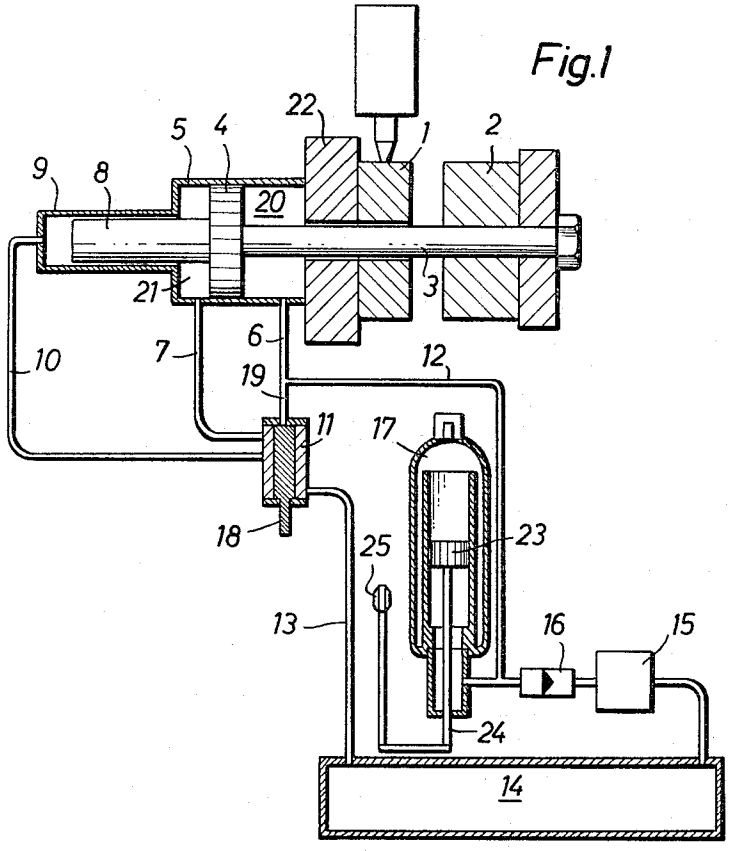
June 27, 1967 M. SCHIFFER 3,327,474

HYDRAULIC DRIVING DEVICE FOR TOOLS OR THE LIKE, PARTICULARLY FOR THE MOVABLE MOLD PARTS OF PLASTIC DIE CASTING MACHINES

Filed Oct. 22, 1965 2 Sheets-Sheet 1

Fig.1



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	6	7	10	13	12
I	●	●			●
II	●		●	●	●
III	●	●	●		●

Fig.2

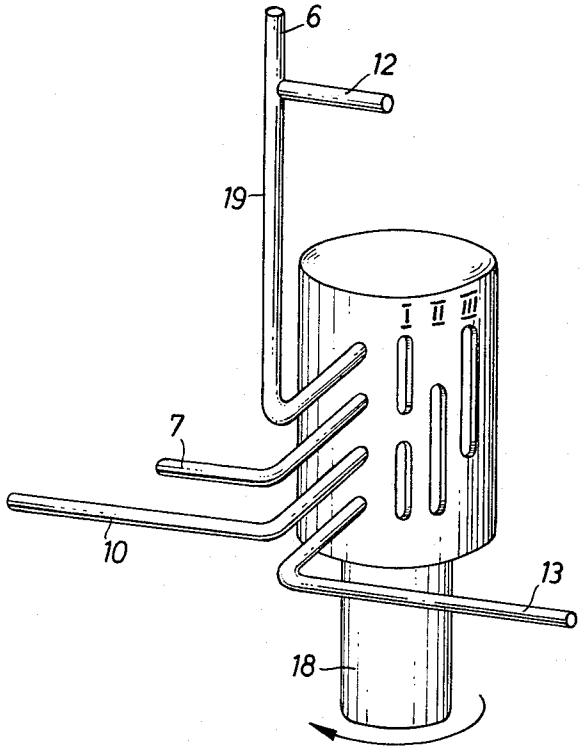


Fig.3

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HYDRAULIC DRIVING DEVICE FOR TOOLS OR THE LIKE, PARTICULARLY FOR THE MOVABLE MOLD PARTS OF PLASTIC DIE CASTING MACHINES

