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Mailliet

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[54] **APPARATUS FOR INDICATING THE POSITION OF THE PISTON OF A FLUIDIC ACTUATOR**

[75] Inventor: **Pierre H. Mailliet,** Luxembourg, Luxemburg

[73] Assignee: **S.A. des Anciens Etablissements Paul Wurth,** Luxembourg, Luxemburg

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[52] **U.S. Cl.** ..... **92/5 R;** 92/33; 92/113; 116/127

[51] **Int. Cl.²** **F01B 31/12**

[58] **Field of Search** ..... 116/124 R, 124 A, 124 F, 116/127; 91/1, 61; 60/699; 92/5 R, 31, 33, 113, 116, 177

[56] **References Cited**

UNITED STATES PATENTS

243,450	6/1881	Lafargue	92/33 X
2,704,047	3/1955	Lushenko	116/124 R
2,936,737	5/1960	Miller	92/31 X
3,077,179	2/1963	Evanson	116/127 X
3,186,311	6/1955	Carlson	92/33 X
3,386,340	6/1968	Engle	91/61
3,633,534	1/1972	Hersey	116/124 R
3,766,831	10/1973	Yeakley	91/61

Primary Examiner—Richard C. Queisser
Assistant Examiner—Daniel M. Yasich

[57] **ABSTRACT**

Apparatus for providing an indication of the position of the piston within a fluidic actuator. The apparatus comprises means positioned within the actuator cylinder and coupled to the piston for converting longitudinal motion of the piston to rotary motion which is transmitted out of the cylinder to a suitable indicator.

8 Claims, 3 Drawing Figures

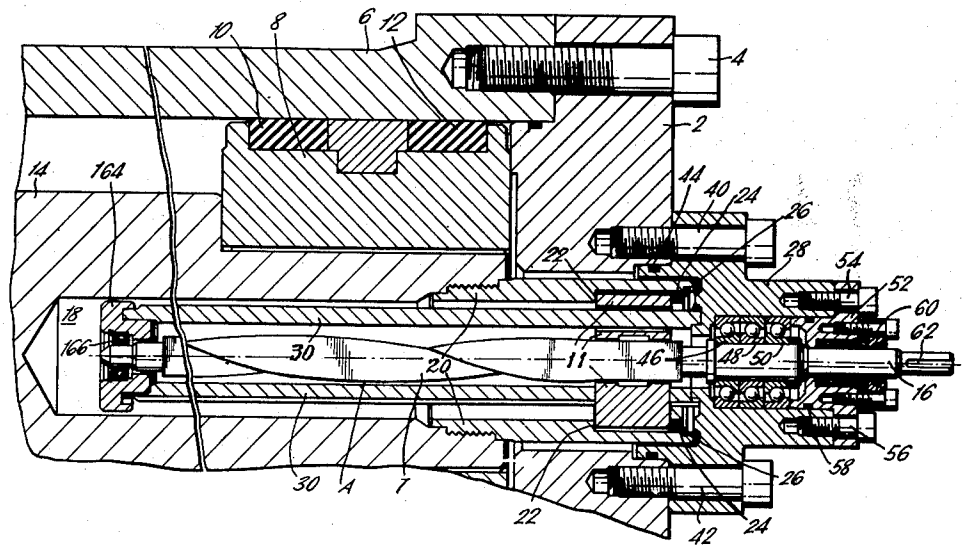

FIG. 1.

