Dec. 3, 1968 T. P. WATSON ET AL 3,414,693

CYLINDER HEAD LIMIT SWITCH ASSEMBLY

Filed April 29, 1966

FIG. 1

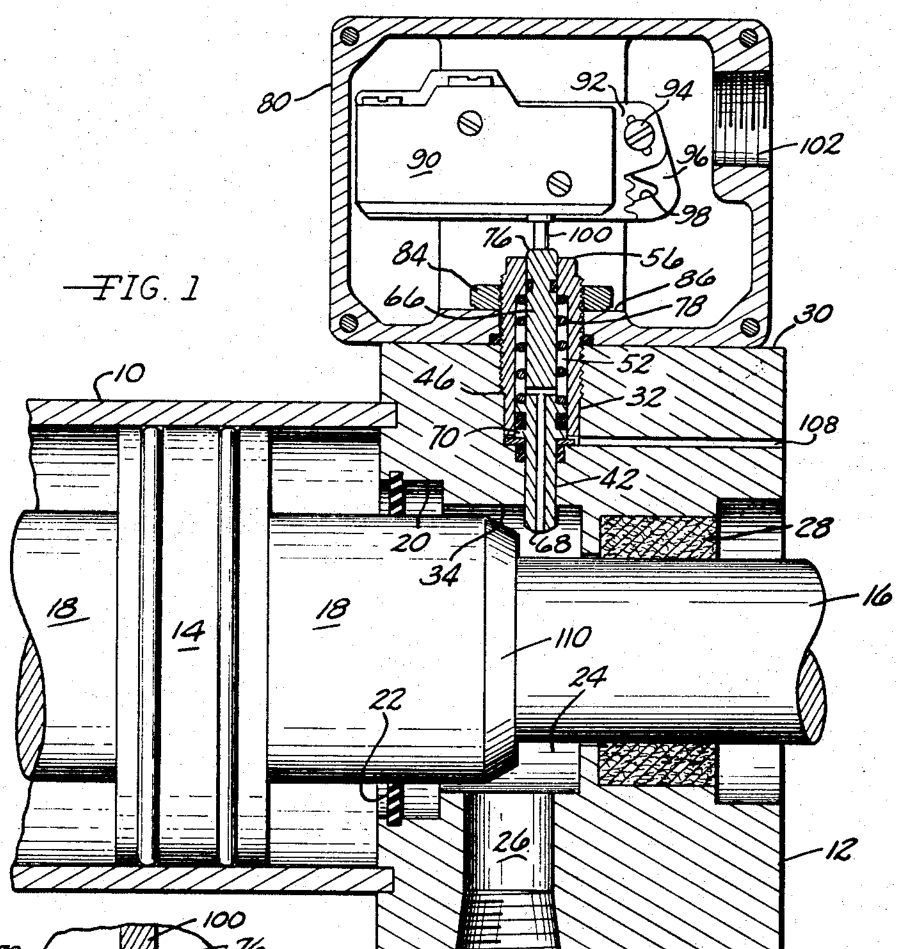


FIG. 2

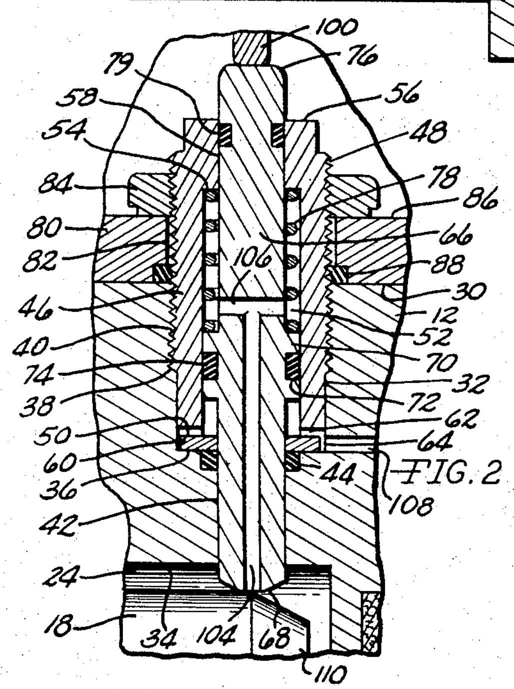
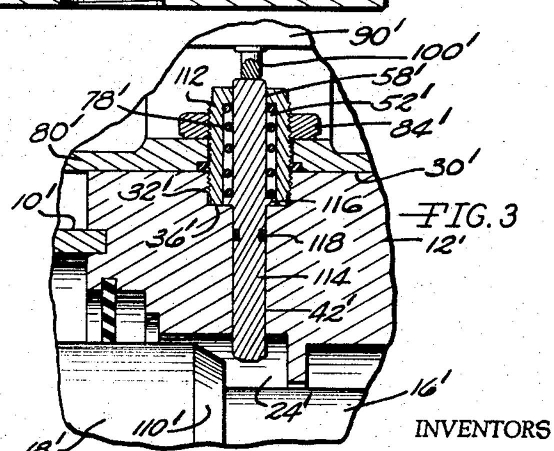


FIG. 3



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CYLINDER HEAD LIMIT SWITCH ASSEMBLY

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The invention pertains to expansible motor apparatus and particularly relates to a cylinder head assembly incorporating a limit switch and actuator.

Expansible chamber motor devices of either the compressed air or hydraulic type, wherein relative axial movement occurs between a sylinder and a piston member located therein, are often controlled by electric switches. In the incorporation of expansible chamber motors in many applications, the control for such motors often includes electric solenoid valves which are operated by switches sensing the position of the motor piston, for instance. The machine designer, when incorporating a limit switch control with an expansible chamber motor device, usually mounts a switch abutment directly on the motor piston structure or on structure motivated or actuated by the movable expansible chamber motor element. An electrical switch is placed within the path of movement of the abutment whereby the abutment is capable of actuating the switch in response to the position of the movable motor component. While the location of the limit switch and its abutment is often determined by the apparatus involved, there are a large number of installations wherein "standard" limit switch actuating means are practical and desired. For instance, in the utilization of expansible chamber motors, it is very common to desire limit switch actuation upon the completion of the full stroke of the motor.

While there has been some development work done with "built-in" limit switch actuators for expansible chamber motor devices, such as that shown in United States Patent 2,960,077, previous limit switch actuators which form a permanent part of the expansible chamber motor have proved expensive, troublesome and incapable of withstanding the shock, impact, vibration and adverse conditions under which such "built-in" limit switch actuators are subjected.

