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Ziegler

[11] **3,918,346**

[45] **Nov. 11, 1975**

[54] **FRICTIONAL LOCK FOR RETAINING A ROTATABLE PISTON AGAINST AXIAL DISPLACEMENT**

[75] Inventor: **William H. Ziegler,** Waterford, N.Y.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

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[21] Appl. No.: **487,838**

[52] **U.S. Cl.** ..... **89/37 C;** 89/37 H; 89/40 E; 89/41 H; 91/41; 92/28; 188/170

[51] **Int. Cl.²** **F41F 21/08**

[58] **Field of Search** ..... 89/37 C, 37 H, 40 E, 41 H; 91/41; 92/27, 28; 188/67, 170

[56] **References Cited**

UNITED STATES PATENTS

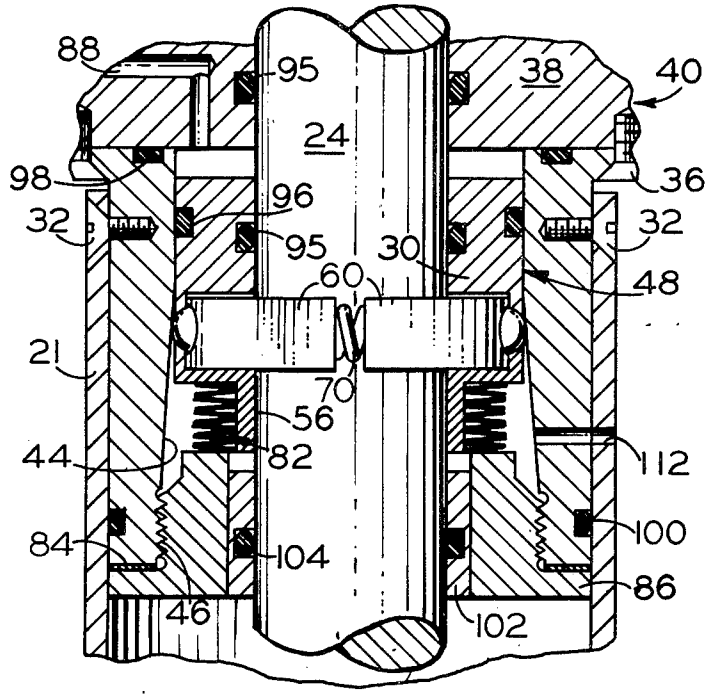
2,632,425	3/1953	Grover	92/28

Primary Examiner—Stephen C. Bentley
Attorney, Agent, or Firm—Robert P. Gibson; Nathan Edelberg; Vincent W. Cleary

[57] **ABSTRACT**

In order to lock a rotatable and slidable actuating piston, responsive to fluid pressure introduced into the cylinder containing the piston, against axial displacement following each actuation movement thereof but not against rotation about the vertical axis thereof, a pair of semi-annular locking elements are each provided with a rotatable ball projecting from the exterior periphery thereof and are mounted in a hollow carrier surrounding the rod portion of the piston so that the balls protrude from the carrier into rolling contact with a fixed cam surface of upwardly decreasing taper extending around the interior of the cylinder. Thus, whenever the piston is to be actuated by the fluidic pressure, a portion thereof is diverted to impart downward displacement to the carrier whereupon the cam surface permits the locking elements to respond to a pair of compression springs therebetween for transverse movement out of frictional locking engagement with the piston rod. When the fluidic pressure on the carrier is terminated, a plurality of alternately stacked concave and convex spring washers impart upward movement to the carrier whereupon the tapered wall in the cylinder cams the balls inwardly to thereby return the locking elements into frictional locking engagement with the piston rod.