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ABSTRACT OF THE DISCLOSURE

A hydraulic device which drives tools or the like from an open to a closed position, causes a strong force to be exerted in the closed position and then returns the tool to an open position. A main piston and an attached auxiliary piston are located in a main cylinder and auxiliary cylinder, respectively, where both cylinders communicate with a single high pressure oil source which activates the device into the three-cycle operation.

The invention relates to a hydraulic driving device for tools or the like, which are driven from an open position to a closed position (forward stroke), exert a strong force in this position, and then are driven back into the open position (back stroke), the tool being connected by a piston rod with a piston, which travels in a cylinder, in which cylinder on the piston rod side of the piston, the forward thrust oil conduit opens and on the other side of the piston the back thrust oil conduit opens, which conduits can be connected either with a pressure-oil source or an oil sump, through a control device adjustable between a plurality of control positions. In this way the invention achieves an improvement with respect to simple construction, compactness, and production cost of the driving device.

Tools or the like, which can be driven from the open position to the closed position, which exert a strong force in this latter position, and then are again moved into the open position, are frequently found in machine tools or material working machines, for example in the form of metal cutting machines, presses, or stamping tools, as well as movable mold parts of plastic die-casting machines, in which the movable mold parts are moved from the open position to the closed position, in which plastic is injected, so that in this closed position the form has to be held closed with great force, whereupon the movable mold part is again moved back into the open position. Heretofore for the most part toggle lever drives have been used for the driving means for tools of this kind, which move the tool in the forward stroke and the back stroke relatively fast, while in the closed position, with the toggle straightened, a relatively large force is exerted. These driving devices have the disadvantage that the height of the mold or tool has to be exactly conformed, by carefully observed adjusting means, because the maximum force occurs only shortly before the straightened position of the toggle lever. Toggle levers are expensive in construction and undergo a certain wear; for extremely large strokes toggle levers can only be conditionally inserted. Furthermore, there is the disadvantage of toggle levers that they require too much room. Machines provided with them have very large dimensions, which prevent them from being set up in positions having only a small floor space.

On account of these disadvantages of toggle levers there have already become known a number of machines having direct hydraulic drive. The necessity, on the one hand, of providing for rapid forward stroke and retraction, and on the other hand for exerting a large force in the closed

position, have, however, led to disadvantages of a particular kind in the known hydraulically driven devices. For example, hydraulic driving mechanisms are known, which consist practically of two independent hydraulic driving mechanisms, namely, a hydraulic lower pressure device for carrying out the movement procedures relating to the forward stroke and retraction, and a hydraulic high-pressure device for generating the force for holding the device in the closed position. However, the construction of two hydraulic drives has the disadvantage of relatively large space requirement and very large manufacturing cost. Besides, the control devices for two pressure oil systems with different pressures become very complicated and costly. There are also known hydraulic drives with a so called adjustable pump, wherein the pump output can be adjusted within limits and has a large stroke capability at low pressure or a small stroke capability at high-pressure. For the stroke movement the pump output is adjusted for high movement capability with low pressure, and in order to generate the force for exerting pressure in the closed position, is adjusted to the lowest motion capability with high-pressure. However, this kind of a pump is very complicated, expensive, and subject to damage. Furthermore, it is difficult to feed the required multiple auxiliary drives, for example for hydraulic ejectors or mold shifters in die-casting machines from this hydraulic system. On account of these disadvantages many manufacturers, who have used such drives previously, have abandoned them.

