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MULTIPLE PISTON ELLIPTICAL FLUID CYLINDER

Filed July 15, 1958

FIG. 1

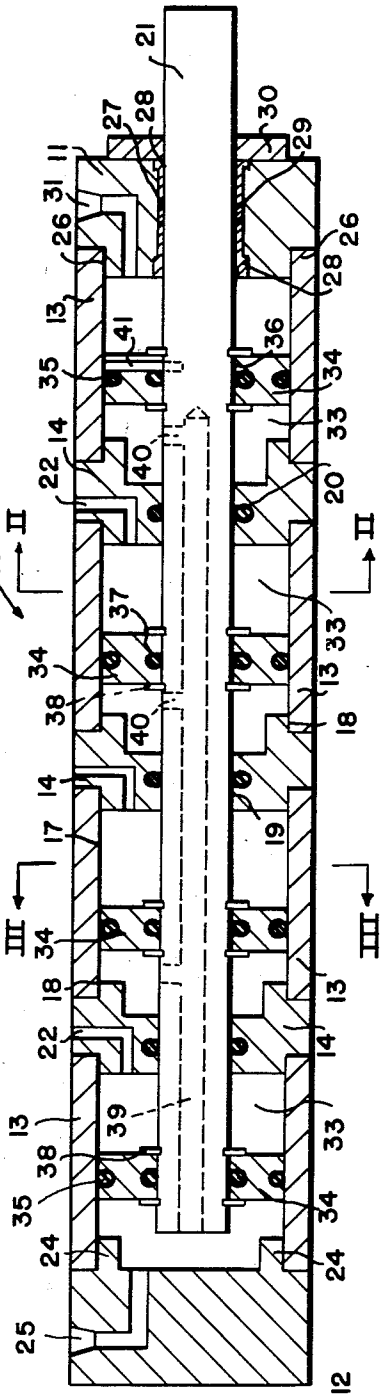


FIG. 3

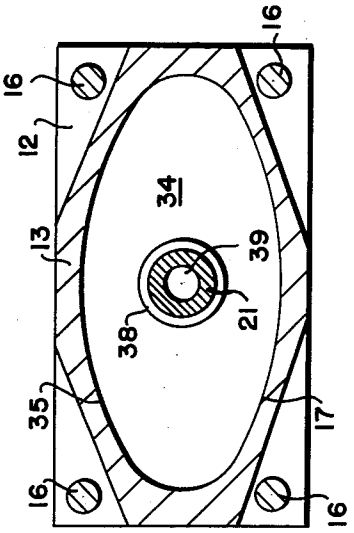
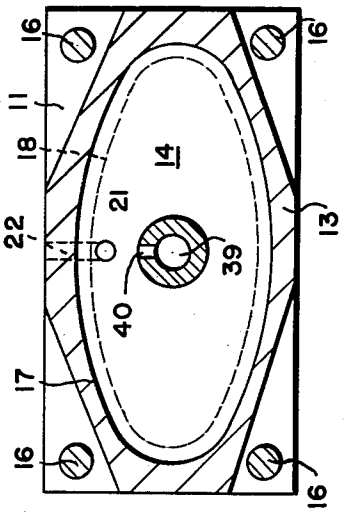


FIG. 2



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MULTIPLE PISTON ELLIPTICAL FLUID CYLINDER

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The present invention relates generally to powering or driving devices and more particularly to fluid cylinders of the force applying type.

It is the primary or ultimate object of the present invention to provide a fluid cylinder which is small in size and has small dimensions but yet is capable of applying extremely high forces to the driven or powered member. As will be understood, fluid cylinders are employed as the actuating means in many types of apparatus. In many instances a high force applying fluid cylinder of small size and dimensions is required since the space and clearances provided for mounting the cylinder are quite restricted due to other considerations. However, cylinders constructed in accordance with prior art teachings have not been able to fulfill these conditions—small size and high force applying capability—and this has somewhat limited the utilization of fluid cylinders where they otherwise might be advantageously employed.