10 Claims, 9 Drawing Figures



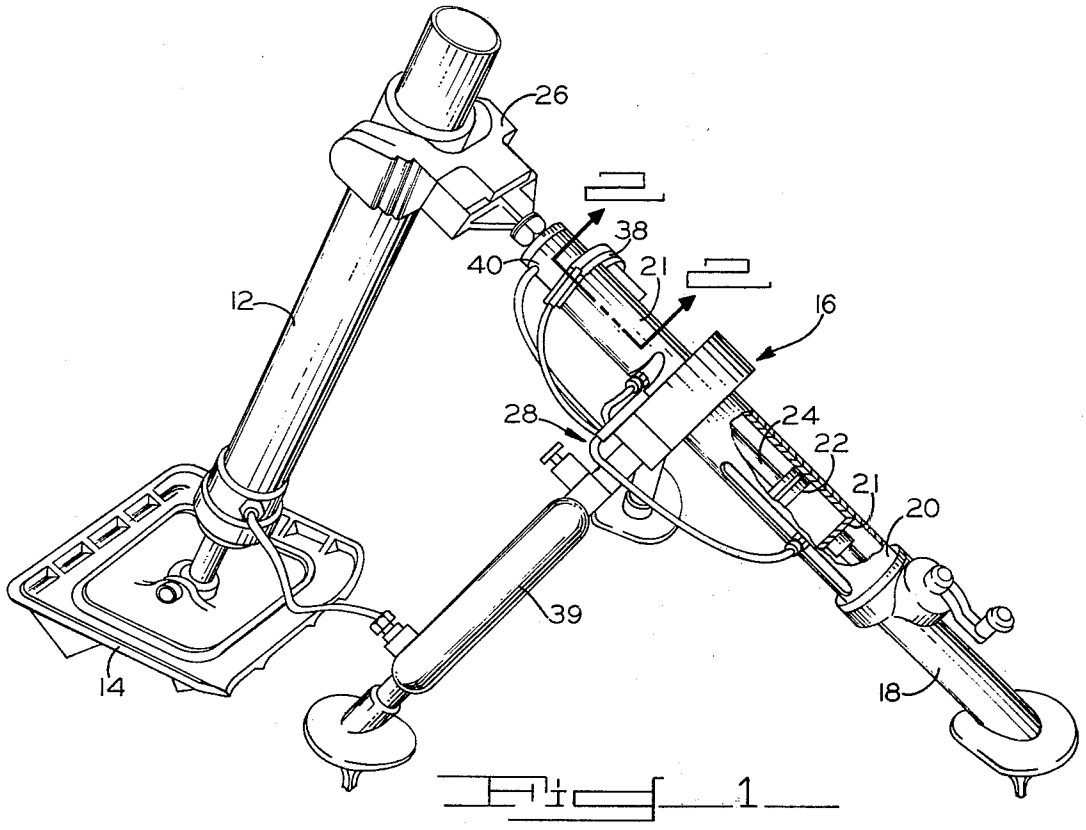

26
38
40
21
12
16
28
24
22
21
20
39
14
18

Fig. 1

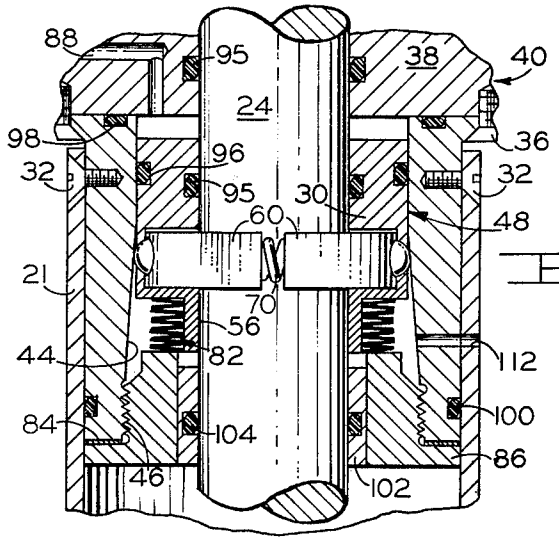

88
95
38
40
24
98
96
36
32
95
30
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48
21
70
56
44
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112
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104
100
86
46
102