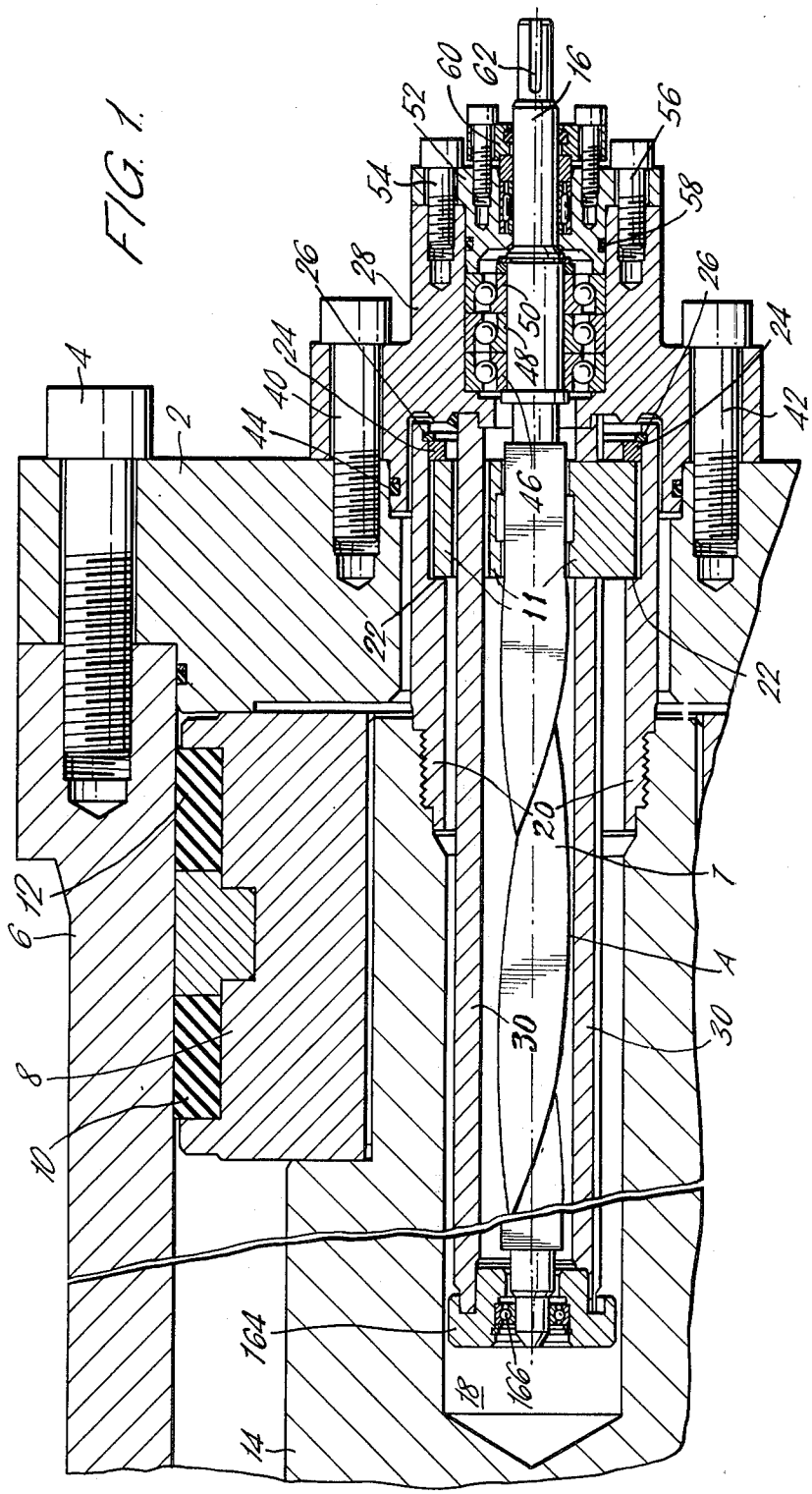
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FIG. 2.

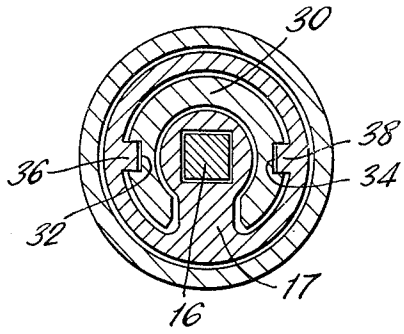
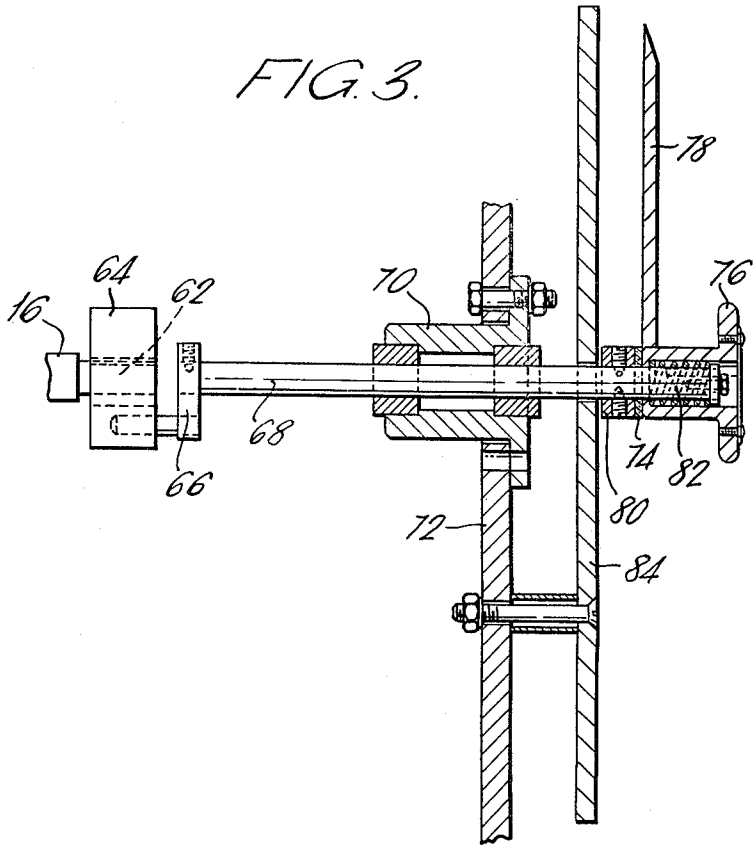


