINDER WITH IMPROVED LOCKING STRUCTURE
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- [58] Field of Search..... 92/27, 24, 28; 188/67, 190; 91/43, 44, 91/45, 394, 395, 408, 409

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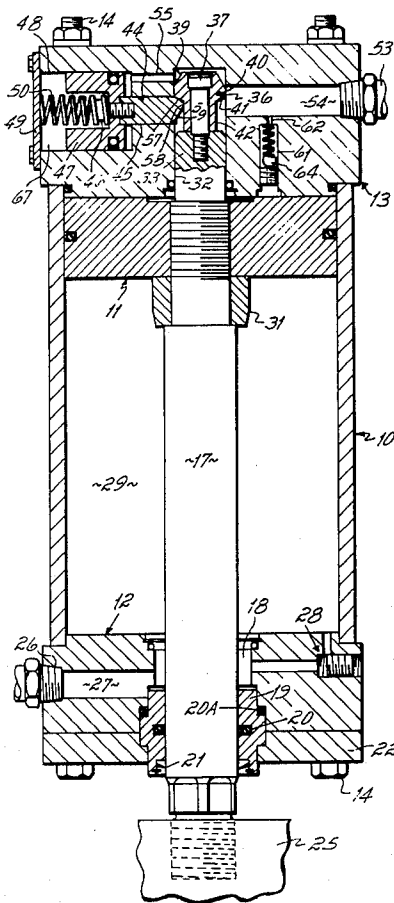
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[57] ABSTRACT

A locking cylinder wherein the main piston is locked at predetermined position by spring biased facial engagement of an inclined cam surface on a latch with an inclined cam surface keeper on the main piston. Latch operating means are actuable to move the latch from the keeper while the latch remains under load. Damping means prevent excessively rapid movement of the latch after it is disengaged from the keeper. Timing means delay application of work pressure over the entire area of the main piston until the latch has been released.

