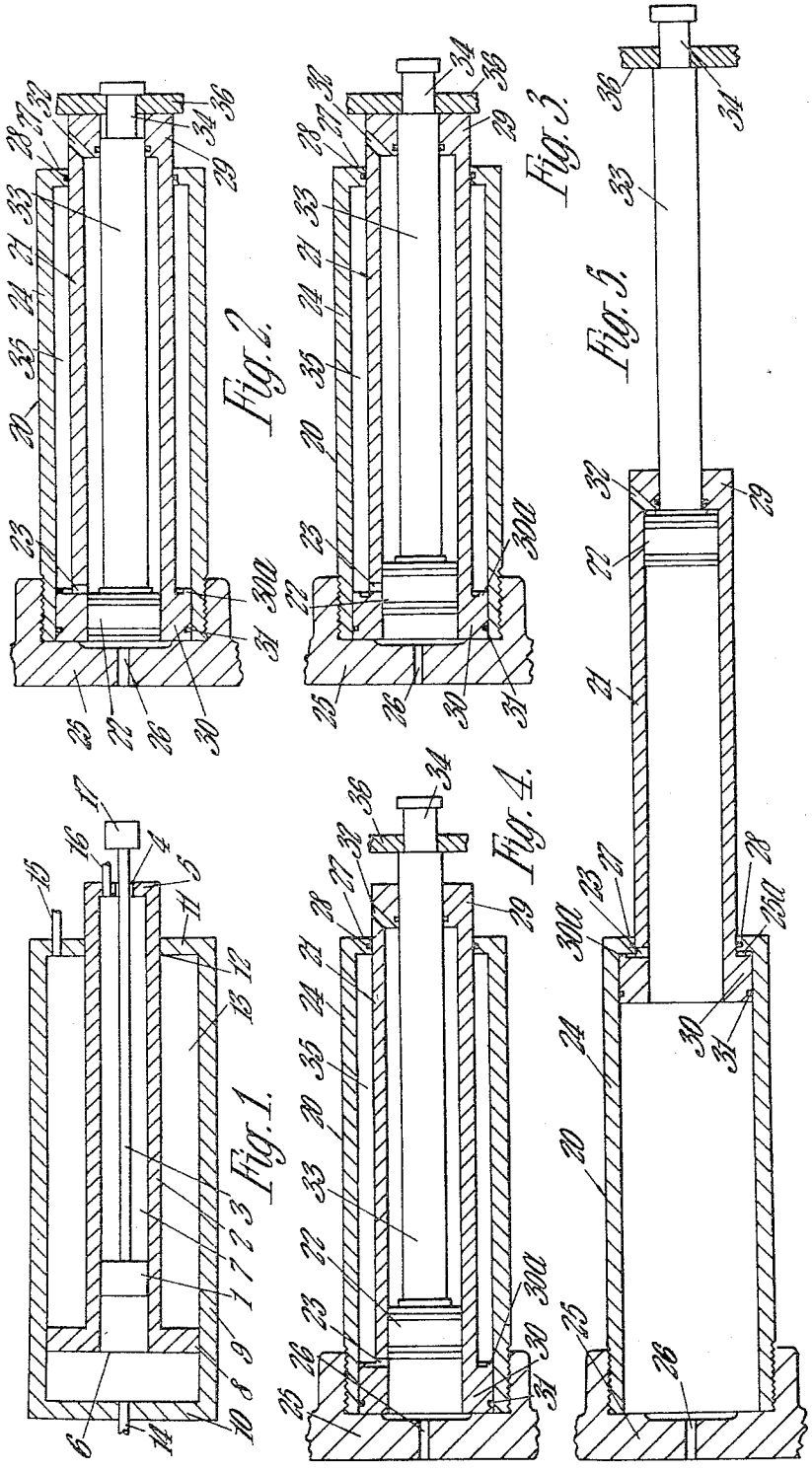
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HYDRAULIC PISTON AND CYLINDER COMBINATIONS

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HYDRAULIC PISTON AND CYLINDER COMBINATIONS

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This invention relates to hydraulic piston and cylinder combinations of the multistage telescopic type in which an inner piston of relatively small cross section and one or more intermediate cylinders of successively larger cross section, telescope into and out of a large cross sectional outer cylinder under the action of liquid under pressure.