There are also machines known in which the hydraulic driving device operates with an auxiliary piston of smaller diameter, which carries out the motion procedures and adds to the supply of oil to the large surfaced main piston, which is necessary for the holding down force in the closed position. These driving devices have the disadvantage, that the speed of motion of the forward stroke and the retraction must be vary small; with too rapid motion there would be the danger, that the oil stream which must be sucked into fill the main piston space might break and that air or vacuum spaces would occur in front of the main piston. This form of machine, furthermore, on account of the required special valve control and tubes with too large cross section (suction capacity) is very expensive.

A further known form of direct hydraulically closing driving system comprises a large low pressure oil container, into which during operation the quantity of oil required at all times during operation is forced from the driving cylinder. The low pressure container has an adjustable safety valve through which the excess quantity of oil can flow off into the oil sump. For the next following stroke the corresponding amount of low pressure oil is taken from the low pressure container, which has a gas cushion. It is true that in this form the second source of oil for the low pressure is not required, but it is very expensive and space consuming, so that serious disadvantages of a different kind arise.

The object of the invention is to overcome the disadvantages of the known systems: In order to overcome these disadvantages it was necessary to start with a hydraulically driven device. Improvement of the toggle lever type of driving device would never have led to a successful result, because of the unavoidable space requirement and the limits of the motions which can be achieved by practically useable toggle levers. If the problem was to be solved by improvement of hydraulic drives, the invention would have to be confined to a system which operates with only a single pressure, because otherwise the disadvantages of space requirement, expense, and cost could not have been overcome.

In accordance with the invention the problem is solved by a hydraulically driven device of the type referred to

earlier, by providing a piston which carries on its side opposite the piston rod an auxiliary piston, which travels in an auxiliary cylinder joined to the main cylinder, in which auxiliary cylinder an auxiliary backstroke oil conduit opens; the diameter of the auxiliary piston being larger than that of the main piston; furthermore, the control device being a switching means, known per se, having at least three different control positions: Position I (forward stroke) connecting the forward stroke oil conduit and the backstroke oil conduit in short circuit and additionally to the source of oil pressure, while the backstroke auxiliary oil conduit is connected to the oil sump, in position II (closed position) the forward stroke oil conduit alone is connected to the oil pressure conduit, while the backstroke oil conduit and the backstroke auxiliary oil conduit are both connected to the oil sump, and in position III (backstroke) the forward stroke oil conduit, the backstroke oil conduit, and the backstroke auxiliary oil conduit are short circuited together and additionally are connected to the pressure oil conduit, and that finally a single high-pressure oil source is used for the oil pressure supply. A device in accordance with the invention is made of very few parts, has a small space requirement, is not easily subject to damage, and is cheap to manufacture. Only a single hydraulic system is used, namely, a high-pressure system. The operating costs are relatively low, because, on account of the short circuit oil connections, in accordance with the invention, the amount of high-pressure oil to be supplied from the high-pressure oil source in the forward stroke corresponds only to the difference between the cylinder volumes of the forward stroke oil conduit and the backstroke oil conduit, which is determined by the difference in diameter of the auxiliary cylinder and the piston rod. In the backstroke the high-pressure oil quantity used amounts to the difference between the cylinder space of the backstroke oil conduit on the one side and the cylinder space of the forward stroke oil conduit and the auxiliary cylnder on the other side. Because in the closed position only the high-pressure is used and there is no flow of oil, except for leakage, the oil used amounts practically at the most to the cross-section of the piston rod.

The invention makes possible cheap manufacture of machines with surprisingly small space requirement, which, because of their low susceptibility to damage and low operating cost, can be set up in large numbers in a small space. The invention makes it possible, therefore, to increase the capacity without additional costs which are nonproportional, that is, a true rationalization.

