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HYDRAULIC ACTUATOR MECHANISM

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This invention relates generally to hydraulic actuator mechanisms and more particularly to hydraulic actuator or jack apparatus for elevating and depressing a cannon for proper aiming.

Elevating mechanisms for cannon elevation and depression must be capable of elevating a cannon barrel from a substantially horizontal position to any required position which may extend from said substantially horizontal position to a position, for example, close to vertical aiming. These requirements necessitate a substantially long stroke for the elevating actuator or jack and an adequate equilibration mechanism capable of automatically compensating for the variation of the load applied to the ends of the jack which, the load being constantly varying in function of the amount of elevation, varies from a maximum load when the cannon is in horizontal position to practically no load when the cannon is aimed vertically. These requirements are due to the fact that, in artillery material and combat vehicles, the trunnions pivotally supporting the cannon on its support frame are often located near the breech to provide more room for the recoil and to facilitate loading of the ammunition into the cannon breech. The trunnions are thus located some distance from the cannon center of gravity, and to counteract this unbalance condition an equilibration mechanism must be used if it is desired to expend reasonably small energy to elevate the cannon, especially in cases where the only source of energy available is manual power.

The present invention has for an object, therefore, to provide a hydraulic elevation mechanism for a cannon requiring relatively small power for elevating or depressing the cannon.

Another object of the present invention is to provide an elevation mechanism for a cannon comprising an automatic built-in equilibration system compensating for the variation of the load moved by the elevation mechanism.

A further object of the invention is to provide a hydraulic actuator using a constant volume of hydraulic fluid.

Another object of the invention is to provide a hydraulic actuator which is easy to manufacture and fool-proof in operation.

Further objects and advantages of the invention will become apparent from the description of the invention when considered with the drawings annexed thereto, but it will be immediately obvious to those skilled in the art that the hydraulic actuator mechanism of the invention presents considerable advantages which makes it a useful device in applications, including applications outside of the field of ordnance, requiring a hydraulic actuator or hydraulic jack capable of moving a relatively heavy load and possessing a high ratio of stroke to total length and including means for equilibrating the load, whether that load is constantly variable or not.

In the drawings:

FIGURE 1 illustrates an example of a hydraulic actuator or jack, according to the invention, utilized to elevate and depress the barrel of a turret mounted cannon;

FIGURE 2 illustrates another example of utilization of a hydraulic actuator according to the invention for elevating and depressing the barrel of a carriage mounted cannon, such as a "Howitzer"; and

FIGURE 3 is a schematic representation of an example of a hydraulic actuator or jack according to the principle of the present invention.

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Referring now to the drawings and more particularly to FIGURE 1 thereof a cannon barrel 10 is shown mounted on a turret 12 of a combat vehicle or ship, not shown. A trunnion 14, situated proximate the breech 15 of the cannon, acts as an elevation pivot axis for the cannon barrel 10 in relation to the turret 12. An elevation hydraulic actuator or jack 16 is disposed between a fixed pivotal point 20 on the turret 12 and a movable pivotal point 18 integral with, or affixed to the cannon barrel on the breech side. Where so required, in order to prevent torsion forces to be imposed upon the trunnion bearings, two actuators or jacks may be symmetrically disposed on both sides of the cannon barrel.

FIGURE 2 represents an artillery piece of the carriage 15 or "Howitzer" type comprising a cannon barrel 10 mounted on a cradle 22. The cradle is provided with a trunnion elevation axis 26 for elevation of the cradle in relation to a fixed carriage 24. A hydraulic actuator or jack 16 is disposed between pivot point 28 on the cradle 22 and pivot point 30 on the carriage 24.

It is apparent that in the applications of FIGURES 1 and 2 the hydraulic actuator or jack 16 operates against a constantly variable load depending from the amount of elevation of the cannon barrel 10. This load constantly varies from a maximum value when the cannon barrel is aimed horizontally to a minimum value, close or equal to zero, when the cannon barrel is aimed vertically. If it is desired to utilize substantially small power, such as manual power, to actuate the hydraulic jack or actuator 16, auxiliary equilibration means must be provided to counterbalance the muzzle side of the cannon barrel, or means must be included in the hydraulic actuator or jack to provide for equilibration. Furthermore, it is evident that the hydraulic actuator or jack must have a substantially large stroke to body length ratio in order to be fitted in the substantially small space available, when the cannon is aimed horizontally and the jack is contracted, and in order to be capable of being sufficiently extended when the cannon is aimed vertically. A ratio of close to 1 to 2 is often required, i.e. a total length when extended of twice the total length when contracted.