It is an object of the invention to provide an expansible chamber motor apparatus having a built-in limit switch actuator which indicates the extreme movement of a piston within a cylinder and wherein the apparatus is economical to manufacture, yet is capable of withstanding the adverse conditions to which such devices are exposed.

Another object of the invention is to provide an expansible chamber motor apparatus incorporating a "built-in" switch actuator wherein the switch actuator forms a part of the support for the switch mounting bracket and a close, unitary assembly between the switch actuator, the switch support and the switch, itself, is provided.

A further object of the invention is to provide an expansible chamber motor apparatus wherein a limit switch actuator is formed as a part of a cylinder head and wherein passage means are associated with the limit switch actuator to prevent any leakage of pressurized fluid into the actuator from adversely affecting the actuator operation.

An additional object of the invention is to provide an expansible chamber motor apparatus employing a limit switch actuator having a casing formed with an exteriorly threaded surface, whereby the threaded surface provides the means for retaining the actuator within the cylinder head and also forms the means whereby limit switch support structure may be mounted to the actuator and upon the cylinder head.

These and other objects of the invention arising from the relationships and details of components of embodiments of the invention will be apparent from the following description and accompanying drawing wherein:

FIG. 1 is a sectional, elevational view of an expansible motor cylinder and piston and associated head incorporating the limit switch and actuator thereof in accord with the invention, for use with expansible chamber motors employing a pressurized hydraulic fluid,

FIG. 2 is an enlarged, detail, elevational, sectional view of the limit switch actuator of FIG. 1 shown in the switch actuating position, and

FIG. 3 is a detail, elevational view of an embodiment of the invention, wherein the expansible chamber motor employs a pressurized gas such as compressed air.