Fig. 2

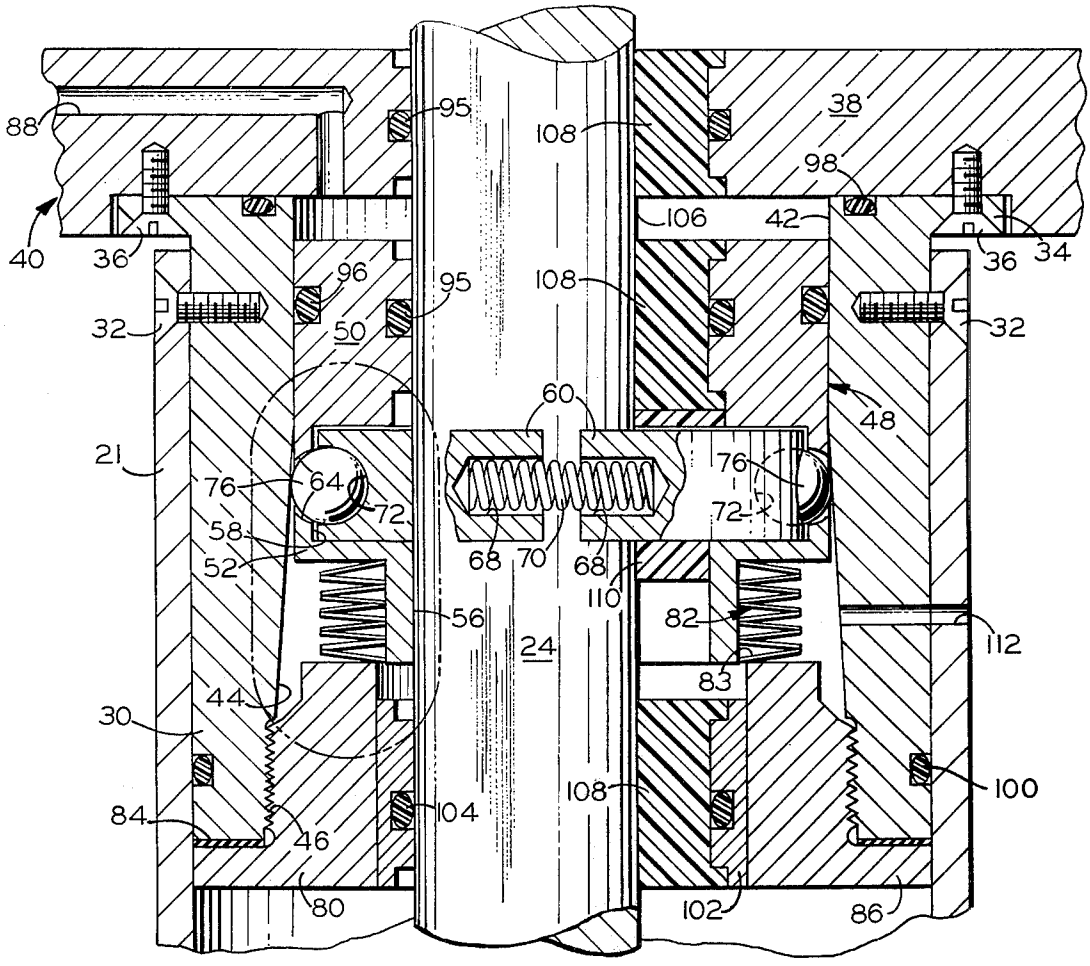

88
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60
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21
76
64
72
76
72
58
68
70
68
52
110
56
82
112
24
83
44
30
108
100
84
104
46
80
102
86