1 Claim, 3 Drawing Figures



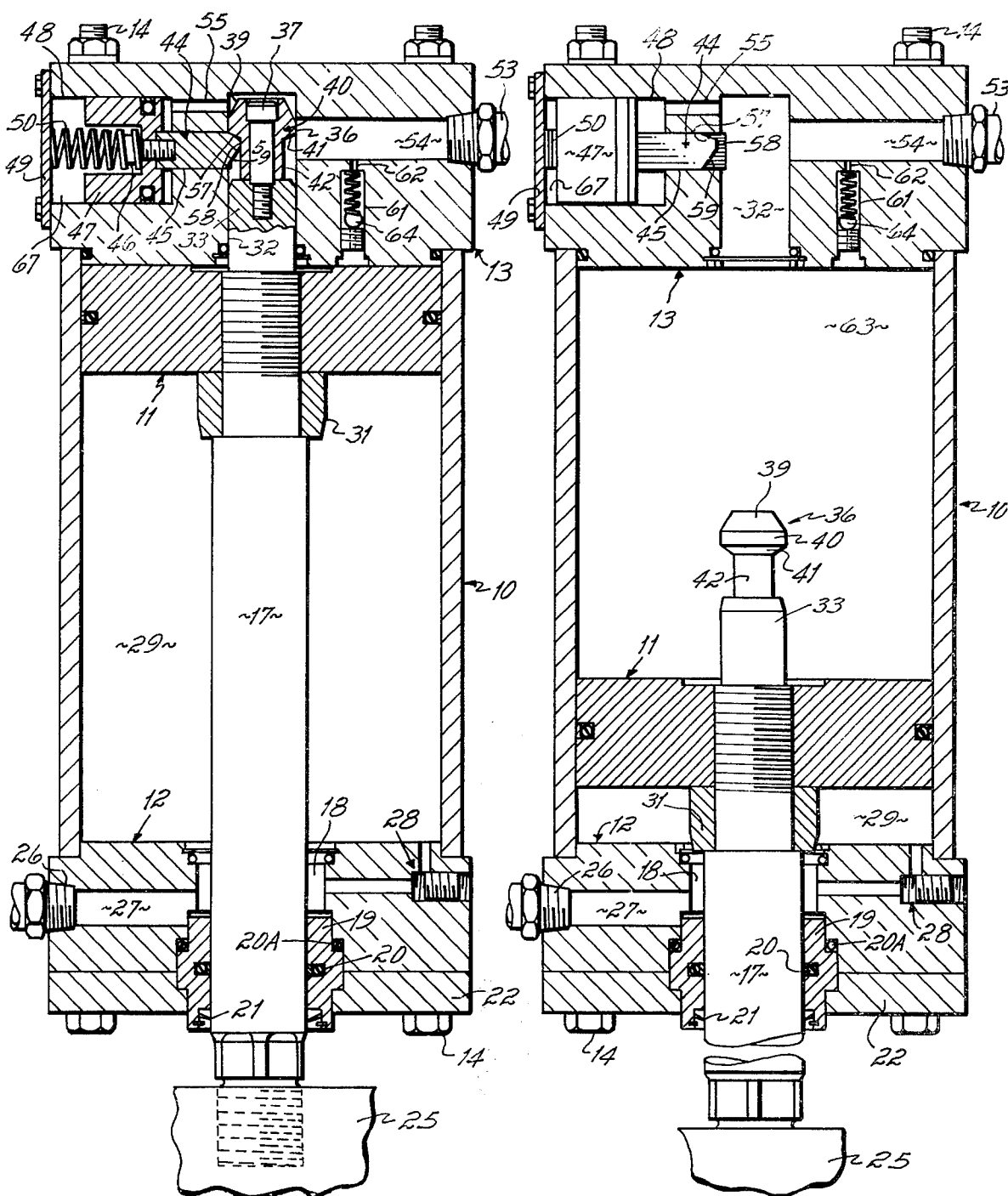


Fig. 1

Fig. 2

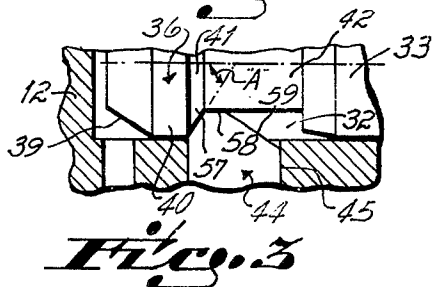


Fig. 3

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LOCKING CYLINDER WITH IMPROVED LOCKING STRUCTURE

This invention relates to locking cylinders, that is, fluid pressure operated devices of the type in which a piston is mechanically and automatically locked in predetermined position in its cylinder, to remain at such position over an extended period of time even though fluid pressure is not thereafter applied to the piston to hold it in such position. In such devices, the piston cannot move from locked position until the locking structure is released to unlock the piston.

Locking cylinders per se are known. They are used, for example, to lock aircraft landing gear in the extended position and/or in the retracted position, so that the piston (and hence, the landing gear) cannot move even though pressure is not applied to the piston to hold it in such position. Hence the supply pump need not be operated to apply pressure fluid or make up leakage during the entire time the piston is to remain in such locked position. In other applications, locking cylinders find use where the piston of a press or lift must support a load or maintain position for a period of time while operation of the supply pump is discontinued. In such applications, absent use of a locking piston, the gradual release of pressure or leakage of fluid from the pressure chamber acting on the piston would permit the piston slowly to move from the desired position. The locking cylinder prevents this by automatically and positively locking the piston mechanically in such position.

In a locking cylinder it is essential, for smooth operation with a minimum of wear, that as the piston moves toward the predetermined position at which it is to be locked, the locking mechanism, whatever its nature, should engage the moving element or piston smoothly and cause locking to occur automatically and with virtually 100% reliability. It is also requisite that once locked, the piston remain locked with complete reliability in the predetermined position even though the application of fluid pressure to the operating chamber be discontinued and even though fluid may leak from such chamber.