In the accompanying drawings:

FIG. 1 is a semi-diagrammatic sectional view through a known type of two-stage hydraulic piston and cylinder combination,

FIG. 2 is a sectional view through a two-stage hydraulic piston and cylinder combination according to the invention in its retracted position,

FIGS. 3 and 4 show the combination of FIG. 2 in partially extended positions, and

FIG. 5 shows the combination of FIG. 2 in the fully extended position.

Multistage cylinders are useful for applications requiring a long stroke where only a restricted space is available for the retracted mechanism and the working of a two stage combination, i.e. a combination having only one intermediate cylinder will now be considered, with reference to FIGURE 1 of the accompanying drawings which is a semi-diagrammatic section through such a combination. (It will be appreciated that in combinations having a greater number of stages, i.e. a greater number of intermediate cylinders, similar considerations will apply.)

The inner piston **1** slides (as piston means) internally in the intermediate cylinder **2**, its rod **3** extending through an opening **4** formed in the head **5** of this cylinder (suitable sealing means being provided) so that in the fully extended position the piston **1** is disposed towards the cylinder head **5** with the rod **3** extending outwardly therefrom, whilst in the fully retracted position the piston **1** aligns substantially with the opposite (open) end **6** of the intermediate cylinder. In this position, in operation, the space **7** in the intermediate cylinder around the piston rod is filled with liquid. The open end **6** of the intermediate cylinder is formed with an outwardly directed shoulder **8** and this slides as piston means internally of the outer cylinder **9**, the open end **6** of the intermediate cylinder being disposed at or towards the head **10** of the outer cylinder in its fully retracted position and the intermediate cylinder extending towards and projecting slightly from the open end **11** of the outer cylinder which has an inwardly directed shoulder **12** for sealing against the outer surface of the intermediate cylinder. Thus, an annular space **13**, which in operation is filled with liquid is formed between the outer and intermediate cylinders. (In combinations have more than two stages, the intermediate cylinders slide as piston means one in another and annular spaces are formed between successive intermediate cylinders.)

In order to extend the combination liquid under pressure is admitted to the head of the outer cylinder through a port **14** and simultaneously liquid is exhausted from the annular space **13** through a port **15** formed in the shoulder **12** of the outer cylinder. The intermediate cylinder slides in the outer cylinder, carrying the inner piston with it, until the outwardly directed shoulder **8** of the intermediate cylinder abuts against the inwardly directed shoulder **12** of the outer cylinder and the annular space **13** is fully exhausted. This is the first stage extension. Continuing the supply of pressurized liquid to the head of the outer cylinder, the liquid in space **7** is then exhausted through a port **16** in the head of the intermediate cylinder, causing the piston to slide in the intermediate cylinder until its limit is reached. This is the second stage extension.

In order to now retract the combination the process is reversed, liquid being introduced to the head of the intermediate cylinder through port **16** whilst liquid is exhausted from the head of the outer cylinder through port **14**, thus causing the piston to slide in the intermediate cylinder and liquid being introduced to the port **15** to cause the intermediate cylinder to slide in the outer cylinder and reform the annular space **13**.

In combinations of the above type, the load is normally attached to the piston rod end (**17** in FIGURE 1) which protrudes from the head of the intermediate cylinder, and for a constant liquid infeed pressure during expansion the thrust available is dependent on the effective piston area. This effective area is greater during the first stage extension where it is equal to the internal cross sectional area of the outer cylinder than during the second stage extension when it is equal to the internal cross sectional area of the intermediate cylinder. Hence, the available thrust varies through the extension stroke of the combination.

Also, as has been shown for a two stage combination, at least three liquid connections are required and this number is increased by one for each additional stage in such multistage devices.

The present invention has as an object the provision of a multistage telescopic piston and cylinder arrangement of the above type which can provide a substantially constant thrust through its extension stroke.

The invention consists in a multi-stage telescopic piston and cylinder combination of the type referred to wherein the, or an, intermediate cylinder has port means formed through the walling thereof adapted to transfer liquid from the annular space surrounding the cylinder to the cylinder interior during extension of the combination. The port means should be so positioned that in the fully extended position of the combination they are still within the confines of the surrounding cylinder.