Fig. 3

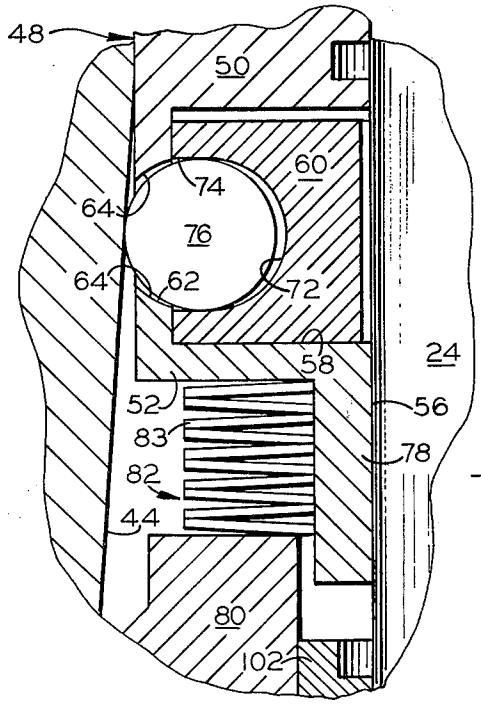

48
50
60
74
64
76
64
62
72
24
58
52
56
83
78
82
44
80
102

Fig. 4

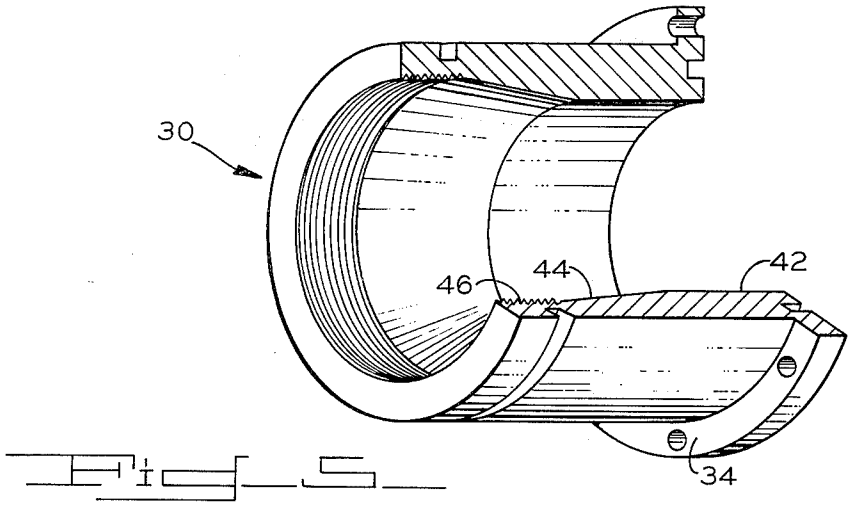


Fig. 5

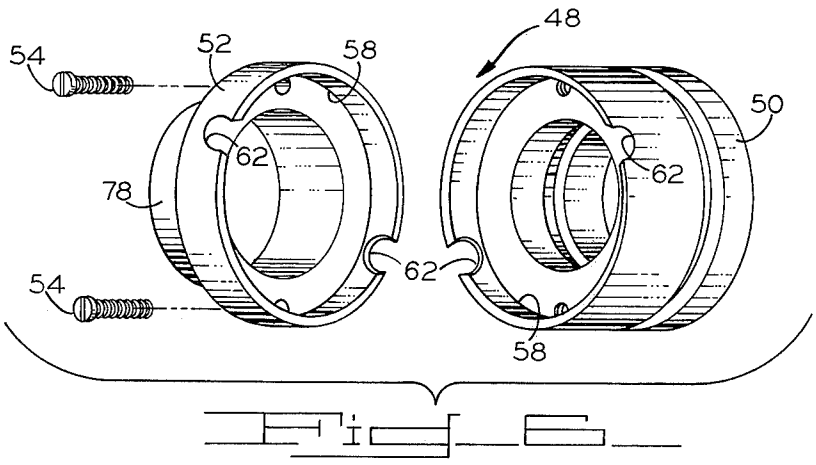


Fig. 6

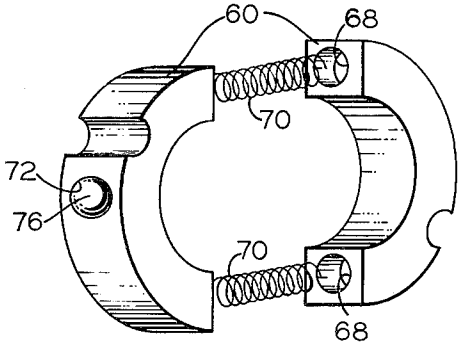
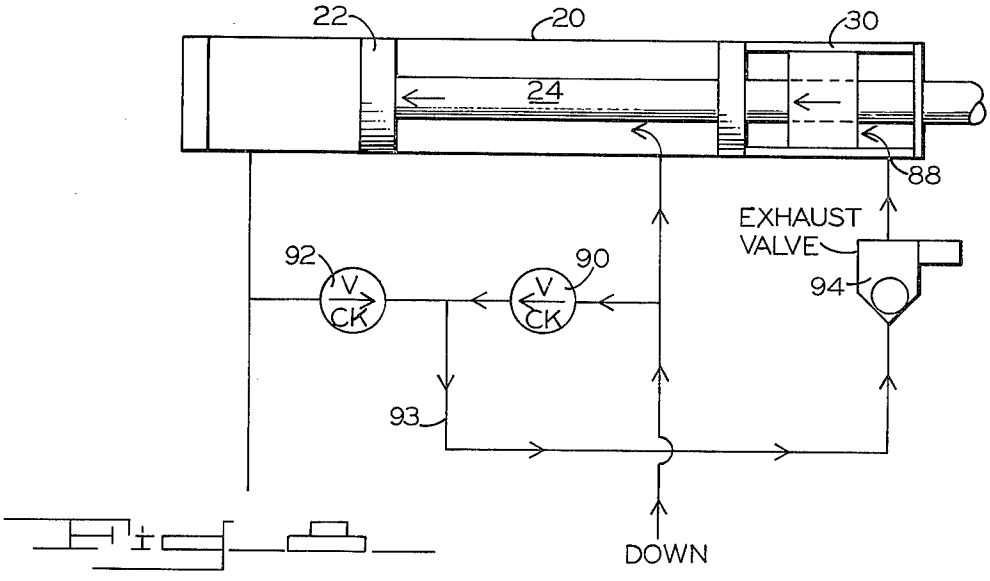
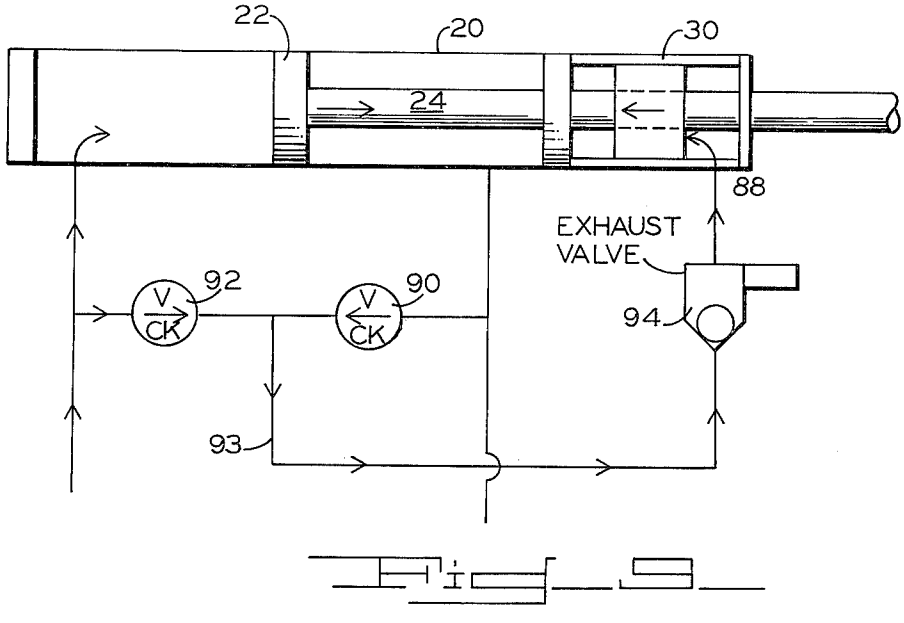


Fig. 7


22
20
30
24
88
EXHAUST
VALVE
92
90
V
CK
94
93
DOWN


22
20
30
24
88
EXHAUST
VALVE
92
90
V
CK
94
93

FRICTIONAL LOCK FOR RETAINING A ROTATABLE PISTON AGAINST AXIAL DISPLACEMENT

BACKGROUND OF THE INVENTION

This invention relates to a piston and cylinder assembly wherein a rotatable piston is arranged to be axially displaced in response to the intermittent activation of a fluidic control system and is more specifically directed to means operative at the completion of each cycle of control system operation for locking the piston against premature axial displacement without interfering with the ability thereof to be rotated within the cylinder.