In achieving the foregoing objectives, it has been found difficult in practice to provide a lock in which unlocking will occur smoothly and without jamming or sticking. It is, moreover, highly desirable that unlocking occur without the application of pressure fluid to the piston to release the load on the lock structure before or during the actual unlocking movement. In the past, unlocking has been especially difficult where the piston is supporting or maintaining a heavy workload, for example where a vertically mounted piston is supporting a massive workpiece or platen in raised position. In such situations, for example as in U.S. Pat. No. 2,181,562 to De Ganahl, a heavy side load may act on the lock "bolt" sufficiently to prevent it from being withdrawn. In such situations jamming and severe wear have been problems. In particular, prior locking cylinders have commonly required that where loading is heavy, pressure be applied to the locked piston to relieve the load on the lock structure itself before actual unlocking can occur, so that the lock bolt is freed of side load before it is withdrawn. This, of course, slows the unlocking procedure and may even require the manual application of pressure first in one direction to the work piston prior to unlocking, then in the opposite

direction to move it from the unlocked position. In other words, while the locking engagement must be positive and foolproof, the lock should be readily releasable even under load, without pressure applied to relieve the load on it.

As the usage of locking cylinders has increased with their application in more widely diversified applications, it has become of greater competitive importance to provide a locking cylinder which is fully reliable and effective in operation, but which does not involve such complicated and expensive internal structure as has been used in the past, and which is simpler but fully automatic in use.

In the present invention, these objectives are accomplished with the provision of structure whereby the lock structure can be unlocked while it bears the full load, and which, moreover, unlocks even as pressure is started to be applied to the piston to move the piston from the locked position. This greatly simplifies operation in actual practice since the sequential application to the main or work piston of pressures in opposite directions is unnecessary.

When the present locking structure is unlocked while pressure is applied to the main piston, the locking member remains under load until the actual instant that unlocking is almost complete. It is then suddenly released from the binding or restrictive forces on it, while it is still subjected to an unlocking pressure force. A sudden unbalance of forces occurs which, if not controlled, could lead to danger of very rapid overtravel with resultant damage to the locking structure. The present invention includes means for automatically dissipating this energy, and for damping movement of the locking member if it tends to overshoot after the work piston is released.

These and the other objects of the invention are achieved in structure which is highly reliable yet not nearly so complex as prior art locking structures.

A locking cylinder embodying the present invention includes a main piston which is slidable in a cylinder. The means for mechanically locking the main piston in predetermined position with respect to the cylinder preferably comprise what may be referred to as a keeper which is mounted or formed on the main piston, and a latch which is mounted to latch operating means, preferably comprising a latch piston, for movement into locking engagement with the keeper when the latter (and the main piston to which it is connected) are in the predetermined locking position. The latch is not connected to move with the main piston, but rather is mounted in the cylinder or housing for movement in the radial direction, that is, toward and away from the keeper axis or the axis of the main piston. A spring or pressure means biases the latch radially inward, thereby urging the latch toward that predetermined position at which the keeper is engaged. The latch operating means are actuable, as by pressure (pneumatic or hydraulic) to apply force to the latch to move it against the biasing and retarding forces, away from the position of latch engagement with the keeper. The latch and/or the keeper have cooperating cam surfaces by which the keeper cams the latch away, against the bias thereof as the keeper is moving toward locking position, and by which the latch facially engages the keeper without unintended release thereof from the predetermined position, once the keeper reaches such position. It has been found that the nature of the cam surface is fairly critical

to achieving proper locking and release of the lock when desired, yet to prevent inadvertent, undesired or premature unlocking.

It is important to understand that the locking engagement between the latch and keeper is an engagement between cooperating inclined cam surfaces thereon, such that the keeper acting under the load of the main piston does exert a camming force on the latch which tends to cam the latter away from locking position and toward a position of lesser facial engagement. This cam force which tends to unlock the latch by camming away is, however, offset by a greater opposing bias on the latch, so that unlatching does not occur unless and until a pressure force is applied directly to the latch piston to move it. At that time, and only then, the camming action permits unlocking to occur without the sticking, jamming or excessive wear that have plagued past structures.