FIG. 3.



APPARATUS FOR INDICATING THE POSITION OF THE PISTON OF A FLUIDIC ACTUATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the determination of the position of movable members and particularly of longitudinally movable members which are moved in response to a pressurized fluid. More specifically, this invention is directed to means for accurately and continuously determining the position of the piston of a hydraulically or pneumatically operated actuator in a manner which does not require contact with the actuator output shaft or to a load coupled thereto. Accordingly, the general objects of the present invention are to provide novel and improved methods and apparatus of such character.

2. Description of the Prior Art

There are numerous situations where the position of the piston of a hydraulic or pneumatically operated actuator is important control data. In the prior art, in an effort to provide such data, piston position has conventionally been determined as a function of the position of the load on the actuator. Thus, it is conventional prior art practice to interconnect a piston actuator and load by means of rod connections or intermediate gears and to employ the connections or gears to generate a signal commensurate with piston position. The determination of piston position via a comparatively complicated intermediate device, which is of necessity susceptible to failure and which must be redesigned and reconstructed for each operating environment, has obvious inherent deficiencies. Additionally, because of the peculiar arrangement of the load, many situations are encountered wherein the use of an intermediate device is either impossible or not economically feasible. When an intermediate position sensing device could not be employed, and access to the movable load was possible, the prior art has typically resorted to the use of a plurality of load operated limit switches which provide stepwise information with respect to the position of the load. There are numerous instances where access to the load is impossible or stepwise positional information is insufficient for control purposes and/or the use of an intermediate position signal generating device between the piston and load is impossible.

In view of the problems briefly discussed above, the prior at has long sought a mechanism directly located on the cylinder of a hydraulically or pneumatically operated jack or actuator for providing information regarding the position of the piston in the jack continuously and completely independently of the load on the piston. It is to be noted that attempts have been made to provide positional information with respect to hydraulically operated jacks by measuring the quantity of hydraulic fluid flow to or from the jack. These prior art flow measuring devices have been comparatively fragile, complicated and inaccurate.

The sensor portion of a positional measuring device for a hydraulic or pneumatically operated actuator must obviously be at least partly arranged within the piston cylinder. The problems associated with sensing the position of a piston located within a cylinder and having no direct engagement point outside of the cylinder are substantial and numerous. Thus, by way of example, the means for transmitting a signal commensurate with piston longitudinal motion through the cylinder casing must be sealed against leakage at the comparatively high pressures which occur. Additionally, frictional contact must be minimized within the cylinder since any metal fragments resulting from abrasion will damage the piston rings and/or the cylinder walls thereby destroying the jack itself. Furthermore, although the piston in a hydraulic or pneumatically operated jack is provided with excellent guidance and support in its working or longitudinal direction, the piston is typically not restrained from rotation within the cylinder casing. The possibility of rotational motion obviously greatly complicates the problem of accurately sensing piston position within the cylinder and thereafter transmitting such motion outside of the cylinder.

It has been suggested that the above briefly described problems could be solved by means of affixing a tubular indicator extension to the piston within an actuator cylinder; the extension passing through an end wall of the cylinder and being provided with a scale relating to piston position. In the case of an actuator having a large stroke this proposed solution would present space problems in addition to the sealing problems alluded to above. Thus, not only would space have to be provided for the lengthy extension, and the extension would be susceptible to damage, but additionally the high working pressures within the cylinder would make it virtually impossible to obtain an adequate sliding seal for the extension.