FIG. 1 illustrates a typical relationship of components of an expansible chamber motor employing the concept of the invention. The motor includes a cylinder **10** having an end closed by a head **12** mounted thereon by tie rods or other conventional head-mounting means. Piston structure is reciprocably mounted within the cylinder **10** and includes a piston **14** and piston rod **16** having enlarged cushioning projections **18** defined thereon adjacent the piston. In the illustration of FIG. 1, the head **12** is that head through which the piston rod extends.

The head **12**, preferably, includes structure for cushioning the movement of the piston **14** as the piston approaches the head. Such cushioning structure includes a cylindrical orifice **20** concentrically related to the axis of the piston having an annular valve ring **22** located therein. The orifice **20** communicates with a chamber **24** and port **26** to which a supply and exhaust conduit, not shown, may be connected. As the piston **14** approaches and nears the head **12**, the right projection **18** will be received within the orifice **20** and cooperate with valving **22** preventing escape of the exhausting hydraulic fluid through the orifice **20** and the chamber **24**, and the fluid "trapped" between the piston and head **12** will cushion the movement of the piston toward the head. The "trapped" fluid is bled into the chamber **24**, or port **26**, by suitable bleed or throttle means, not shown. This type of operation is typified in the assignee's United States Patent 2,719,510. The head **12** includes a gland **28** which seals the piston rod with respect to the head to prevent the leakage of fluid from the motor.

Head **12** is provided with flat exterior surfaces such as that at **30** and a radially disposed opening **32** is formed in the head which intersects the exterior surface **30** and terminates short of the inner surface **34** of the chamber **24**. The opening **32** is defined at its "bottom" by a radial shoulder **36** and a radial shoulder is defined at **38**. Threads **40** are formed in opening **32** from the shoulder **38** to the exterior surface **30**.

A radially extending, cylindrical bore **42** is defined in the head **12** coaxial with the axis of the opening **32** and is formed with an inner end which intersects the chamber inner surface **34** for communication with the chamber **24**, and the outer end of the bore intersects the radial shoulder **36**. A seal-receiving recess **44** is formed in the head at the intersection of the bore **42** and the shoulder

36. As will be apparent from FIGS. 1 and 2, the diameter of the bore **42** is considerably less than the diameter of the opening **32**.

A cylindrical casing **46** is received within the opening **32**. The casing is exteriorly provided with threads **48** adapted to mate with the threads **40** of the opening, and the axial length of the casing **46** is considerably greater than the axial depth of the opening **32**, whereby when the lower end **50** of the casing is disposed adjacent the radial shoulder **36**, the upper or outer end of the casing substantially extends beyond the head exterior surface **30**.

Internally, the casing **46** is provided with a concentric, cylindrical chamber **52** which intersects the casing lower end **50**. The chamber **52** is of a diameter greater than the diameter of the bore **42** and terminates at its outermost end in a radial face **54** axially spaced from the end **50**. The casing outer end **56** is provided with a bore **58** of a diameter less than that of the chamber **52** which is coaxial with the chamber and intersects the chamber at the face **54**. The outermost end of the bore **58** intersects the outer end of the casing, whereby the chamber **52** and bore **58** define an axial passage through the casing.

An annular washer **60** is received within the opening **32** and rests upon the radial shoulder **36**. The inner end **50** of the casing is provided with small radial passages **62** which communicate with clearances **64** defined in the periphery of the washer **60** whereby a fluid passage is established between the innermost portion of the chamber **52** and the periphery of the washer for a purpose which will be later described. The washer **60** serves as a retainer for sealing means located within the recess **44** and also serves as an abutment for the flange of the plunger, as will be apparent later.