As more fully explained in the copending patent application of William H. Ziegler and Gary W. Woods, Ser. No. 406,404 filed Oct. 15, 1973, now U.S. Pat. No. 3,866,515, an infantry mortar is provided with an improved tripod mount incorporating a fluidic system of digital feedback control for actuating a piston to restore the firing tube of the mortar to an established sighting inclination in direct response to a predetermined minimum of recoil displacement which may be imparted thereto in either azimuth or elevation. It has been found, especially in the larger caliber mortars, that the pressure available within the control system for retaining the piston against premature displacement prior to the firing of the mortar is insufficient to support the weight of the firing tube, particularly when a round of ammunition is loaded therein. Obviously, any premature displacement of the piston beyond the minimum set into the control system will automatically activate the restoring function thereof thereby reducing the pressure by the accumulation of the discharge gases generated during previous firings. Consequently, the control system will be unable during the next. several firing cycles of the mortar to restore the firing tube to the established sighting inclination until the required pressure is provided by the newly accumulated discharge gases.

Accordingly, it is an object of this invention to provide means for locking a rotatable and slidable piston against axial displacement in a cylinder but not against rotation about the central axis thereof.

It is another object of this invention to provide piston locking means, as aforesaid, which can be readily adjusted to provide a predetermined resistance to the unlocking thereof.

A further object of the present invention resides in the provision of a piston lock, as aforesaid, which can be incorporated in a fluidic control system to frictionally engage with the exterior periphery of the rod portion of the piston at the conclusion of each displacement thereof within the cylinder.

Still another object of this invention is to provide a piston lock, as aforesaid, which will function in an equally effective manner whether the exterior periphery of the piston rod is cylindrical throughout or includes a slabbed portion therealong.

Summary of the Invention

It has been found that the foregoing objects can be achieved in a conventional piston and cylinder assembly by locking means provided with a pair of semi-cylindrical locking elements separated by a compression spring and seated within a hollow carrier for frictional engagement with the exterior periphery of the piston rod. The carrier is slidably disposed in a cylindrical housing which is, in turn, fixedly secured within the cylinder. A rotatable ball is mounted in the exterior periphery of each locking element to protrude through the carrier walls for rotatable contact with a tapered surface of upwardly decreasing diameter within the interior of the fixed housing. The carrier is normally urged upwardly in the housing by spring means of predetermined bias so that the tapered surface therein cams the rotatable balls inwardly of the carrier to bring the locking elements into frictional locking contact with the exterior periphery of the piston rod. However, even though the piston rod is thus firmly locked against axial displacement in the cylinders, the rolling contact between the rotatable balls and the tapered wall surface within the fixed housing will still permit the carrier together with the piston rod to be rotated about the central axis thereof.

Unlocking of the piston rod is achieved whenever a portion of the air flow introduced into the cylinder by the fluidic control system to impart axial displacement to the piston is initially diverted against the upper end of the carrier to overcome the frictional engagement between the locking elements and the piston and simultaneously force the carrier downwardly against the bias of the spring means. Thus, the compression spring between the locking elements forces them apart out of locking engagement with the piston rod in direct relation to the increase in the diameter of the tapered interior of the fixed housing. The piston is then free to be displaced by the flow of air thereagainst during the operation of the fluidic control system. As soon as the bias of the spring means exceeds the air pressure on the carrier, the latter is urged upwardly in the cylindrical housing to cam the locking elements back into locking engagement with the piston rod.

In the event the exterior periphery of the piston rod is slabbed along the axis thereof in the area of engagement with the locking elements, the same effective locking action can nevertheless be achieved simply by providing suitable inserts between the interior of the carrier and the slabbed surface of the piston rod to complete the cylindrical periphery thereof.

Brief Description of the Drawings

The exact nature of the invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification relating to the annexed drawings, wherein:

FIG. 1 is a perspective view of a mortar supported by a tripod, one leg thereof being partially broken away to disclose an actuating piston for imparting elevational movement to the mortar tube;

FIG. 2 is an enlarged section taken along line 2—2 in FIG. 1 to show the internal details of the means for locking the actuating piston against actual displacement;

FIG. 3 is a sectional view similar to that of FIG. 2 but additionally enlarged to show the details of the locking means where the piston rod is of slabbed configuration;

FIG. 4 is a fragmentary enlargement of a portion of the locking means in the unlocked position thereof;

FIG. 5 is an isometric view of the cylindrical housing;

FIG. 6 is an isometric view of the two portions of the carrier tilted in opposite directions to show the internal structure thereof;

FIG. 7 is an exploded isometric view of the locking elements;

FIG. 8 is a schematic diagram showing the flow path of the air when the piston is being displaced downwardly in the cylinder therefor; and

FIG. 9 is a diagram similar to that in FIG. 8 but showing the flow path during the return of the piston to a locked position.