SUMMARY OF THE INVENTION

The present invention overcomes the above briefly discussed and other deficiencies and disadvantages of the prior art by providing a technique and apparatus for continuously and accurately determining the position of a piston of a hydraulically or pneumatically operated actuator. Apparatus in accordance with the present invention includes means disposed within the cylinder of a fluid operated actuator for converting longitudinal movements of the piston into rotational motion which is transmitted through a cylinder wall to a suitable indicator. Apparatus in accordance with the present invention is further characterized by means which prevents unintentional rotary motion of the longitudinal-to-rotational converting means, such as might be caused by rotation of the actuator piston, thereby insuring accurate positional measurements.

In a preferred embodiment of the invention the piston of a hydraulically or pneumatically operated actuator, and possibly also the piston rod, are provided with a recess or blind hole which extends inwardly from a first end of the piston. A shaft rotatably supported at the cylinder wall, and specifically to a cylinder cover plate, extends into the recess in the piston. At least a portion of the shaft is constructed so as to perform the function of a worm gear. An extension of the rotatable shaft penetrates the cylinder wall and is connected to an indicator located to the exterior of the cylinder.

Also in accordance with the preferred embodiment of the invention, a "setting ring" or nut is carried by the inner wall of the recess in the piston. The "setting ring" moves with the piston and engages the portion of the shaft which functions as a worm gear whereby longitudinal movement of the "setting ring" results in rotation of the shaft. In order to avoid unintentional rotation of the "setting ring", which would falsify the measured value, apparatus in accordance with the present invention may also include means which guides the "setting

ring" in the longitudinal direction while preventing rotational movement thereof. The means for guiding the "setting ring" may take the form of a slotted tube affixed to the cylinder cover plate and projecting into the piston recess. The slotted tube, when employed, will be rigid and will be coaxial with the "setting ring"; the "setting ring" being provided with wedges which travel in slots in the tube. In one embodiment the "setting ring" is positioned to the interior of the slotted tube and is provided with means for simultaneously guiding and imparting rotation to the worm gear portion of the shaft. In a preferred embodiment, the portion of the shaft which performs the function of worm gear was constructed such that a complete working stroke of the piston was converted into a complete or partial rotation of the shaft.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be better understood and its numerous objects and advantages will become apparent to those skilled in the art by reference to the accompanying drawing wherein like reference numerals refer to like elements in the several figures and in which:

FIG. **1** is a longitudinal view, partly in section, of a portion of an actuator having incorporated therein the piston position measuring apparatus of a preferred embodiment of the present invention;

FIG. **2** is a cross-sectional side view of the embodiment of FIG. **1** taken through the portion of the device located within the actuator cylinder; and

FIG. **3** is a side elevation view, partly in section, of an indicating instrument which may be associated with the apparatus of FIG. **1.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. **1,** the cylinder of a fluid operated actuator is indicated at **6.** A cover plate **2** for a first end of cylinder **6** is affixed to the cylinder by means of bolts such as bolt **4.** A longitudinal movable piston **8** is located within cylinder **6;** piston **8** being provided with sealing rings **10** and **12** in the conventional manner. The piston **8** is attached to a piston rod **14;** rod **14** ultimately being coupled to the load mechanism operated by the actuator. In FIG. **1** the piston **8** is shown in its most inward position; i.e., at the beginning of a stroke. In the interest of facilitating understanding of the invention, the means whereby the operating fluid is supplied to the interior of the actuator cylinder has not been shown. It will be understood that the operating fluid will be delivered to the rear side of piston **8** via suitable passages provided therefore in cover plate **2** and, if necessary, operating fluid may be delivered to the other side of piston **8** via a port provided in the wall of cylinder **6.**

In accordance with the present invention longitudinal movements of piston **8** and piston rod **14** are converted into rotary movement of a shaft **16** and the rotational movement of shaft **16** is transmitted to an indicator located to the exterior of the actuator. The foregoing objective is achieved by providing the piston **8** and rod **14** with a central recess or blind hole **18.** The shaft **16** is introduced into recess **18** and the recess and shaft are dimensioned such that the shaft does not leave the recess during the operating stroke of the piston. The portion **7** of the shaft **16** which is located within the actuator cylinder and extends into recess **18** is constructed as elongated gear means as for example, an extended worm gear or as a square bar twisted about its longitudinal axis Drive means comprising a setting ring or nut **17,** which may most clearly be seen from joint consideration of FIGS. **1** and **2,** is mounted so as to move with piston **8.** The setting ring **17** is also mounted, in the manner to be described in detail below, so as to be restrained against rotation. The setting ring **17** engages and thus imparts rotational movement to the twisted square bar or gear comprising shaft **16.**

The setting ring **17** is held in a piston rod insert **20** by means of contact with abutting face **22** of insert **20,** which prevents longitudinal movement of the nut **17** relative to the positon from the right to the left as the apparatus is shown in FIG. **1,** and by a spacer **24** and a split ring **26.** Insert **20** is screwed into an internal thread provided in the recess **18** of the piston-piston rod assembly. As will be obvious to those skilled in the art, the piston **8** and insert **20** can, if desired, be integral.