In accordance with a further feature of the invention there is used for a control device a rotary valve known per se. Heretofore hydraulically driven devices of the type described in the beginning were mostly controlled by so called magnetic valves. These are costly to procure and require much room and are also very subject to damage. While such valves could be used in the invention, this would have the disadvantage that the advantages achieved for the first time by the invention, for example smaller production cost, and particularly smaller susceptibility to damage, would not be fully realized. The proposal to use, in connection with the invention, a rotary valve known per se, is therefore also of inventive significance. The use of the rotary valve makes it possible to achieve and bring into operation the advantage of the invention to the fullest extent.

In addition to the advantages of the rotary valve described, it also makes possible the control of any other procedures, not belonging to the invention, but which must be taken in account in using the invention—for example, the drive of injection and ejection means in plastic die-casting, can also be taken over by the rotary valve. For this purpose all that is required is to connect to the available rotary valve additional oil conduits and to provide in the control cylinder of the rotary valve the additional control ducts.

In accordance with a further feature of the invention a pressure oil reservoir is used as a source of oil, which is fed by an oil pump sucking oil from the oil sump and pumping the oil through a check valve which blocks the return of oil from the oil storage reservoir to the pressure oil pump. This has the advantage that a relatively small oil pump can be used with low energy requirement. The oil requirement of the hydraulic driving means fluctuates in time with the different operations of the process of the driving mechanism. If the feed were directly from the oil pump, this pump would have to have a capacity to handle the maximum oil flow, but would only have to supply this maximum oil flow from time to time. Therefore, the oil pump would either have to be capable of being switched very rapidly on and off, or the unrequired excess of oil would have to be allowed to flow off through an overflow valve into the oil sump. It is evident that this method would be very uneconomical, both from the point of view of investment cost for the large oil pump, and also on account of the operating cost. The invention, on the other hand, uses the fact that the maximum oil requirement occurs only for short time, while before and after this the oil requirement is smaller. By taking the necessary pressure oil from an oil reservoir, in accordance with the invention, it is provided, on the one hand, that the short term oil requirements are available, on the other hand, that the pressure oil reservoir can be fed by a relatively small pump, which pumps oil into the pressure oil reservoir in those periods in which the maximum oil requirement is not present.

In accordance with a further feature of the invention it is proposed, that the oil reservoir be provided with a piston separating the oil and air sides, the piston having a piston rod which extends outward and which has a contact cam for an oil pump switch. As soon as the oil reservoir is completely full and the piston rod has reached an end position the feed pump is stopped by the operation of the contact. As soon as oil is drawn from the oil reservoir the pump is again set in operation by the contact cam, which is adjustable in respect to its throw. Thereby there is provided a particularly economical cooperation of the oil reservoir and the oil pump.

A specially advantageous use of the invention is for plastic die-casting machines, in that the cylinder cover through which the piston rod passes carries the stationary section of the plastic injection mold. The plastic injection device is also joined to the cylinder cover and the piston rod carries the movable section of the plastic mold at its free end. This direct drive of the plastic mold, in which the movable mold section, or its supporting plate, is mounted directly on the piston rod, makes possible, in contrast with the prior art, the advantageous use of special mold guiding rods, the reduction of the number of necessary mold holding and guiding plates, an exceptionally shortened and space economizing construction, the advantageous arrangement of the mold on the back side of the machine and a more rapid injection procedure in continuous operation.

An illustrative example of the invention is described herebelow, with reference to the annexed drawings.

FIGURE 1 is a schematic representation of a driving device in accordance with the invention;

FIGURE 2 is a diagram of the control plan for the rotary valve; and

FIGURE 3 is a somewhat diagrammatic perspective view of an illustrative embodiment of the rotary valve.

The hydraulic driving device shown in FIGURE 1 serves for closing, holding together, and opening a plastic injection mold which consists of a stationary mold part **1** and a movable mold part **2**. To the stationary mold part **1** is fastened the plastic injection device shown above it. The plastic injection mold operates in the following way:

The movable mold part **2** is moved over to the stationary mold part **1** during the forward stroke; there, in

the closed position, it is held together with great force, whereupon the actual plastic injection takes place, after which, by the back stroke of the movable mold part away from the stationary form part, the plastic injection mold is again opened. Up to this point the process is known.