A plunger **66** is reciprocally mounted within the casing **46** and bore **42**. The plunger includes a cylindrical inner end portion terminating in an inner end **68** having beveled edges. The plunger inner end portion is dimensioned so as to be closely, yet slidably receivable within the bore **42**. An annular flange **70** is defined upon the plunger **66** about the configuration thereof adjacent the inner end portion. The flange **70** includes an annular groove **72** in which an O-ring seal assembly **74** is mounted. The flange **66**, in the embodiments of FIGS. 1 and 2, is dimensioned relative to the chamber **52** so as to form a piston therein, and a sealed, sliding relationship between the plunger flange and the chamber is produced by the O-ring assembly.

The outermost portion of the plunger **66** is of a reduced diameter which is capable of axial sliding movement through the bore **58** and terminates in an outer end **76**. The overall length of the plunger from the inner end **68** to the outer end **76** is greater than the distance from the chamber inner surface **24** to the casing outer end **56**, as will be apparent from FIGS. 1 and 2. A seal **79** mounted on the plunger outer portion seals the plunger with respect to bore **58**.

A compression spring **78** is located within the chamber **52** interposed between the chamber face **54** and the flange **70**. The biasing force exerted by the spring **78** tends to bias the plunger **66** to its innermost position, as represented in FIG. 1. As shown in Fig. 1, the normal position for the flange **70** is in engagement with the washer **60** due to the biasing action of the spring.

The support for the limit switch preferably consists of a rectangular housing **80** which employs a removable cover, not shown, whereby the limit switch may be completely enclosed within the housing. The housing includes a mounting opening **82** defined therein which is of a diameter slightly greater than the diameter of the casing **46**, whereby the casing may extend through the housing opening such that the casing outer end **56** and the plunger end **76** will be located within the housing. A nut **84** threaded upon the threads **48** of the casing bears against the housing inner surface **86** and maintains the housing in firm engagement with the head exterior surface **30**. A sealing O-ring **88** may be formed within a recess defined in the housing adjacent opening **82** to seal the housing against the entrance of moisture.

A limit switch **90** of the type commonly known as a "micro" switch is mounted within the housing **80** upon adjustable mounting means **92** including a screw **94** and a housing mounted bracket **96**, whereby the switch may be adjusted in a radial direction with respect to the cylinder **10** by inserting a screwdriver in the bracket notch **98**. Tightening of the screw **94** firmly affixes the position of the limit switch **90** within the housing **80**. The limit switch includes an actuator **100** which is in coaxial alignment with the plunger **66** and is engaged by the outer end **76** of the plunger during switch actuation. The switch housing is provided with suitable access means for conductors at **102**.

In the embodiment of FIGS. 1 and 2 wherein the pressurized medium introduced into the cylinder is a hydraulic fluid, an axial passage **104** is defined in the plunger **66** intersecting the inner end **68** thereof for communication with the chamber **24** and communicates with the casing chamber **52** through radial passages **106** at a location between the flange **70** and the face **54**. The passages **104** and **106** thus establish communication between the chamber **24** and the chamber **52**.

The area at the plunger inner end **68** subjected to pressurized fluid within the chamber **24** is substantially equal to the area of the flange **70** subjected to pressurized fluid within the chamber **52**. Thus, the passages **104** and **106** equalize fluid pressure on opposite sides of the plunger flange **70** and eliminates movement of the plunger due to fluid pressure within the chamber **24**.

In order to insure proper movement of the plunger **66** and in order to bleed off any fluid which may have seeped past the seal **44**, whereby the plunger is able to quickly return to the normal position shown in FIG. 1, a passage **108** is defined in the head **12**. At one end the passage **108** communicates with the atmosphere exterior of the head, and at the other end the passage communicates with the opening **32** adjacent the radial shoulder **36** and at the periphery of the washer **60**. Thus, the clearances **64** provided on the periphery of the washer **60** permit any fluid trapped below the flange **70**, when the plunger is in the operating position as shown in FIG. 2, to escape from the passage **108**, as the plunger tends to return from the position of FIG. 2 to that of FIG. 1.