In accomplishing the above object the fluid cylinder of the present invention is elliptical in cross sectional shape and has a plurality or multiplicity of pistons. The elliptical shape of the pistons and the number thereof provide large surface areas in order that high forces may be developed while the overall size of the fluid cylinder is extremely small.

A further object of the invention is to provide a fluid cylinder wherein the piston rod does not rotate but is always retained in one position with respect to the cylinder housing. The elliptical pistons guide and prevent rotation of the piston rod and in this manner guides, ways, etc. for guiding the movement of the driven member attached to the piston rod are completely eliminated.

Another object of the invention is to provide a multiple piston elliptical fluid cylinder which is characterized by its extreme versatility and flexibility and is adapted to be tailored for each individual application. The fluid cylinder of the present invention comprises a plurality of identical cylinder wall elements, cylinder spacer elements and elliptical pistons which are assembled in stacked relation and the fluid cylinder can be constructed to have exactly the force applying capability required; depending upon the number of wall elements, spacer elements and elliptical pistons employed.

Yet a further object of the present invention is to provide a multiple piston elliptical fluid cylinder having the characteristics outlined above which embodies improved features of construction. Of particular importance are the use of a common piston rod which is tapped to provide fluid passageways, the simple and identical construction of the various elements and parts, the various fluid sealing means employed, the mounting means for attaching the elliptical pistons to the piston rod and the guiding means for guiding the piston rod—all of which provide an improved fluid cylinder of the small size which is easily and inexpensively manufactured and assembled.

These, as well as other objects and advantages of the invention, will become more readily apparent upon consideration of the following specification and accompanying drawing wherein there is disclosed an illustrated embodiment constructed in accordance with the teachings of the present invention.

In the drawing:

Figure 1 is a longitudinal sectional view of a multiple piston elliptical fluid cylinder constructed in accordance with the teachings of the present invention;

Figure 2 is a sectional view taken along the section line II—II of Figure 1; and

Figure 3 is a sectional view taken along the section line III—III of Figure 1.

Referring now to the drawing, there is shown a multiple piston elliptical fluid cylinder which comprises a main cylinder portion generally designated by the reference numeral **10** and front and rear cylinder heads **11** and **12**, respectively, which are received on opposite ends of the main cylinder portion **10**. The main cylinder portion **10** is assembled from a plurality of cylinder wall elements **13** and cylinder spacer elements **14**. Each of these elements is shaped with truncated side edge portions (see Figures 2 and 3) so that the main cylinder portion is generally elliptical in cross section throughout its length. The front and rear cylinder heads **11** and **12** are rectangular in shape and receive the ends of four longitudinally extending tie rods **16** adjacent the corners thereof. The tie rods extend the length of the main cylinder portion between the front and rear cylinder heads and retain the heads, cylinder spacer elements and cylinder wall elements in axially aligned assembled relation. It will be noted that the shape of the main cylinder portion is such that this portion does not interfere with the free passage of the four tie rods **16**.

Each of the cylinder wall elements **13** is a hollow or annular sleeve-like member having an appreciable axial dimension which is machined or formed to define an elliptical inner surface **17**. Separating the adjacent cylinder wall elements **13** are the cylinder spacer elements **14** which have elliptical notches **18** around the edges and on both sides thereof that serve as seats for the ends of the generally elliptical cylinder wall elements **13**. The cylinder spacer elements **14** are centrally apertured at **19** and circular seating grooves are provided intermediate the ends of these apertures. Received and mounted in the seating grooves are O-rings **20** having such diameters that portions thereof extend beyond the internal surfaces of the apertures to form fluid tight seals with a common longitudinally extending piston rod **21**. The O-rings **20** are made from a deformable and resilient material, such as neoprene, for example, and have inherent lubricating properties whereby the common piston rod is guided for longitudinal movement in an easy manner while yet positive fluid tight seals are provided beetwen opposite sides of the cylinder spacer elements **14**. The spacer elements **14** are each provided with a right angled passageway **22** extending between the back sides and the side edges thereof which passageways define a plurality of relief passageways whose function will be hereinafter more fully explained.