Referring now to FIGURE 3 in the drawings, the hydraulic actuator or jack of the invention, designated generally by numeral 16, comprises a first outer cylinder 32 provided with an internal bore 34. The first cylinder 32 has a closed end 36 and an open end provided with a stuffing box or end cap 38 having a bore 40 substantially aligned with the axis of the cylinder. The bore 40 is provided with sealing means 42.

A projecting cylindrical member 44 is disposed also along the axis of the cylinder 32 and has one end integral with or attached to the closed end 36 of the cylinder. The other end of the projecting cylindrical member 44 has an end face 46 situated substantially within the bore 40 of the end cap 38. A channel 48 leads to the end face 46.

A second cylinder 50 having an outer surface 52 of a diameter corresponding to the diameter of the bore 40 of the end cap 38 is adapted to be slidable therethrough. The second cylinder 50 has a bore 54 adapted to slidably surround the projecting cylindrical member 44. The inside bore 54 of the second cylinder has a closed end 56, and upon its open end an annular piston member 58 is disposed, integral therewith or attached thereon by any conventional means. The annular piston member 58 has a conventional sealing means 62 disposed to cooperate with the inner bore 34 of the first cylinder 32, and another sealing means 60 disposed to cooperate with the outer surface of the projecting cylindrical member 44.

The annular piston member 58 thus divides the bore of the first cylinder 32 into an annular contract chamber 64

and an annular equilibration chamber 66, and within the bore 54 of the second cylinder 50 an extend chamber 72 is provided between the end face 46 of the projecting cylindrical member 44 and the closed end 56 of the cylinder.

The hydraulic actuator or jack 16 is provided with mounting lugs or ears 74 and 76 for attachment to pivot pins on the components operated by the actuator or jack.

Contract chamber 64 is connected by way of port 68 and a pipe 78 to a control mechanism, designated generally by 80, and extend chamber 72 is connected by way of channel 48 and a pipe 82 to the control mechanism 80. The control mechanism 80, which is no part of the present invention, comprises a fluid transfer pump, power operated or manually operated by way, for example, of a handwheel 84, and an appropriate valving mechanism adapted to prevent leakage of fluid between pipes 78 and 82 when the pump is not operated. Additionally, the control mechanism 80 includes a source of fluid and a fluid accumulator to maintain the system slightly pressurized. The control mechanism may be a device as disclosed in United States Letters Patent No. 2,893,355, granted July 7, 1959, in the name of Russell E. Bauer.

The equilibration chamber 66 is at all times in fluid communication with an accumulator 110 by means of a pipe 96. The accumulator 110 is provided with a chamber 116, and chamber 116 and the equilibration chamber 66 are normally filled with a non-compressible fluid from a reservoir 102 by means of pump 100, pipes 98 and 104 and flow valves 106 and 108, bleed plug 94, being removed during the filling operation. The accumulator 110 consists of a cylinder 112 provided with a free piston or diaphragm member 114 dividing the cylinder into chamber 116 normally filled with non-compressible fluid and another chamber 118 normally filled with a compressible fluid such as air or a gas.

Prior to operating the hydraulic actuator or jack 16, chambers 72 and 64 are filled with fluid by means of the pump included in the control mechanism 80, bleed plugs 90 and 92 being removed. When the system is filled with fluid the bleed plugs are reinserted and the hydraulic actuator or jack is ready for normal operation.

The inner second cylinder 50 is caused to be displaced in relation to the outer first cylinder 32 by transferring fluid between the chambers 64 and 72, by means of the control mechanism 80. Assuming that the hydraulic actuator or jack is in a contracted position, fluid is transferred from contract chamber 64 to expand chamber 72, until the inner cylinder 50 has been displaced outwardly projecting from the end cap 38 of the desired length.

In order to contract the hydraulic actuator or jack 16 the transfer pump of the control mechanism 80 is actuated in an opposite direction, thereby transferring fluid from expand chamber 72 into contract chamber 64.

The cross-sectional areas of the annular contract chamber 64 and of the cylindrical expand chamber 72 are preferably equal so that the volume of fluid exhausted from a chamber is equal to the volume of fluid admitted to the other chamber, with the result that the volume of fluid utilized for operating the actuator or jack remains constant and the output power developed by the actuator or jack is the same irrespective of whether it is operating in one direction or the other.

When the actuator or jack is in an expanded condition, the equilibration chamber 66 is filled with fluid and little or no fluid is present in fluid chamber 116 of the accumulator 110. The air or gas in the accumulator gas chamber 118 is in a fully expanded condition, and the equilibration portion of the system is equilibrating little or no load.