By the above arrangement, the thrust available from the, or each, intermediate cylinder is substantially reduced, since this is utilised to expel the liquid from said annular space, and transfer it to the cylinder interior. Thus, the thrust is substantially constant throughout the extension of the combination, being proportional to and dependent only on the cross sectional area of the innermost piston, and

irrespective of the number of stages (i.e. number of intermediate cylinders) in the combination, only two liquid connections are necessary, viz. one for the head of the outer cylinder and one for the head of the, or the innermost, intermediate cylinder.

The invention will now be described by way of an example, with reference to FIGURES 2 to 5 of the accompanying drawings, which show in section a two-stage piston and cylinder combination at various points in its expansion stroke. The combination comprises an outer cylinder **20**, an intermediate cylinder **21** and an inner piston **22**, port means **23** being provided in the wall of the intermediate cylinder to reduce the available thrust thereof during extension of the combination.

The outer cylinder comprises a cylindrical metallic sleeve **24**, the head end being formed by a screw-on cap **25** having a duct **26** therethrough for admitting and exhausting liquid and the opposite (open) end of the cylinder which has an inwardly directed shoulder **27** carrying an annular seal **28** which in operation forms a sliding seal with the exterior walling of the intermediate cylinder. This latter component is of conventional construction and slides in the outer cylinder with its head **29** projecting from the open end of the outer cylinder. The open end of the intermediate cylinder has an outwardly directed shoulder position **30** with external circumferential seal **31** which slides in piston-like fashion within the outer cylinder and the cylinders are so dimensioned that when in the fully retracted position, i.e. with the open end of the intermediate cylinder abutting against the head **25** of the outer cylinder, the head **29** of the intermediate cylinder which is itself provided with a duct **32** for admittance and exhaust of liquid, projects slightly from the open end of the outer cylinder.

Immediately adjacent the shoulder portion at the open end of the intermediate cylinder, a series of circumferentially spaced openings of any convenient shape, comprising the port means **23**, are formed through the wall thereof.

The inner piston **22** slides within the intermediate cylinder its rod **33** extending through a central opening having suitable sealing means formed in the head of the intermediate cylinder and at its free end the piston rod has a reduced diameter portion **34**. The arrangement is such that in the fully retracted position of the combination with the piston head and the open end of the intermediate cylinder abutting against the head of the outer cylinder, the end of the piston rod projects slightly from the head of the intermediate cylinder, whilst the shoulder forming the junction between said reduced diameter portion and the main body of the rod lies within the central opening in the head of the intermediate cylinder as shown in FIGURE 2. Also, the piston head **22** is of such a width that in this fully retracted position the port means **23** are uncovered, i.e. the width of the piston is not greater than the width of the shoulder portion **30** of the intermediate cylinder. In the retracted position the annular space **35** between the intermediate cylinder and outer cylinder and the interior of the intermediate cylinder which two volumes are connected by the port means are filled with liquid, for example oil.

To extend the combination from the fully retracted position oil under pressure is admitted through the duct **26** whilst the duct **32** is opened to exhaust oil. The inner piston will move first, within the intermediate cylinder in preference to the intermediate cylinder moving in the outer cylinder due to the lesser resistance to movement of the inner piston, for reasons yet to be described. As the piston telescopes out from the intermediate cylinder it covers the port means (see FIGURE 3) thereby trapping oil in the annular space **35**. Thus, whilst the ports are so covered movement of the intermediate cylinder is inhibited.

While the port means are covered by the piston head the shoulder in the piston rod forming the junction between the reduced diameter portion **34** and the main body thereof emerges from the head of intermediate cylinder and engages a plate **36** connected to the load which plate has a central hole through which the reduced portion of the rod can slide freely but which is of smaller diameter than the main body of the rod. It is the presence of this plate which causes the inner piston to move freely from its fully retracted position in preference to the intermediate cylinder. The plate rests on the head of the intermediate cylinder in the FIGURE 1 position thereby increasing its resistance to movement whilst the inner piston by virtue of its reduced diameter portion can move relatively free of resistance through the plate opening until the plate is engaged by the piston rod shoulder.