Description of a Preferred Embodiment

As shown in the drawings wherein similar reference characters are utilized to designate corresponding parts throughout, the locking means of the present invention is particularly applicable to an infantry mortar of the type wherein a firing tube **12** is pivoted on a baseplate **14** and is supported in an established sighting inclination by a tripod mount **16.** One leg **18** of mount **16** is diametrically enlarged, as indicated at **20** in FIG. **1,** to slidably house a cylinder **21** and an actuating piston **22** therein provided with an upwardly extending piston rod **24** terminating in a pivotal yoke **26** slidably engageable with tube **12.** As more fully explained in the aforementioned patent application of Messrs. Ziegler and Woods, whenever baseplate **14** is sufficiently disturbed, either manually or in response to recoil forces thereagainst, to alter the sighting inclination of firing tube **12** beyond a predetermined minimum, a fluidic control system **28** is automatically energized to release the discharge gases which accumulate in a pressure chamber **39** in one of the other legs of tripod mount **16.** Such gases flow through suitable conduits to impart either axial displacement or rotation, or both, to piston **22** and thereby to piston rod **24** in the direction required to restore firing tube **12** to the original sighting inclination thereof. Since the restoration movement of piston **22** in elevation is accomplished by a differential pressure thereon, a suitable locking valve (not shown) has heretofore been incorporated in control system **28** to retain piston **22** in a stationary position until movement of the firing reactivates **12** received control system **28.** While such arrangement has been satisfactory where relatively small caliber mortars are concerned, it has been found that actuating piston **22** is frequently unable to support the relatively greater weight of the firing tube **12** of a larger caliber mortar, especially with a round of ammunition loaded therein, without incurring some leakage of the locking valve or other deterioration of the control system **28** during the frequent long periods of inactivity which may be required between successive firings of the mortar.

Accordingly, these locking valves have been replaced by the mechanical locking means of the present invention wherein a cylindrical housing **30** is fixedly secured within cylinder **21,** as by screws **32.** The upper end of housing **30** terminates in a flange **34** which is secured, as by screws **36,** to the underside of a collar **38** on a sensor unit **40** responsive to movement of firing tube **12** in azimuth. Housing **30** is of tubular construction and is provided with a cylindrical interior portion **42** at the upper end thereof and an adjacent tapered portion **44** of downwardly increasing diameter terminating in a cylindrical threaded portion **46.**

Slidably disposed within the interior of housing **30** is a cylindrical carrier **48** formed by upper and lower hollow sections **50** and **52,** respectively, which are joined in mating end-to-end relation by a pair of diametrically opposed screws **54** to provide a common bore **56** therethrough for the passage of piston rod **24.** The adjoining ends of carrier sections **50** and **52** are each counterbored to provide wells, as best indicated at **58** in FIG. **6,** which mate to seat locking elements **60** therein. In addition, the vertical wall of the mated wells **58** is centrally drilled from within the interior thereof to provide mating openings **62** at diametrically opposed locations. The true center of such mated openings **62** is inwardly offset relative to the interior periphery of mated wells **58** so that the vertical distance at the inner end of the resulting spherical contour **64** through the wall of carrier **48** is greater than at the outer end thereof, as best shown in FIGS. **3** and **4.**

Locking elements **60,** preferably fabricated of a relatively soft metal such as brass, are of identical semi-annular configuration and are each provided with diametrically opposed recesses **68** which are axially aligned to form seats for the ends of a pair of parallel compression springs **70.** Each locking element **60** is provided with a socket **72** in the exterior periphery thereof substantially midway of springs **70.** While the center of each socket **72** is transversely offset relative to the exterior periphery of locking element **60,** the spherical interior of socket **72** is linearly extended inwardly thereof to form a cylindrical entry **74** for a rotatable ball **76.** Thus, when locking elements **60** are properly assembled into carrier **48,** the bias of compression springs **70** forces balls outwardly to protrude from openings **62** into contact with tapered portion **44** in the interior of fixed housing **30.** Openings **62** serve to retain balls **76** in carrier **48** when the latter is removed from housing **30.**

Carrier section **52** is provided with a depending portion **78** of reduced diameter which cooperates with an annular insert **80** threaded upwardly into the lower end of housing **30** to provide a seat for a compression spring **82** preferably in the form of a plurality of Belleville washers **83** stacked with the concave and convex faces thereof in alternate succession. The interior diameter of insert **80** is slightly greater than the overall diameter of the depending portion **78** of carrier section **52** to permit the telescoping entry therein during the downward movement of carrier **48,** as will be hereinafter explained. The upward bias imparted to carrier **48** by spring **82** can be set at a predetermined level by adjusting the distance to which insert **80** is threaded into cylindrical housing **30** or changing the number of spring washers **83** employed. Such adjustment requires the corresponding selection of a gasket or packing **84** for insertion between the bottom of housing **30** and a mating flange portion **86** at the lower end of insert **80.**