Any unintentional rotational movement of setting ring **17** will lead to an incorrect indication of piston position. Accordingly, to prevent the rotation of setting ring **17,** a slotted supporting tube **30** is rigidly attached, for example by welding, to a base plate **28.** The base plate **28** is attached to cylinder cover plate **2** by means of bolts **40** and **42.** The supporting pipe **30** also extends into recess **18** in the piston-piston rod assembly. As may best be seen from FIG. **2,** the supporting tube **30** is provided, in the disclosed embodiment, with two longitudinally extending grooves **32** and **34.** The setting ring or nut **17** is shaped so as to define a pair of generally coaxial passages. The innermost of these passages is of suitable shape so as to engage the twisted square bar comprising shaft **16.** The second or outwardly disposed passage in nut **17** receives the slotted support tube **30.** The setting ring **17** is provided with inwardly extending longitudinal projections **36** and **38** which respectively engage grooves **32** and **34** of the supporting pipe **30.** Accordingly, the setting ring **17** is guided in the longitudinal direction along the supporting tube **30** and can not rotate with respect thereto. The setting ring or nut **17,** although an integral member, may be considered as two elements; a first element being located outside of the supporting tube **30** and the second element being located within the tube **30,** the two elements being interconnected by the slot in tube **30** as shown in FIG. **2.**

The portion of the setting ring **17** located to the exterior of the support tube **30** is carried longitudinally by piston **8** via insert **20** and, as noted, rotational movement of setting ring **17** is prevented by means of the engagement of projections **36** and **38** on ring **17** with grooves **32** and **34** of tube **30.** The portion of setting ring **17** located to the interior of tube **30,** however, engages and causes rotation of the stationary shaft **16** during longitudinal movement of the piston. As may be seen from FIG. **2,** sufficient clearance is provided between tube **30,** setting ring **17** and shaft portion **7** of **16** so that excessive abrasion or friction is avoided and maximum measuring precision is insured. In operation the piston **8** and piston rod **14** can rotate without influencing the longitudinal position measurement.

The shaft **16,** or more precisely a cylindrical extension thereof, is passed out of the actuator cylinder through an aperture provided in the cylinder cover

plate **2.** The aforementioned base plate **28,** in the manner to be described below, provides for the support of shaft **16** as it extends out of the actuator cylinder. A sealing ring **44** insures against leakage between the interior and exterior of the cylinder between plates **2** and **28.**

The base plate **28** is also provided with a central aperture. Bearing means for the mounting of shaft **16** are positioned in the aperture in plate **28** in the manner shown; the bearings being indicated at **46, 48** and **50.** The bearings **46, 48** and **50** are located against an internal shoulder in the aperture in plate **28** and are restrained against longitudinal movement in the opposite direction by means of a bearing bracket **52;** bracket **52** in turn being attached to base plate **28** via bolts **54** and **56.** A sealing ring **58** is provided to prevent leakage of pressurized fluid from the interior of the actuator cylinder to the outer atmosphere past the supporting bearings for shaft **16.** Additionally, the bearing bracket **52** carries a gland **60** to provide additional sealing.

The end of shaft **16** which extends out of the actuator; i.e., the portion of the shaft which extends outwardly past the base plate **28,** is provided with a keyway **62.** As will be described below in the discussion of FIG. **3,** the keyway **62** permits the coupling of shaft **16** to a position indicator.