As indicated above, the main cylinder portion **10**—comprising the alternate stacked wall elements **13** and spacer elements **14**—is held in tight assembled relation by the tie rods **16** extending between the front and rear cylinder heads **11** and **12**. The rear cylinder head **12** is generally rectangular in cross section and is formed with an inwardly directed elliptical flange **24** which receives the outer end of the rearmost cylinder wall element of the cylinder housing portion. The rear cylinder head **12** is also bored or tapped to provide a passageway **25** extending between the forward face and the top edge thereof which is adapted to supply actuating fluid to the multiple piston elliptical fluid cylinder of the present invention as will be further explained. The front cylinder

head 11 is also generally rectangular in cross section and has a notch 26 adapted to nest with the forward end of the first cylinder wall element 13 in the manner shown. The front cylinder head has a central aperture 27 therein that is lined with a pair of flanged annular bushings 28 and an annular resilient gasket 29. The flanged annular bushings 28 extend inwardly from opposite sides of the front cylinder head 11 and clamp the annular resilient gasket 29 therebetween so that the forward end of the common piston rod 21 is accurately guided for longitudinal movement while the annular gasket 29 provides the requisite fluid tight seal. An annular cover plate 30 is mounted on the forward face of the front cylinder head.

The front cylinder head has a right angled return passageway 31 communicating between the rear surface and the side edge thereof to provide a means for supplying fluid for returning the cylinder to its initial or retracted position after actuation thereof.

It will be noted that all of the parts thus described are characterized by their extreme simplicity and that the main cylinder portion is assembled from a plurality of identical wall and spacer elements whereby the multiple piston elliptical fluid cylinder may be easily manufactured and assembled at a low cost. In the illustrated embodiment of the invention the main cylinder portion is shown to comprise four cylinder wall elements and three cylinder spacer elements arranged in stacked alternating fashion but it should be clearly understood that more or less of these elements may be employed depending upon the force applying capability required of a cylinder for any given application. The means employed for guiding the common piston rod—including the apertures 19 and O-rings 20 in each of the spacer elements and the bushings 28 and annular gasket 29 in the front cylinder head—is particularly advantageous since the piston rod is positively guided for longitudinal movement at spaced points throughout its length and the required fluid tight seals are provided. Also, this means is afforded by simple boring and grooving operations and includes inexpensive O-rings, bushings and a gasket whereby the manufacture of the multiple piston elliptical cylinder is greatly facilitated.

The assembled main cylinder portion 10 in cooperation with the front and rear cylinder heads 11 and 12 and the fluid tight seals betwen the spacer elements 14 and the piston rod 21 forms a plurality of fluid tight, axially aligned and spaced elliptical fluid chambers 33. Received and guided within each of the elliptical fluid chambers 33 is an elliptical piston 34 (see Figure 3 of the drawing) which is mounted on and movable with the common piston rod 21. Each of the elliptical pistons has a seating groove running around its elliptical outer periphery into which is seated a resilient and deformable O-ring type seal 35 that provides a fluid tight seal between the elliptical inner surface 17 of the cylinder wall element associated therewith and the opposite sides of the elliptical piston. The elliptical pistons have axial apertures 36 therein which are internally grooved to provide a seat for resilient and deformable O-rings 37 thereby defining fluid tight seals between the opposite sides of the elliptical pistons and the common piston rod 21. Thus, each of the chambers 33 is divided into forward and rear fluid tight compartments by the elliptical piston 34 due to the O-ring type seal 35 and O-ring 37 carried thereby. Each of the elliptical pistons in mounted on the common piston rod by a pair of snap rings 38 received within suitable axially spaced and circumferentially extending grooves machined on the piston rod so that the elliptical pistons are always retained in their correct relative longitudinal positions. The means providing the fluid tight seals between the cylinder wall elements, the piston rod and the elliptical pistons and the means for rigidly mounting the pistons on the piston rod are characterized by their extreme simplicity in manufacture and assembly.