The invention can typically be used, as one example, in locking cylinders wherein the work piston is arranged in vertical position and is required to support a load in raised position. In the detailed description which follows the invention is explained with particular reference to that such use. However, the invention structure can be used in pneumatic or hydraulic locking cylinders whether or not they are mounted in vertical position, and also to lock the main piston in extended position with respect to the cylinder, instead of in the retracted position described herein.

The details and advantages of the structure of this invention can best be further described by reference to the drawings, in which:

FIG. 1 is an axial section of a locking cylinder formed in accordance with a preferred embodiment of the invention, showing the piston locked in withdrawn position;

FIG. 2 is a view similar to FIG. 1, but shows the piston unlocked and in the extended position;

and FIG. 3 is an enlarged view of a portion of the latch and keeper, showing them in interengaged or locking relation.

The structure shown for purposes of explanation includes a cylinder or tube 10 in which a main piston 11 is longitudinally slidable. Cylinder 10 is closed at its lower end by a head 12, and at its upper end the cylinder is closed by a cap 13.

A piston rod 17 extends axially from piston 11 and projects externally through a bore 18 in head 12. A cartridge or bushing 19 is seated against a shoulder in bore 18 and provides a guide and bearing for piston rod 17. Cartridge 19 also includes O-rings 20, 20A which prevent the loss of pressure fluid through bore 18, and a rod wiper 21 for wiping dirt particles from the rod. The cartridge is retained and seated in head 12 by a retainer plate 22. The cylinder, head, retainer and cap are connected by tie rods 14 (only the upper and lower ends of which are shown) to form a unitary assembly. A mechanical means of mounting the structure is provided, not shown. By way of example the structure may be trunnion mounted.

Piston 11 is slidable in cylinder 10 between the retracted or raised position shown in FIG. 1, in which it abuts the cap 13, and a lowered or extended position in which it abuts the head 12. In FIG. 2 the piston is shown approaching extended position. In use, piston rod 17 is connected to operate a work load which may be a platen or die 25 connected to the lower end of the

piston rod. In these circumstances the load is a downward force which at all times tends to move the piston rod away from retracted position and toward extended position.

Pressure applied to the cylinder chamber 29 beneath the piston tends to lift piston 11, thereby retracting rod 17 and raising load 25. Pressure fluid is applied to chamber 29 through a coupling 26 in head 12, into a bore 27 which ordinarily communicates with chamber 29 through bore 18. Release of fluid from chamber 29 through coupling 26 permits piston 11 to be lowered, if and when the lock structure to be described is unlocked.

A cushion piston 31 is mounted to piston rod 17, between a shoulder on the rod and the lower face of piston 11. The purpose of the cushion piston is to gradually slow the movement of the main piston as it approaches head 12. This cushion piston 31 is sized to form a sliding seal with bore 18, with which it interfits when the rod is in extended position. The cushion piston is inwardly tapered at its lower end, and as piston rod 17 moves toward extended position the cushion piston 31 closes bore 18. When bore 18 is thus closed, fluid can escape from chamber 29, to permit piston 11 to be lowered, only through a flow restrictor or an adjustable needle valve 28 that communicates with bore 27.

Cap 13 has a stopped axial bore or port 32. Bore 32 communicates through a lateral passage 54 with a cap pressure coupling 53. A blocking piston 33 projects from rod 17 above the upper face of piston 11. This blocking piston 33 preferably blocks the application of pressure to the full surface area of the main piston 11 when the latter starts to move from retracted position and until the lock is almost or fully released, and it also cushions the upward movement of the main piston as the latter approaches cap 13, as will be explained.

The locking structure to which the invention is particularly directed is disposed, in preferred embodiment, partly in cap 13, and partly on piston rod 17 above the blocking piston 31.