As will be obvious to those skilled in the art, should the portion of shaft **16** which extends into piston-piston rod recess **18** become unduly long with respect to its cross-section, a sagging of the shaft could result. Should the possibility of a bending or sagging of shaft **16** be presented due to the dimensions of the actuator, shaft **16** may be rotatably supported at its inwardly disposed end in the manner shown in FIG. **1.** The supporting and mounting of shaft **16** at the inwardly disposed end is achieved by means of apparatus **164** which is affixed to the slotted supporting pipe **30** and is provided with a ball bearing **166;** bearing **166** receiving a cylindrical tip portion of shaft **16.**

Referring now to FIG. **3,** the keyway **62** of shaft **16** may be engaged by a connecting member **64.** Connecting member **64** is rigidly and eccentrically coupled to a transfer arm **66** which, in turn, drives a shaft **68.** The shaft **68** is supported and mounted in a bearing block **70** which is attached, by means of a plate **72,** to the outer casing of the actuator. The shaft **68** extends through plate **72** and is connected to a box nut **76** via a coupling slip ring **74.** An indicator finger or dial **78** is attached, in any suitable manner, to the box nut **76.**

The coupling slip ring **74** is retained by means of a further ring **80** affixed to shaft **68** in the manner shown. The box nut **70** is elastically and uniformly urged against the slip ring **74** by means of the internal spiral spring **82.** The elastic coupling of the box nut to the slip ring prevents bending of the indicator dial or finger **78** in the event of an accidental blockage of the natural movement thereof. The attachment plate **72** also serves to support an indicator panel **84** which is positioned behind the dial **78.**

While not limited thereto in its utility, the above described invention has been found to be particularly well suited for use in association with a clay gun of a blast furnace tap hole plugging machine. In such clay guns the quantity of packing material expelled is of interest to the operator, who must due to safety considerations remain a considerable distance from the tap hole, and may be determined as a function of the longitudinal movement of a hydraulically operated piston. The present invention has proven to be extremely reliable in the severe working environment of proximity to a blast furnace.

As will now be obvious to those skilled in the art, the present invention comprises an accurate and substantially maintenance-free means for determining the position of the piston of a hydraulically or pneumatically operated actuator. In accordance with the present invention the conversion of the longitudinal movement of the piston into the rotation of an output shaft greatly facilitates solution of the problem of providing adequate sealing between the interior of the actuator and the outside atmosphere and, in fact, permits such sealing to be achieved with conventional apparatus. Additionally, the incorporation of the slotted supporting pipe **30** of the present invention permits the above described measuring device to be utilized in apparatus wherein the piston and piston rod are not axially aligned. The apparatus of the present invention can be universally employed as a result of the independence of the measuring device from the particular load on the actuator.

While a preferred embodiment of the present invention has been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustration and not limitation.

What is claimed is:

1. Apparatus for determining the position of a piston of a fluid operated actuator, the piston being movable longitudinally within a cylinder and being provided with a recess in a first end thereof, the position determining apparatus comprising:

elongated gear means extending into the recess in the actuator piston;

means mounting said gear means for rotation, said mounting means being at least in part supported from a wall of the actuator cylinder which faces the piston first end;

drive means mounted on the actuator piston for movement therewith, said drive means engaging said gear means, longitudinal motion of the actuator piston with respect to said gear means being coupled to said gear means by said drive means and producing rotation of said gear means;

means for transmitting the rotational motion of said gear means through said actuator cylinder wall, said motion transmitting means being coupled to said gear means; and

means positioned exteriorly of the actuator cylinder and connected to said transmitting means for providing an indication of piston longitudinal position.

2. The apparatus of claim **1** wherein said means mounting said gear means for rotation comprises:

bearing means supported by said actuator cylinder wall; and

means for preventing leakage of fluid between the interior and exterior of said cylinder about said bearing means.

3. The apparatus of claim **1** further comprising:

means for preventing rotation of said gear means in response to rotational movements within the actuator, said rotation preventing means interconnecting said drive and mounting means.

4. The apparatus of claim 3 wherein said rotation preventing means comprises:

a supporting member extending generally coaxially of said gear means, said supporting member limiting said drive means to longitudinal movement with the actuator piston.

5. The apparatus of claim 4 wherein said drive means comprises:

ring means mounted for longitudinal movement with the actuator piston, said ring means being provided with at least a first passage which engages said elongated gear means, said ring means further being provided with at least a first projection which engages said supporting member.

6. The apparatus of claim 5 wherein said ring means comprises:

a nut, said nut defining a pair of generally coaxial passages therethrough, the inner of said passages engaging said elongated gear means and the outer of said passages receiving said supporting member.

7. The apparatus of claim 6 wherein said supporting member comprises:

a slotted tube.

8. The apparatus of claim 7 wherein said means mounting said gear means for rotation comprises:

bearing means supported by said actuator cylinder wall; and

means for preventing leakage of fluid between the interior and exterior of said cylinder about said bearing means.

* * * * *