Further movement of the piston again uncovers the port means (FIGURE 4) thus connecting the annular space **35** to the interior of the intermediate cylinder behind the piston. The intermediate cylinder can now slide within the outer cylinder since oil in the annular space can escape to the interior of the cylinder through the port means but the intermediate cylinder does not contribute any thrust to the load, since this is utilized in expelling the oil from the annular space. The piston "floats" in a position just adjacent the port means, as shown in FIGURE 3, until the first stage extension is complete, in which position the shoulders of the intermediate and outer cylinders (**27** and **30**) abut and the port means remain within the confines of the outer cylinder (see FIGURE 5) and by virtue of an upstanding rim **30***a* formed towards the outside of the intermediate cylinder shoulder **30**, the port means still communicate with space **25***a* which is all that remains of annular space **25**. Second stage extension of the piston within the intermediate cylinder then proceeds until the combination is fully extended as shown in FIGURE 5, and it will be seen that by this arrangement substantially constant thrust expansion may be achieved, the thrust being dependent only on the effective area of the inner piston **22**.

To retract the apparatus the oil flow is reversed, oil under pressure being admitted through duct **32** and being exhausted through duct **26**. First stage retraction of the piston in the intermediate cylinder proceeds until the port means **23** are covered by the piston **22** and again uncovered on the rod side of the piston whereupon oil is forced through the port means and between the abutting shoulders of the intermediate and outer cylinders (see FIGURE 5) to gradually reform and enlarge the annular space **35**, this constituting the second stage retraction. This proceeds until the initial fully retracted position is attained.

It will be appreciated that whilst the above description relates to a two stage combination the invention can readily be extended to combinations with more stages by providing openings in the wall of each intermediate cylinder. In each case, only two liquid connections are needed. Moreover, various modifications are possible within the scope of the invention as defined in the appended claims.

We claim:

1. A multi-stage hydraulic piston and cylinder device comprising an outer cylinder, an intermediate cylinder telescopically mounted in said outer cylinder for sliding therein, between retracted and extended positions, under the influence of liquid introduced into the outer cylinder, said intermediate cylinder including a cylindrical wall and an outwardly directed shoulder portion leading from said wall, said shoulder portion co-operating piston-wise with said outer cylinder whereby when said intermediate cylinder is in a retracted position within said outer cylinder the walls of said cylinders define an annular space therebetween, inner piston means telescopically mounted within said intermediate cylinder for sliding therein, between retracted and extended positions, under the influence of liquid introduced into the intermediate cylinder, means

defining port means through said wall of said intermediate cylinder and means for controlling a flow of liquid from said annular space through said port means to the interior of said intermediate cylinder behind said piston means as said intermediate cylinder moves from its retracted position towards its extended position.

2. A multi-stage hydraulic piston and cylinder device comprising an outer cylinder, an inner piston, at least one intermediate cylinder interposed between said piston and said outer cylinder, said piston and said cylinders being arranged in telescopic relation one within another for sliding between extended and retracted positions under the influence of pressurized liquid introduced to the device, said intermediate cylinder including a hollow cylindrical wall portion and an outwardly directed flange portion leading from said wall portion said flange portion operating as piston means in the cylinder surrounding said intermediate cylinder whereby when said intermediate cylinder is in a retracted position with respect to said surrounding cylinder an annular space is formed between said cylinders, and said wall portion of said intermediate cylinder defining port means, for passing liquid from said annular space to the interior of said intermediate cylinder during movement of said intermediate cylinder in said surrounding cylinder from said retracted position towards an extended position, and means providing movement of the piston from the retracted position of the device before the intermediate cylinder to cause said port means to deliver said liquid to the interior of the intermediate cylinder behind said piston.

3. In a multi-stage hydraulic piston and cylinder device including an outer cylinder, an intermediate cylinder telescopically slideably mounted within said outer cylinder for movement therein between a retracted position and a projected position, and piston means slideably mounted within said intermediate cylinder for movement therein between a retracted and a projected position, said intermediate cylinder comprising a cylindrical wall portion and an outwardly directed flange leading from said wall portion and co-operating piston-wise with said outer cylinder whereby when said intermediate cylinder is in a retracted position within said outer cylinder an annular space is formed between said cylinders, the improvement comprising means defining port means through said wall of said intermediate cylinder, and means controlling movements of said piston means and said intermediate cylinder whereby as said intermediate cylinder moves in said outer cylinder from said retracted position towards said projected position liquid may be transferred through said port means from said annular space to the interior of said intermediate cylinder, behind said piston means.