The movable mold part **2** is fastened upon a piston rod **3**, which connects the movable mold part **2** with the actual hydraulic driving mechanism.

On the piston rod **3** is fixed a piston **4**, which travels in a cylinder **5**. Into the cylinder **5**, on the side of the piston rod **3**, opens the forward stroke oil conduit **6**; on the other side of the piston **4**, the back stroke oil conduit **7**. The piston **4** carries, on its side turned away from the piston rod **3**, an auxiliary piston **8**, which travels in an auxiliary cylinder **9** joined to the cylinder **5**. Into the auxiliary cylinder **9** opens a back stroke auxiliary oil conduit **10**. The diameter of the auxiliary piston **8** is larger than that of the piston rod **3**.

The oil conduits **6**, **7**, and **10** are joined to a rotary valve **11**, **18**. Also joined to this rotary valve **11**, **18** are the pressure oil conduit **12** and the oil sump conduit **13**. The oil sump conduit **13** leads to an oil sump **14**, from which the oil pressure pump **15** delivers the pressure oil through a check valve **16** to an oil reservoir **17**, which is connected to the previously mentioned pressure oil conduit **12** leading to the rotary valve **11**, **18**. The check valve **16** blocks the movement of oil from the direction of the pressure oil reservoir **17** to the pressure oil pump **15**.

The pressure oil reservoir **17** contains a piston **23**, which separates the oil side from the air side, and which moves in either direction in dependence upon the pressure difference; in doing so it operates a pressure oil pump switch **25** by means of a rod **24**. By this means there is provided an economical automatic drive for operation of the driving mechanism.

The rotary valve **11**, **18** is adjustable by known means (not shown) between three control positions. Control position I is for the forward stroke, control position II for the closed position of the mold, and control position III for the back stroke. According to the way in which the mechanism is used the rotary valve can be provided with additional control positions; for example, in a plastic injection molding machine, positions for plastic injection step or for other hydraulically operated motions of the machine.

FIGURE 2 shows the control plan for the rotary valve **11**, **18**. FIGURE 3 shows, for better comprehension, a schematic perspective representation of the control cylinder **18** of the rotary valve **11**, **18**, in its coaction with the oil conduits, **6**, **7**, **10**, **12**, **13**. It should be borne in mind, that the oil conduits **6** and **12**, as can be seen in FIGURE 1, are connected by a common conduit **19** to the rotary valve **11**. The rotary valve **11**, **18** is preferably so designed that the control positions I, II and III are each 120° apart. Only for the purpose of better illustration are they shown relatively displaced by a smaller angle, so that the control ducts for all control positions are visible at the same time in FIGURE 3.

In the forward stroke position, the rotary valve assumes position I. Since the same high pressure operates in both cylinder chambers **20** and **21** of cylinder **5**, the force acting upon piston **4** is proportional to the difference in diameter of the piston rod **3** and the auxiliary piston **8**, that is, a relatively small force directed toward the left. This force must do work; firstly the work, which would also have to be done if the piston **4** had a surface equal in size to the difference between the cross sections of the piston rod **3** and the auxiliary piston **8**, secondly the friction work required by the flow from the cylinder space **21** into the space **20**, and finally, the friction work required for the emptying of the auxiliary cylinder **9** into the oil sump. The volume of pressure oil required is, as a result of the hydraulic short circuit, very small. In control position II, the closed position, the cylinder space **21** and the auxiliary cylinder **9** are emptied, because they are both connected through the rotary valve to oil conduit **13** leading to the sump. The cylinder space **20** stands under pressure. This pressure provides the closing force for the movable form part **2** in the closed position.