When the fluidic control system **28** is activated by movement of mortar tube **12** in elevation, a portion of the air flow to the restoration piston **22** is diverted through a suitable inlet **88** in collar **38** into the interior of fixed housing **30** to act against the upper face of carrier **48.** Such diversion is accomplished by a pair of check valves **90** and **92** provided in control system **28** in opposed functional relation, as best shown in FIG. **8** and **9.** When the flow of air is introduced into cylinder **20** in the direction required to force piston **22** downwardly, as shown in FIG. **8,** air will also pass through check valve **90** but will be blocked by check valve **92** and diverted through a suitable conduit **93** to close a normally open exhaust valve **94** and pass therethrough into inlet **88.** However, when the flow of air is introduced into cylinder **21** in the direction required to force piston **22** upwardly, as shown in FIG. **9,** air will also pass through check valve **92** but will be blocked by check valve **90** and diverted into conduit **93** for passage into inlet **88** in the same manner as described above. In

order to prevent any leakage of the air flow directed against the upper end of carrier **48**, suitable O-rings **95** are provided in collar **38** and carrier section **50** for sealing contact with pisiton rod **24**. An O-ring **96** of larger diameter is also provided in the exterior periphery of carrier section **50** for sealing contact with the interior of cylindrical housing **30**. A still larger diameter O-ring **98** is provided between housing flange **34** and the underside of collar **38** for additional sealing effect. The lower end of fixed housing **30** is also sealed by a similar O-ring **100**. Tilting of piston **22** in cylinder **20** is prevented by a suitable guide bushing **102** press-fitted into annular insert **80** to surround piston rod **24** in slidable contact therewith and such bushing **102** is also sealed by an O-ring **104**.

As explained in the aforementioned copending application of Messrs. Ziegler and Woods, piston rod **24** is slabbed along the length thereof, as indicated at **106** in FIG. **3**, to cooperate with the interior periphery of cylinder **21** in forming a passage (not shown) for the entry of air into sensor unit **40**. In order to present a cylindrical periphery for the frictional engagement of locking elements **60**, suitable inserts **108** of nylon, or similar material, are provided between slabbed surface **106** and the interior periphery of collar **28**, carrier **48**, and guide bushing **102**. However, in order to provide maximum locking engagement between element **60** and slabbed surface **106**, an additional insert **110** is provided below and adjacent insert **108** within carrier **48**.

Once the pressure against the upper end of carrier **48** overcomes the bias of Belleville spring **82** as well as the frictional contact between locking elements **60** and piston rod **24**, carrier **48** will begin to move downwardly. Simultaneously therewith, locking elements **60** will begin to move out of frictional engagement with piston rod **24**, as balls **76** ride along tapered portion **44** of fixed housing **30** and permit a corresponding expansion of compression springs **70**. In order to eliminate any resistance due to the air trapped beneath carrier section **52**, a suitable exit passage **112** is drilled through cylinder **20** and housing **30** in the general vicinity of Belleville washers **83**. During this downward movement of carrier **48** together with locking elements **60** therein, piston **22** is freed for the elevational movement required to return mortar tube **16** to the original sighting inclination thereof prior to the next firing thereof. However, in the event the displacement imparted to mortar tube **12** by the recoil forces generated during firing is limited to movement in azimuth alone, there will be no air flow which can be tapped to actuate carrier **48** for disengaging elements **60** out of frictional contact with piston rod **24**. Nevertheless, since balls **76** on the exterior of the locking elements **60** are in rolling contact with tapered section **44** of fixed housing **30**, carrier **48** is free to rotate therein together with piston rod **24** during the recoil movement of firing tube **12** in the azimuth direction. In fact, elements **60** can be unlocked from piston rod **24** in the manner previously described even while piston rod **24** is being rotated together with carrier **48** in response to azimuth displacement of firing tube **12**. Such flexibility of operation is required in those instances wherein the firing of tube **12** imparts recoil movement thereto in both azimuth and elevation.

Once the air pressure against the upper end of carrier **48** falls below the bias of Belleville spring **82**, the resulting upward movement imparted thereby to carrier **48** will cause tapered section **44** in housing **30** to cam balls **76** inwardly thereby forcing locking elements **60** together into frictional engagement with the exterior periphery of piston rod **24**. Upward movement of carrier **48** is halted when the diameter across the interior of housing **30** equals the overall distance between balls **76**. At that point, locking elements **60** are in maximum frictional contact with piston rod **24**.

Thus, there is here provided a reliable and sensitive lock responsive to a fluidic control system incorporated in a tripod mount for a mortar for retaining an elevating piston against the weight of the firing tube of the mortar. The lock is automatically engaged with the elevating piston during all periods of inactivity between successive firings of the mortar and is also automatically disengaged therefrom whenever the recoil forces generated during the firing of the mortar imparts a predetermined minimum elevational displacement of the firing tube. The lock is also readily adjustable for mortars with firing tubes of different weights.