In operation, the plunger **66** will be in the normal innermost position shown in FIG. 1. In this position, the inner end **68** of the plunger wil be disposed within the path of movement of the right piston structure projection **18**, and the projection is provided with a tapered surface **110**, whereby as the piston **14** approaches the head **12** and the projection enters the chamber **24**, the surface **110** will engage the plunger end **68** and lift the plunger, FIG. 2. Of course, raising of the plunger **66** will cause the plunger to actuate the limit switch actuator **100** and, upon a predetermined axial movement of the plunger, the actuator **100** will operate the contacts within the limit switch **90** to either open or close the limit switch contacts, depending on the type of limit switch employed. Thus, the limit switch **90** can be used to control any electrical device which is to be controlled upon termination of the movement of the piston **14** within the cylinder **10**. When pressurized fluid is introduced into the port **26** to move the piston **14** to the left, as soon as the piston projection **18** disengages from the inner end of the plunger **66**, the plunger will return from the limit switch actuating position of FIG. 2 to the normal position of FIG. 1. The resulting inward movement of the plunger will permit the limit switch contacts to return to the normal condition.

FIG. 3 illustrates an embodiment of the invention which is used with pressurized expansible chamber motors utilizing pressurized gases, such as compressed air. In the embodiment of FIG. 3, components similar to those previously described are indicated by primed reference numerals.

In the embodiment of FIG. 3, the bore **42'** is shown to be of a greater relative axial length than that of the opening **32'**, and due to the difference in conditions between air and liquid operated cylinders, it is possible to somewhat vary the dimensional relationships of similar components between the embodiments of FIGS. 1 and 3. The casing **112** is substantially identical to the casing **46** and has a lower end which is adapted to directly engage the radial shoulder **36'**. The casing **112** is provided with a chamber **52'** and has a bore **58'** formed at the upper end thereof coaxial with the chamber **52'**.

The plunger **114** is formed with a flange **116** adapted to directly engage the radial shoulder **36'** at the normal position under the influence of the compression spring **78'**. In order to prevent the escape of air between the plunger inner portion and the bore **42'**, an O-ring **118** is mounted within an annular recess refined in the inner end portion of the plunger.

The axial length of the casing **112** is such that the casing extends substantially beyond the exterior surface **30'** of the head **12'**, whereby the limit switch housing may be mounted to the casing by the nut **84'** in a manner identical to that of the previously described embodiment.

The plunger **114** is operated by the piston rod projection **18'** in the manner previously described, and as the flange **116** does not have a sealing relationship with the chamber **52'**, and as air is being employed as the pressurized medium, it is not necessary in the embodiment of FIG. 3 to utilize pressure-compensating and bleed passage in the plunger or head, as in the previous embodiment.

Expansible chamber limit switch and limit switch actuating structure in accord with the invention has proved very dependable through many thousand cycles of operation. The fact that the inner end portion of the plunger **66** is firmly supported by the bore **42** throughout a substantial axial distance of the plunger inner end provides the plunger with a rugged and high strength mounting which resists the impact imposed on the plunger each time the piston projection **18** engages the plunger. The simplified construction of the casing and plunger and the minimizing of the number of components involved substantially reduces the opportunity of malfunction or disassembly due to vibration. In that the nut **84** serves to mount the housing on the head **12** and is directly associated with the casing **46**, tightening of the nut serves as a locknut to also maintain the casing within the head opening **32**. Thus, should the nut **84** become unloosened, the resultant looseness of the switch housing **80** will be readily apparent to the operator before damage is likely to occur to the casing, plunger, or other associated apparatus.

In the described embodiments, the limit switch and associated actuating apparatus is shown as mounted in the head of an expansible chamber motor through which the piston rod extends. The limit switch apparatus may be associated with either head of a cylinder and in many cases limit switch apparatus will be mounted on the head located at each end of a common cylinder.