In control position III, the back stroke, the piston chambers **20**, **21** and the auxiliary cylinder **9** are all impacted by oil pressure. On the left side of piston **4**, in FIGURE 1, in effect the entire surface is subjected to oil pressure while on its other side only a surface which is smaller than the piston surface by the area of piston rod **3**, is subjected to oil pressure. Consequently, a force directed toward the right operates on piston **4**, causing the back stroke, that is, the opening of the mold parts **1** and **2**.

It is evident, therefore, that the invention makes possible both the forward stroke and back stroke motions in the simplest manner, merely with a hydraulic high-pressure system, without having to take into account unnecessary losses—except leakage losses. This advantage of the invention arises from the fact, that in the forward stroke and back stroke only relatively small piston surfaces are subjected to oil pressure, in the direction in which work is done, namely, the surfaces corresponding to the differences between the different piston surfaces. The emptying and filling of the relatively large cylinder spaces, which, during the stroke movements are not used for performance of work, occurs in the short circuit hydraulic path, therefore, except for friction work, without having to do work. In the closed position, however, the relatively large piston surface, which is exposed on the side of the piston **4** from which the piston rod **3** extends, is fully available. This piston surface, which is the difference between the surface of piston **4** and the cross-section of piston rod **3**, is the very largest piston surface which effectively comes into action during the work cycle. Therefore it exerts the largest force, namely, the large force which is required in the closed position. The effective forces which operate during the remainder of the work cycle are substantially smaller.

What is claimed is:

1. A hydraulic driving device for tools or the like, of the type which operate in a three-part cycle, namely, a forward stroke, in which the tool is driven from an open position to a closed position, a middle portion during which great force is exerted, and a back stroke in which the tool is moved from the closed position to the open position; the tool being connected by a piston rod with a piston traveling in a main cylinder, into one side of which (the side from which the piston rod projects) opens a forward-stroke oil conduit and into the other side of which opens a back stroke conduit, the conduits being connectable by means of a control device having several control positions with a source of pressure oil or an oil sump, selectively, characterized by the facts that:

(1) The piston carries on its side turned away from the piston rod an auxiliary piston;

(2) The auxiliary piston travels in an auxiliary cylinder; into which a back-stroke auxiliary oil conduit opens;

(3) The diameter of the auxiliary piston is larger than the diameter of the piston rod;

(4) The control device is adjustable between at least three different positions;

(5) Said control device having in position I, the forward-stroke position, means providing a short circuit connection between the main cylinder spaces on opposite sides of said piston and means for placing the auxiliary cylinder in communication with the oil sump;

(6) Said control device having in position II, the closed position, means for placing the side of the main cylinder opposite the piston rod and the auxiliary cylinder both in communication with the sump, while sealing off said last mentioned side of the main

cylinder from the other side of the main cylinder and from the source of pressure oil;

(7) And said control device having in position III, the back stroke position, means for connecting both sides of the main cylinder and also the auxiliary cylinder to the pressure oil source and sealing them off from the sump;

(8) The pressure oil source consisting of a single high pressure oil source.

2. A hydraulic driving device in accordance with claim 1, characterized by the fact that said control device is a rotary valve.

3. Hydraulic driving device in accordance with claim 1, characterized by the fact that said single pressure oil source includes an oil reservoir, into which oil is pumped at intervals by a pressure oil pump which draws oil from said sump and forces it into said oil reservoir through a conduit containing a check valve which blocks the flow of oil from the oil reservoir toward the oil pump.

4. Hydraulic driving device in accordance with claim 3, characterized by the fact that said oil reservoir includes

a piston separating an oil side from an air side, which, through a rod, operates a pressure oil pump switch.

5. Hydraulic driving device in accordance with claim 1, for operating the movable mold part of a plastic injection molding machine, characterized by the fact that the stationary part of the mold has mounted on it the plastic injection device and is itself mounted on the cylinder cover through which the piston rod extends, said piston rod having mounted on its free end the movable mold part of the plastic injection mold.

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