When the actuator or jack is actuated toward a contracted position, the equilibration fluid is transferred from the equilibration chamber 66 into the fluid chamber 116 of the accumulator, via port 70 and pipe 96, thereby compressing the air or gas in the accumulator gas chamber

118. The resultant pressure upon the left face, as seen in the drawing, of the annular piston member 58 is proportional to the pressure of the air or gas in the accumulator gas chamber and is variable from a minimum when the actuator or jack is fully extended, to a maximum when the actuator or jack is fully contracted. As the load applied to the actuator or jack is also substantially constantly varying from a minimum to a maximum, it is evident that, by proper design, adequate dimensioning of the components and choice of the capacity of the accumulator, the constantly variable load will be adequately balanced by the equilibration portion of the invention.

It is also evident that, in applications where a constant load is to be moved by the actuator or jack, a source of fluid under constant pressure may be connected to the equilibration chamber 66.

What is claimed as new is:

1. A hydraulic actuator having a stroke substantially equal to its length for elevating and depressing a cannon for tipping said cannon substantially between a horizontal position and a vertical position, said actuator being mounted between a fixed support and a pivot point on said cannon and comprising in combination: a first cylinder with an inner bore having a closed end and an open end; an end cap affixed to said open end, said end cap being provided with a bore axially aligned with said first cylinder; a cylindrical projecting member attached to the closed end of said first cylinder and disposed coaxially therein from said closed end to within the bore in said end cap, said cylindrical member thereby defining an annular space within said first cylinder; a second cylinder having an inner bore coaxially and slidably disposed around said cylindrical projecting member and an outer surface slidable through the bore in said end cap, said second cylinder having an open end surrounding said projecting member and a closed end defining a cylindrical chamber situated between the end face of said projecting member and the inner face of the closed end of said second cylinder, said cylindrical chamber being normally filled with substantially incompressible fluid; an annular piston slidably disposed in the annular space within said first cylinder, said annular piston being affixed to the open end of said second cylinder and defining in said first cylinder a first annular chamber toward the closed end thereof and a second annular chamber toward said end cap and said annular piston having an effective area in said second annular chamber substantially equal to the effective area of the end face of said cylindrical projecting member, said first and second annular chambers being normally filled with substantially incompressible fluid; means transferring said substantially incompressible fluid between said second annular chamber and said cylindrical chamber to cause said second cylinder to linearly move in relation to said first cylinder; and conduit means connecting said first annular chamber to a source of variable pressure for constantly substantially balancing the weight of said cannon in any elevation position thereof, said source of variable pressure comprising an accumulator cylinder, a free piston in said cylinder, a normally closed gas filled chamber on one side of said piston and a fluid filled chamber on the other side of said piston, said fluid filled chamber being normally in fluid communication with said first annular chamber to cause fluid transferred between said first annular chamber and said fluid filled chamber to reciprocate said free piston so as to increase and decrease the pressure of the gas contained in said gas filled chamber.

2. A hydraulic actuator having a stroke substantially equal to its length and comprising: a first cylinder with a bore having a closed end and an open end; an end cap closing said open end and being provided with a bore along the axis of said first cylinder; a second cylinder slidably disposed within said first cylinder for slidable fit through said bore in said end cap, said second cylinder having an open end facing the closed end of said first cylinder and

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a closed end projecting through the end cap of said first cylinder; an internally projecting coaxial cylindrical member affixed to the closed end of said first cylinder for slidable fit within said second cylinder, said cylindrical member having an end face disposed within said second cylinder facing the closed end thereof, said projecting cylindrical member having a length substantially equal to the length of the bore of said first cylinder; an annular piston affixed to the open end of said second cylinder and slidable around said projecting cylindrical member and within the bore of said first cylinder; a cylindrical expand chamber disposed between the end face of said projecting cylindrical member and the closed end of said second cylinder; an annular contract chamber disposed between the annular piston and the end cap of said first cylinder; an annular equilibration chamber disposed between the annular piston and the closed end of said first cylinder; means transferring substantially uncompressible fluid between said expand chamber and said con-

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tract chamber; and means continuously introducing and exhausting variable pressure fluid into and from said equilibration chamber for balancing the weight of the load tending to contract said actuator, said last mentioned means comprising an accumulator cylinder, a movable partition in said accumulator defining a normally closed gas chamber on one side of said partition and a fluid chamber on the other side of said partition, said fluid chamber being normally in fluid communication with said equilibration chamber to cause fluid transferred between said equilibration chamber and said fluid chamber to vary the pressure of the gas in said gas chamber.

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