In the described embodiments, the axes of the casing and plunger are radially disposed with respect to the axis of the piston rod. However, it is intended that the limit switch actuating structure may be mounted in the head such that the axis of the plunger and casing may be parallel, though offset, with respect to the piston rod axis. In such an arrangement, it is not necessary that a projection such as **18** be mounted on the piston structure. Instead, the plunger inner end portion may be of such length as to directly engage the piston as it approaches the associated head. In such an arrangement, the structure employed with respect to the limit switch and the casing, plunger, etc. is identical to that shown in the described embodiments.

While the plunger **66** will usually be employed to operate an electric switch, it is within the scope of the invention to substitute other types of switches therefor. For instance, a hydraulic valve could be positioned on the head **12**, preferably mounted on the casing **46**, for actuation by the plunger **66**. Also, the structure of the invention mounted within the head has utility even though not employed with a switch in that the degree of extension of the plunger **66** from the casing **46** provides a visual indication as to whether or not the piston **14** is at its limit position relative to the associated head.

It is appreciated that various modifications may be apparent to those skilled in the art without departing from the spirit and scope thereof and it is intended that the invention be defined only by the scope of the following claims.

We claim:

1. Expansible chamber motor apparatus comprising, in combination, a cylinder having an end, a head enclosing said cylinder end and mounted thereon, said head including an exterior surface and an inner surface, piston structure reciprocably mounted within said cylinder, an actuating surface defined on said piston structure disposed toward said head whereby said surface is located adjacent said head inner surface upon said piston structure being located adjacent said head, a threaded opening defined in said head intersecting said head exterior surface, a smooth cylindrical first bore defined in said head coaxial with and intersecting said threaded opening and said head inner surface, a radial shoulder defined in said opening at the intersection of said opening and bore, said bore being of lesser diameter than said opening, a cylindrical casing having an inner end and an outer end and a threaded outer surface received within said threaded opening, said casing inner end being disposed adjacent said radial shoulder and said casing being of greater axial length than said opening whereby said casing outer end extends from said opening and projects beyond said head exterior surface, a cylindrical chamber defined in said casing coaxial therewith intersecting said casing inner end and defining a radial face disposed toward said casing inner end and axially spaced therefrom, said chamber having a diameter greater than that of said first bore, a second bore defined in said casing coaxial therewith intersecting said chamber face and said casing outer end, said second bore being of lesser diameter than said chamber, a plunger having a first cylindrical inner end portion reciprocally received within said first bore adapted to extend inwardly beyond said head inner surface, an enlarged circumferential flange reciprocably received within said chamber and an upper end portion reciprocably mounted within said second bore and adapted to extend therethrough, a compression spring within said chamber interposed between said face and said flange biasing said plunger toward said head inner surface, said plunger being of greater length than the distance from said head inner surface to said casing outer end whereby said plunger outer end extends from said second bore upon said plunger inner end being engaged by said piston actuating surface.

2. Expansible chamber motor apparatus as in claim **1**, a limit switch support mounted on said head exterior surface having a mounting opening defined therein, said casing outer end extending through said mounting opening, a nut threaded on said casing outer end holding said support in engagement with said head exterior surface and a limit switch mounted on said support having an actuator in alignment with said plunger upper end.

3. Expansible chamber motor apparatus as in claim **1**, wherein said flange normally engages said radial surface under the influence of said spring and said casing inner end engages said radial shoulder.

4. Expansible chamber motor apparatus as in claim **1**, wherein said plunger flange forms a piston operatively associated with said chamber, an axially extending passage defined in said plunger intersecting the plunger lower end and communicating with said casing chamber intermediate said flange and said chamber face, said passage establishing communication between the interior of said cylinder and said chamber.

5. Expansible chamber motor apparatus as in claim 4, wherein a passage is defined in said head establishing communication between the atmosphere exterior of said head and said chamber adjacent said radial shoulder.

6. Expansible chamber motor apparatus as in claim 5, wherein an annular washer circumscribes said plunger and is received within said chamber in engagement with said radial shoulder, said casing lower end engaging said washer and said flange adapted to normally engage said washer under the biasing force of said spring.

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