The snap rings 38 prevent longitudinal movement of the elliptical pistons 37 and the O-rings provide fluid tight seals between the opposite sides of the pistons but yet the means for mounting the elliptical pistons the common piston rod is such that the elliptical pistons are floatingly mounted. Thus, the elliptical pistons are free to turn with respect to the common piston rod. This is particularly important in that free sliding movement of the piston rod is always insured even if the individual cylinder wall elements 13 and cylinder spacer elements 14 are not perfectly aligned since the floatingly mounted pistons will always align themselves rotatively with the elliptical inner surfaces 17 of the cylinder wall elements 13. It should be apparent that this feature greatly facilitates the construction and assembly of the multiple piston elliptical fluid cylinder and also allows proper operation and free movement of the piston rod.

As set forth above, in some instances it is desirable that any turning or rotative movement of the common piston 21 about its longitudinal axis be prevented in order that the driven member attached to the protruding end of the piston rod remains in proper position without the necessity of ways, etc. The fluid cylinder of the present invention is ideally suited for such uses because the elliptical pistons are non-circular and provide an excellent anti-turn means. To accompish this end one of the elliptical pistons 37 is rigidly attached to the common piston rod 21 as, for example, by means of a pin 41 as shown in Figure 1 of the drawing. Only one of the elliptical pistons is rigidly mounted on the piston rod to prevent turning thereof while the rest of the pistons are floatingly mounted for rotative movement. In this manner rotation of the piston rod is prevented while yet all but one of the pistons are free to turn to compensate for any misalignment of the various cylinder elements.

By employing the arrangement above described for mounting the pistons on the common piston rod it is possible to eliminate the notches 17 on the sides of the cylinder spacer elements 14, the flange 24 on the rear cylinder head 12 and the notch on the front cylinder head 11. These members would be provided with flat planer end surfaces against which the ends of the cylinder wall elements would be tightly held by the plurality of tie rods 16. Such construction, which is greatly simplified and inexpensive, is possible since the floatingly mounted pistons will compensate for any misalignment between the various axially stacked cylinder elements.

The common piston rod 21 is tapped axially from the rear and thereof throughout a portion of its length to provide the longitudinally extending passageway 39 and is also tapped normally at spaced points along its length to define transverse passageways 40 communicating between the passageway 39 and the compartments in the chambers 33 to the rear of the elliptical pistons 34. Thus, an inlet means, comprising the inlet passageway 25, passageway 39 and one of the transverse passageways 40, is provided into each of the chambers 33 on one side of the elliptical pistons for actuating the multiple piston elliptical fluid cylinder. The properly tapped common piston rod forms a portion of the inlet means and this precludes the necessity of complicated and expensive machining and boring in other portion of the fluid cylinder. As previously described, the forward compartment of the first or forward chamber 33 is in communication with the return passageway 31 while the forward compartments of the rest of the chambers 33 are connected to atmosphere via the relief passageways 22 in the cylinder spacer elements 14.

In the operation of the multiple piston elliptical fluid cylinder described above, fluid under pressure is supplied to the inlet passageway 25 and this fluid will be carried to the rear compartment of each of the chambers 33 via this passageway and the passageways 39 and 40 in the common piston rod. The fluid under pressure will exert a force on each of the elliptical pistons there-

by causing forward movement of the same and the piston rod to which these members are attached. One of the most important aspects of the present invention is the provision of a multiplicity of elliptical pistons wherein the individual pistons provide large areas for the fluid under pressure to act against and this, along with the number of elliptical pistons, allows the application of very high forces to the piston rod and the driven member connected thereto while yet the entire fluid cylinder is extremely small, especially in its thickness dimension. Such a fluid cylinder is well adapted for applications requiring a high force applying fluid cylinder where the space for mounting such a cylinder is restricted due to other considerations.