A latch keeper or cam member designated at 36 projects longitudinally or axially from piston 11 and is preferably secured above the upper end of cushion piston 33 by a shouldered bolt 37. This latch member 36 at its outer or upper end has an enlarged head portion with a downwardly and outwardly flaring conical or cam surface 39. The purpose of this surface 39 is to cam "open" a latch member (to be described) when piston 11 is approaching the predetermined position in which it is to be locked. Adjacent to the conical cam surface 39, the head of keeper 36 has a cylindrical land 40. Below land 40, keeper 36 is provided with an inwardly and downwardly steeply flared conical cam surface 41. As best shown in FIG. 3, a line on cam surface 41 should intersect the axis of the piston rod at an angle A of substantially 75° to 89°. This angle is rather critical, for reasons explained hereinafter. Cam surface 41 defines the end of a neck portion 42 of reduced diameter on keeper 36.

The keeper 36 is mounted to blocking piston 33 at the end of rod 17 by a shouldered bolt 37, preferably with some play (both radially and axially) so that it can shift in the radial direction or "cock" in use to equalize the load it carries when locked, and to distribute wear more uniformly about it. This will also enable it to compensate for slight misalignment if multiple latches are

provided. Alternatively, however, cam 36 can be made integral with piston rod 17.

A latch or lock member 44 is slidable in a transverse or radial bore 45 in cap 13. The latch 44 is mounted, as by a bolt 46, to a latch piston 47 for longitudinal movement in bore 45. Latch piston 47 is slidable in its own cylinder 48 in the cap, in the direction toward and away from bore 32 and the axis of movement of piston 11, to move the latch to engage the keeper at the desired position of the main piston where the latter is to be locked. A cover plate 49 closes the latch cylinder 48 and is fastened, as by bolts, to cap 13. Biasing means such as fluid pressure or a mechanical spring as shown at 50 urges piston 47 and latch 44 attached thereto toward bore 32 and the axis of movement of piston 11.

Pressure for operating latch piston 47 is supplied through cap 13 from the pressure coupling 53 via bore 54 which leads to the inner end of bore 32. Bore 32 is connected by a smaller bore 55 to the inner end of latch cylinder 48.

Latch 44 is so dimensioned that when the latch piston 47 is seated at the inner end of its cylinder 48, the inner end of the latch projects into bore 32 in position to engage the cam surfaces 39 and 41 on the keeper when the keeper is moved therepast. As shown in FIGS. 2 and 3, latch 44 and bore 45 are preferably rectangular in cross-section, to prevent rotation of the latch in the bore. Alternatively, the latch may be keyed to the bore to prevent rotation, so that the cooperating cam surfaces, to be described, always retain the proper orientation.

At its inner end, latch 44 is angulated at 57 to conform to the angulation A of conical cam surface 41 on the keeper. When the latch is locking the piston in the withdrawn position, as shown in FIG. 1, this surface 57 on the latch facially interengages the cam surface 41 on the keeper. Surface 57 may be nominally planar, but preferably should conform to the curvature of keeper 36. In any event, wear in use will tend to establish such conformity. The end surface area 58 of the latch may conform to the curvature of the neck 42 of the keeper although this is not necessary. The other or lower side corner of the latch has a downwardly and outwardly flaring cam surface 59 which substantially conforms to the cam surface 39 on the forward or upper end of the keeper for engaging the latter.

A bore 61 including a flow restricting orifice 62 extends between fluid passageway 54 and the chamber 63 above piston 11 (see FIG. 2). The bore 61 also includes a spring operated ball check valve 64 which opens to permit the release of fluid from chamber 63 into passage 54 as the main piston 11 is moving upward, but which closes to block the flow of fluid from passage 54 into chamber 63.

OPERATION OF THE LOCKING CYLINDER

When main piston 11 is in the retracted and locked position shown in FIG. 1 spring 50 holds the latch in engagement with the keeper 36, and thereby mechanically locks the piston in the predetermined position shown, against the force of the load 25 which causes a camming force to act through the keeper on the inclined surface of the keeper. The piston is locked even though there may be no fluid pressure in chamber 29 beneath it. The angle A is such that the camming force exerted by keeper 36 on latch 44 is not sufficient to

overcome the bias of spring 50 and cam the latch out of locking position.