The foregoing disclosure and description of the invention is illustrative only. Various changes may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. In a fluidic system for imparting intermittent axial displacement to a piston slidably disposed in a cylinder, means for locking the piston in a stationary position at the conclusion of each displacement thereof, comprising,

a housing fixed within the interior of the cylinder, said housing having a tapered interior portion and a port for the entry therein of a flow of fluid,

a hollow carrier slidably fitted between said housing and the piston in position to be axially displaced by said flow of fluid,

a pair of arcuate locking elements seated in said carrier for transverse movement into and out of locking engagement with the piston,

a ball rotatably mounted in the exterior of each of said locking elements for protrusion from said carrier,

first spring means seated between said locking elements for urging said balls into rolling contact with said tapered interior portion of said housing, and

second spring means normally urging said carrier toward said entry port whereby said tapered interior portion of said housing cams said balls inwardly to force said locking elements into frictional locking engagement with the piston.

2. The piston locking means defined in claim **1** wherein said carrier is provided with diametrically opposed openings of spherical contour for rotatably retaining said balls therein.

3. The piston locking means defined in claim **1** wherein said first spring means comprises a pair of compression springs seated between said locking elements at diametrically opposed locations.

4. The piston locking means defined in claim **1** wherein said second spring means comprises a plurality of alternately stacked concave and convex spring washers selected to impart a predetermined bias against said carrier.

5. In a fluidic control system responsive to the recoil displacement of the firing tube of a mortar for actuating a piston rod to return the tube to the original sighting inclination thereof, means for locking the piston rod against axial displacement following each actuation thereof, comprising,

a fixed cylindrical housing surrounding the piston rod, said housing having an entry port for admitting a flow of fluid therein and a tapered interior portion spaced from the piston rod,

a hollow carrier slidably disposed intermediate the interior of said housing and the exterior of the piston rod in the path of said flow of fluid from said entry port, said carrier having diametrically opposed transverse openings therethrough,

a pair of semi-annular locking elements seated in opposed relation in said carrier for transverse movement into and out of locking engagement with the piston rod,

a ball rotatably mounted in the exterior of each of said locking elements to protrude through said transverse openings in said carrier.

a pair of compression springs seated between said locking elements at diametrically opposed locations for urging said balls into rolling contact with said tapered interior portion of said housing, and

a plurality of alternately stacked concave and convex spring washers adjacent the end of said carrier remote from said entry port in said housing for imparting axial displacement thereto whereby said tapered interior portion of said housing cams said balls inwardly to force said locking elements into frictional engagement with the exterior periphery of the piston rod.

6. The piston rod locking means defined in claim **5** wherein said carrier is rotatably disposed in said housing for rotation together with the piston rod when said locking elements are in frictional engagement therewith.

7. The piston rod locking means defined in claim **5** including an insert adjustably threaded into said housing to impart a predetermined degree of compression to said stack of spring washers.

8. The piston rod locking means defined in claim **5** wherein said transverse openings are spherically contoured with the end thereof at the interior of said carrier diametrically larger than the end at the exterior thereof to thereby retain said balls for rolling contact with said tapered interior of said housing.

9. In a tripod mount having a pison rod rotatably and slidably disposed in a cylinder for supporting the firing tube of a mortar at a desired inclination and a fluidic control system responsive to the recoil displacement of the firing tube in both azimuth and elevation for actuating the piston rod to restore the tube to the original inclination thereof, the combination of,

a cylindrical housing fixed in the cylinder to surround a portion of the piston rod, said housing having a port in the upper end thereof for entry of fluid from the control system and an interior portion of upwardly decreasing taper disposed below said port,

a hollow carrier rotatably disposed in said housing in the flow path of the fluid from said entry port for axial displacement relative to said housing and to the piston rod, said carrier having opposed openings extending transversely therethrough,

a pair of semi-annular oppositely disposed locking elements seated in said carrier for transverse movement into and out of locking engagement with the piston rod,

a ball rotatably mounted in the exterior of each of said locking elements in position to protrude through said transverse openings in said carrier,

a pair of compression springs seated between said locking elements for urging said balls into rolling contact with said tapered interior portion of said housing,

an insert adjustably threaded into the end of said housing remote from said entry port, and

a plurality of alternately stacked concave and convex spring washers seated between said insert and the underside of said carrier whereby the flow of fluid through said entry port in said housing at the beginning of each actuation of the piston rod forces said carrier downwardly against said spring washers to thereby permit said compression springs to urge said locking elements out of frictional engagement with the piston rod and whereby said spring washers urge said carrier upwardly at the conclusion of each actuation of the piston rod to thereby permit said tapered interior portion of said housing to cam said balls inwardly and return said locking elements into locking engagement with the piston rod.

10. The combination defined in claim **9** including,

a slabbed surface extending along the exterior periphery of the piston rod beyond the ends of said housing,

a plurality of chordal inserts secured to the interior of said carrier in contact with said slabbed surface for completing the exterior periphery of the piston rod,

means for sealing the interior of said housing against leakage of the flow of fluid directed against said carrier, and

an exit passage through the housing and the cylinder positioned to permit the escape of the air trapped between said carrier and said threaded insert during the downward displacement of said carrier.

* * * * *