To return the piston rod and the elliptical pistons to their original or retracted positions the passageway **25** is connected to tank and fluid under pressure is supplied to the return passageway **31**. Fluid is admitted through this last mentioned passageway to the forward compartment of the first chamber **33** thereby causing reverse movement of the piston rod and elliptical pistons with the fluid in the rear compartments of the chambers flowing to tank through passageways **40**, **39** and **25**. It will be noted that on the return stroke fluid is admitted only to one of the forward compartments and this allows conservation of the actuating fluid, such as air, for example. Of course, if desired, fluid under pressure can be supplied through suitable passageways to all of the forward compartments for returning the piston rod and elliptical cylinders to their original positions.

When fluid under pressure is supplied to only one of the forward compartments of the chambers **33** the other forward compartments are in communication with the atmosphere through the relief passageways **22** and these passageways provide a means for relieving any pressure or exhausting any fluid within these forward compartments of the chambers due to failure of the seals between the elliptical pistons and the wall elements and the piston rod or for any other reason. In the case where fluid under pressure is supplied to all of the forward compartments these relief passageways would be blocked or upon enlargement thereof may serve as the additional return passageways.

It should thus be apparent that I have accomplished the objects initially set forth. There is provided a fluid cylinder which, due to the multiplicity of elliptical pistons in combination with the many features of improved construction, is of small size and dimensions but yet has high force applying capacibility. The fluid cylinder shown in the drawing has four chambers but it should be apparent that a cylinder having more or less of these chambers may be constructed by inserting or removing wall elements, spacer elements and the elliptical pistons and providing a longer or shorter piston rod as required. In this manner the resultant multiple piston fluid cylinder will have the desired force applying capability for any given application.

Many changes may be made in the illustrated embodiment of the invention without departing from the clear teachings thereof. Accordingly, reference should be had to the following appended claims in determining the true scope and intent of the present invention.

I claim:

1. A small size fluid cylinder for applying a high moving force and adapted to be mounted in a limited mounting area providing minimum space comprising a main cylinder portion, a pair of cylinder heads at the ends of said main cylinder portion, said main cylinder portion comprising a plurality of identical axially elongated annular and generally elliptical wall elements, said wall elements each having an elliptical internal surface, a plurality of identical relatively short axially extending spacer elements, said spacer elements being positioned between adjacent ones of said wall elements in axially aligned relation with respect thereto, the number of alternating and axially stacked wall elements and spacer elements being selected to provide an elliptical fluid cylinder having desired force applying characteristics, said spacer elements, said wall elements and said cylinder heads defining a plurality of axially aligned and spaced elliptical fluid chambers, a common piston rod extending axially through said spacer elements and at least one of said cylinder heads and movable axially with respect thereto, a plurality of elliptical pistons mounted in axially spaced relation on and carried by said common piston rod, one of said elliptical pistons being received in each of said elliptical fluid chambers and having fluid sealing contact with the elliptical internal surface of the wall element associated therewith to divide each of said elliptical fluid chambers into a pair of expansible and contractable fluid tight compartments, means to supply fluid under pressure simultaneously to one set of the like ones of the pairs of expansible and contractable compartments to move said piston rod under a high force, said means to supply comprising an axial bore in said common piston rod, a plurality of radially extending and axially spaced passageways in said piston rod communicating with at least a portion of said one set of said like ones of said compartments, inlet means communicating with at least one of the other set of the like ones of said compartments for supplying fluid under pressure thereto to return said piston rod, a plurality of tie rods extending between said cylinder heads for maintaining said cylinder heads, said wall elements and said spacer elements in assembled relation, and said tie rods being disposed adjacent the ends of the major transverse axis of said elliptical fluid cylinder whereby the width of said elliptical fluid cylinder along the minor transverse axis thereof is maintained at a minimum to allow mounting of said elliptical fluid cylinder in a limited mounting area.

2. Apparatus according to claim 1 further comprising means mounting said elliptical pistons on said common piston rod, and said means mounting preventing axial movement of said pistons with respect to said piston rod but permitting relative rotational turning movement between at least a portion of said elliptical fluid pistons and said piston rod to permit individual registry and alignment between said elliptical fluid pistons and the elliptical fluid pistons and the elliptical wall elements associated therewith.

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