Piston 11 can be unlocked without application of pressure beneath it in cylinder 29, which is a distinct operating simplification and advantage. To unlock the locking structure, pressure fluid is applied to coupling 53, and coupling 26 is connected to tank or atmosphere. Pressure at coupling 53 acts through bore 54, bore 32 and passageway 55 into the latch piston cylinder 48. Pressure at the inner end of latch cylinder 48 moves latch piston 47 and latch 44 away from keeper 36, thereby disengaging the latch from the keeper. At the same time, the pressure in bore 32 exerts a downward force on the end area of keeper 36, thereby urging piston rod 17 and piston 11 downwardly as rapidly as the latch 44 is disengaged. As unlatching occurs, ball check valve 64 is closed on its seat, and blocking piston 33 closes bore 32; hence essentially no operating pressure is initially applied over the upper face of piston 11. This has been found useful in the preferred embodiment to minimize the load on the latch during unlatching and thereby to prevent sticking or jamming and permit smoother operation.

Where the force tending to extend main piston 11 is substantial, a strong mechanical camming force is applied by keeper 36 to latch 44, and, once pressure is applied to latch piston 47 to start the latch moving out of engagement with the keeper, this camming force tends excessively to accelerate the unlocking movement of latch piston 47. If unrestrained, this effect could damage piston 47 by slamming it against cover 49. We have found that this can be effectively prevented if the chamber 67 (between the latch piston 47 and cover 49) is sealed sufficiently that it can act as a dash pot. Ordinary leakage past ungasketed cover plate 49 will spill sufficient air (where pneumatic pressure is used) for this to occur. In this manner, fluid is released relatively slowly from chamber 67, thereby cushioning and preventing excessively rapid outward movement of the latch piston.

Downward movement of piston 11 occurs only as latch 44 is moved out of the way to permit the piston to move. Application of full force to the upper face of piston 11 is preferably blocked until the blocking piston 33 has opened bore or port 32, at which time pressure fluid from bore or port 32 is admitted to chamber 63 and acts over the entire upper face of the main piston 11, thereby applying larger force to the piston and causing more rapid downward movement.

Piston 11 moves downwardly under the combined force of the load 25 and the application of pressure to its upper face, and pressure fluid is released from the chamber 29 beneath the piston through bore 18, passage 27, coupling 26, and suitable valving and porting not shown. After cushion piston 31 slides into and closes bore 18 (see FIG. 2) it thereby limits the escape of fluid from chamber 29. Thereafter, fluid is released from chamber 29 only at a restricted rate through the needle valve or restrictor 28 to passageway 27, to provide the cushioning previously mentioned.

When piston 11 is to be raised from extended position, pressure fluid is applied through coupling 26, and passageway 54 is connected to exhaust or tank, through suitable external valves and porting, not shown. This pressure fluid acts initially only on the end area of cushion piston 31 and thereby lifts the piston slowly. When the piston has been raised sufficiently that cushion pis-

ton 31 no longer blocks bore 18 pressure fluid is admitted to the chamber 29.

As the piston 11 approaches raised position, the keeper 36 enters bore 32. The blocking piston 33 shortly thereafter closes bore or port 32. The blocking piston 33 is preferably dimensioned so that this closure begins before keeper cam surface 39 engages the latch. The ball check valve 64 opens, and fluid is slowly released to passage 54 through restrictor 62 to reduce the rate of upward movement of the piston.

When the upper edge 39 of keeper 36 engages cam surface 59 on the latch it cams the latch outwardly, compressing spring 50. As keeper 36 is moved upwardly, land 40 slides across the end of the latch. The latch end 58 then slides off land 40 and latch cam surface 57 engages the lower conical cam surface 41 on the keeper. Preferably this occurs when the upper face of piston 11 is substantially facially against the lower face of the head. The piston is locked in this position. Pressure fluid can then be released from chamber 29, and latch 44 will securely hold the piston 11 in the retracted position without further application of fluid pressure to either coupling 53 or 26.

It will be noted that when the latch and keeper are in locking relation, as shown in FIGS. 1 and 3, their contact is over the inclined cam surface 57 and 41. The inclination results in an "unlocking" force reactor acting on the latch, tending to move it away, i.e. radially outward. This force is opposed and overcome by the frictional retarding forces, and by the force of biasing means 50.