4. In a multi-stage hydraulic piston and cylinder device comprising an outer cylinder, an intermediate cylinder telescopically mounted within said outer cylinder for movement therein between retracted and projected positions, and internal piston means mounted within said intermediate cylinder for sliding movement between retracted and projected positions, said intermediate cylinder including a hollow wall portion and an outwardly directed flange leading off said wall and co-operating piston-wise with said outer cylinder whereby when said intermediate cylinder is in a retracted position in said outer cylinder an annular space is formed between said cylinders, the improvement comprising means defining at least one opening through said wall portion of said intermediate cylinder adjacent said flange, and means controlling projecting movements of the piston means and intermediate cylinder whereby during said movements liquid may be transferred from said annular space through said opening to the interior of said intermediate cylinder behind said piston means.

5. An extensible and retractable multi-stage hydraulic ram comprising an outer cylinder having a head end and a partially open end, an intermediate cylinder for movement therein between retracted and projected positions,

said intermediate cylinder comprising a hollow wall portion terminating in a partially open head end projecting from said partially open end of said outer cylinder, an outwardly directed flange leading from said wall portion and cooperating piston-wise with said outer cylinder whereby an annular space is formed between said cylinders, means defining port means through said wall portion for transferring liquid between said annular space and the interior of said intermediate cylinder during extension and retraction of the combination, inner piston means mounted within said intermediate cylinder for movement therein between retracted and projected positions, means defining a first liquid connection in the head end of said outer cylinder, means defining a second liquid connection in the head end of the wall portion of said intermediate cylinder, and means controlling projecting movements of the piston means and intermediate cylinder whereby during said movements liquid may be transferred from said annular space through said port means to the interior of said intermediate cylinder behind said piston means.

6. The ram defined in claim 5, wherein said inner piston means includes a piston portion and a rod portion, said rod portion projecting from said partially open head end of said intermediate cylinder and said rod portion having a reduced diameter section remote from said piston portion, said section being partially accommodated in said head end of said intermediate cylinder when said piston means is in said retracted position.

7. An extensible and retractible hydraulic piston and cylinder device comprising a hollow outer cylinder having walling defining a closed head end and a partially open end, an intermediate cylinder telescopically mounted in said outer cylinder for sliding between a retracted position and an extended position, said intermediate cylinder comprising a hollow wall portion terminating in a head end projecting from said partially open end of said outer cylinder, an outwardly directed flange at the opposite end of said wall portion, said flange cooperating piston-wise with said outer cylinder whereby an annular space is formed between said cylinders when said intermediate cylinder is in a retracted position, and means defining port means through said wall portion adjacent said flange for transferring liquid between said annular space and the interior of said intermediate cylinder during extension and retraction of the device, piston means mounted in said intermediate cylinder for sliding therein between retracted and extended positions, means defining a first liquid transmission duct in the walling at the head end of said outer cylinder, means defining a second liquid transmission duct in the walling at the head end of said intermediate cylinder and means enabling said piston means to move from a completely retracted position of the device before said intermediate cylinder and uncover said port means to provide a flow path for liquid from said annular space through said port means to the interior of said intermediate cylinder behind the piston means.

8. Extensible and retractable hydraulic apparatus comprising an outer cylinder having walling defining a head end and a partially open end, an intermediate cylinder telescopically mounted in said outer cylinder for sliding therein between retracted and projected positions, said intermediate cylinder comprising a wall portion terminating in a partially open head end projecting from said partially open end of said outer cylinder, an outwardly projecting flange at the opposite end of said wall portion, said flange cooperating piston-wise with said outer cylinder whereby an annular space is formed between said cylinders, means defining at least one opening through said wall portion immediately adjacent said flange, for transferring liquid between said annular space and the interior of said intermediate cylinder during extension and retraction of the apparatus, and an upstanding circumferential rib formed towards the outside of said flange on a face thereof adjacent said opening, a piston mounted for sliding in said intermediate cylinder between retracted

and extended positions, a rod formed on said piston, said rod projecting from said partially open head end of said intermediate cylinder, and means providing initial free movement of the piston from a completely retracted position of the apparatus to provide communication through said port means between said annular space and the interior of said intermediate cylinder to the rear of said piston, means defining a first liquid connection in the walling at the head end of said outer cylinder, means defining a second liquid connection in the walling at the head end of said intermediate cylinder.

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