In this connection it has been found that the angle or slope A (see FIG. 3) of the cooperating cam surface 57 and 41 is fairly critical. If the cam surfaces 41 and 57 are too steep, that is, if angle A is too close to 90°, the gravity and/or pressure load can create an excessively high friction load against latch 44, and the pressure applied to piston 47 may not be sufficient to disengage the latch, or the disengaging movement will cause undesirably severe and rapid wear on the latch. On the other hand, if the angle A is too small, then frictional engagement between latch and cam, plus the bias force, will not be sufficient to prevent the keeper from camming the latch to unlocked position, thereby prematurely releasing the main piston with possibly serious results. Tests have shown that, depending upon the areas of the interengaging surface involved, the coefficients of friction of the materials of which the latch and keeper are constructed, and the relative movement necessary to effect disengagement, the angle A should be substantially 75° to 89°.

In the embodiment shown, only a single latch and keeper have been shown, with the keeper positioned on the axis of the piston rod. However, where an unusually heavy load must be supported, or where wear is likely to be severe, it may be desirable to provide a plurality of several such latch and keeper mechanisms. In such case, for example, several latches may be arranged in the containing member, movable to engage the respective keepers in the manner described.

From the foregoing, it can be seen that when piston 33 is seated in bore 32, it blocks application of pressure over the entire sectional area of the main piston 11. This minimizes the load on the latch during unlatching, as above described. However, where the load on the main piston is not large, or where the force on the latch is not so large as to make unlatching difficult with the

pressure available to act in piston 47, it is not necessary to block or temporarily delay the application of pressure over the entire face of the main piston. In such circumstances piston 33 may be omitted or it need not tightly seal with its bore 32.

In the embodiment illustrated, the latch 44 is actuated by operating mechanism comprising the latch piston 47, which when subjected to pressure, applies a force to the latch to move it away from keeper 40, against the bias of spring 50 and against the retarding forces applied to the latch by the load acting through the keeper. Alternatively, we contemplate that other forms of latch operating means may be employed. For example, the latch 44 may be withdrawn by a solenoid which is electrically controlled to respond to a desired signal, or to a prescribed time sequence, or to a given pressure level.

Having described our invention, we claim:

1. In a locking cylinder having a main piston slidable in a cylinder and locking means for mechanically locking said piston with respect to said cylinder, the improvement comprising,

means defining a keeper on said main piston, said keeper projecting axially from the surface of said main piston and being mounted thereto by means permitting the keeper to shift radially,

a latch engageable with said keeper at a predetermined locking position of said keeper and main piston to lock said keeper and main piston in said predetermined position, by restraining movement of said keeper therefrom,

means mounting said latch for slidable movement angularly toward and away from said keeper for engagement of said latch therewith at said predetermined position,

a latch piston connected to said latch to move the latch away from said keeper in response to an unlatching pressure thereon,

means biasing said latch piston radially toward said predetermined position,

a passage for applying pressure fluid from a source to said latch piston to move the latch away from said predetermined position,

a port through which pressure fluid from said source must flow to act on the full area of said main piston,

a blocking piston mounted to said main piston, said blocking piston having a crosswise area which is substantially less than the full area of the main piston; said crosswise area exposed to pressure fluid from said source which tends to move said main piston away from said predetermined position, said blocking piston cooperating with said port when said latch is engaged with said keeper to close said port to flow therethrough, the application of pressure to the full area of the main piston being blocked until said latch has been disengaged from said keeper and said main piston has moved away from said predetermined position sufficiently that said blocking piston no longer closes said port,

said latch having an inclined cam surface which bears on a cooperating inclined cam surface provided on said keeper in said locking position, the cam surfaces being such that the unlocking camming force applied by said keeper to said latch when engaged therewith is insufficient to overcome the opposed frictional and biasing forces that restrain cammed movement of said latch, but sufficient in combination with the force of said pressure fluid on said latch piston to move said latch piston and latch radially away from said keeper.

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