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(54) IMPROVEMENTS RELATING TO HYDRAULICALLY OPERATED DIE CLAMPING ASSEMBLIES

(71) We, CINCINNATI MILLING MACHINES LIMITED, a British Company of, Kingsbury Road, Birmingham 24, in the County of Warwick, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be obtained, to be described in and by the following statement:—

This invention relates to a hydraulically operated die clamping assembly in or for a casting or moulding machine having die carrying members movable towards and away from each other to move die parts, when carried by such members, between a closed position in which the die parts co-operate to define a die cavity, and an open position in which the die parts are separated to permit of a cast or moulded product being removed.

The die carrying parts are required to be moved from the open position to the closed position in as short a time as possible in order to avoid uneconomically lengthening the cycle time of the machine. When in the closed position the die parts are required to be held together with a closure force sufficient to prevent separation of the dies and leakage of casting or moulding material at the interface between the die parts even under high pressures of casting and moulding material.

If a simple hydraulic piston and cylinder unit or ram were provided for effecting opening and closing movement of the die carrying members, the effective area of the piston or ram would require to be selected in relation to the maximum pressure capable of being supplied from the hydraulic pump or source utilised to ensure establishment of the requisite closure force. On the other hand, such pump or source would also have to supply the hydraulic fluid at a very high rate in order to meet the first requirement, i.e. rapid closure.

In order to overcome this problem it is known to provide a more sophisticated form of hydraulic piston and cylinder or ram means which incorporates two chambers, one of these, usually termed the 'quick advance or booster

chamber, being of relatively small diameter, and the other, usually termed the main or working chamber, being of relatively large area. It is then necessary to provide valve means to ensure that hydraulic fluid under pressure is supplied only to the quick acting or booster chamber during the closure movement of the die carrying parts, whilst fluid can be drawn in from a tank or reservoir into the main or working chamber concurrently. When the die carrying parts have reached the closed position, the valve means is arranged to change over to another setting in which communication to the reservoir tank or chamber is shut off and hydraulic fluid, preferably under increased pressure, is applied to the main or working chamber, and possibly also to the quick acting or booster chamber in order to exert the required closure force.

The invention is concerned specifically with a hydraulically operated die clamping assembly of this kind comprising a main body having a longitudinally extending main chamber subdivided into inner and outer chambers by a co-axial inner tubular member communicating respectively with the chamber of an inner closure ram and an outer clamping ram of larger effective piston area, a primary valve for establishing the supply of hydraulic fluid from a pressure source selectively to only the inner passageway, or to both of the passageways, and a secondary valve in the form of a sleeve surrounding the inner tubular member and movable axially between open and closed positions respectively for establishing and cutting off communication between the outer passageway and a prefill source. Such a die clamping assembly is hereinafter referred to as being of the kind specified.

Heretofore the sleeve surrounding the inner tubular member has been adapted not only to operate as the secondary valve but also to perform the function of the primary valve. This has been accomplished by providing one or more ports extending through the wall thickness of the inner tubular member and by making the sleeve a close sliding fit on the

exterior of the inner tubular member, so as to operate as a sleeve valve in relation to said port or ports. The secondary valve function is then performed by an integral valve disc
5 projecting radially from the outer surface of the sleeve or by one end of the sleeve co-operating with an annular valve seat external to, and concentric with, the inner tubular member.

10 With this arrangement the internal diameter of the sleeve is determined by the external diameter of the inner tubular member which in turn is determined by parameters such as the force required to be exerted to effect
15 closure of the die carrying parts in the short time required.

Consequently, insofar as the sleeve per se forms the primary valve function, the surfaces in contact, namely the inner surface of the
20 sleeve and the outer surface of the inner tube, have a relatively large diameter compared with that which is necessary or economic from a manufacturing point of view to perform this function.

25 Moreover, in order to ensure relatively free flow of hydraulic fluid from the tank or reservoir into the main or working chamber during closure of the die parts, the opening presented by the secondary valve must be adequately large, and in consequence the sleeve
30 must either be provided with a radially projecting flange, the periphery of which acts as the valve, or must be made of a very substantial wall thickness in order to increase its external diameter, or must have a long
35 axial travel between the open and closed positions in regard to its secondary valve function.

Moreover, during part of the operating cycle when fluid under pressure is being
40 applied through the interior of the inner tube and through the port or ports of the inner tube to the main or working chamber, that part of the inner tube which is embraced by the sleeve is subjected to a relatively high
45 internal pressure, whereas externally the sleeve itself is subjected to the relatively low or atmospheric pressure existing in the tank or reservoir. It is, therefore, necessary to machine the inner surface of the sleeve and the external
50 surface of the inner tube to very precise limits to ensure that on the one hand the sleeve can effectively perform its primary sleeve valve function with respect to the ports in the inner tubular member, and at the same time will
55 not bind or stick under internal pressures to which the inner tubular member is subjected.

These considerations cause quite severe manufacturing problems.

60 The object of the present invention is to provide an improved arrangement in respect of the primary and secondary valves and the means whereby fluid is conveyed from the pressure source to the inner closure ram and the outer clamping ram which will simplify
65 manufacture and maintainance of the work-

ing parts and will also provide ready access to those parts of the valve means which operated to produce change-over from the setting applicable to the closure stage to the setting applicable to the clamping stage.

70 According to the invention we provide a hydraulically operated die clamping assembly of the kind specified wherein firstly the duct means is defined by a main outer body connected or adapted for connection to one of the relatively movable parts of the ram means and affording a longitudinally extending main chamber which is sub-divided internally by a co-axial inner tubular member into an inner
75 passageway communicating with the inner chamber of the ram means, and an outer generally annular chamber communicating with the outer chamber of the ram means, and wherein secondly the valve means comprises a valve body disposed at the outer end of the main body and formed with ducts through
80 which fluid can be supplied to the outer ends of said inner and outer passageways and containing a primary valve settable in alternative positions, in one of which it permits of the flow of fluid from said pressure source to the inner passageway only, and in the other of which positions it permits of flow of
85 fluid to the outer passageway, a secondary valve in the form of a sleeve assembled co-axially with the main body in the main chamber thereof but with radial clearance with respect to the inner tubular member, and
90 slidable axially between a rearward open position in which it permits of inflow of fluid through a way in the main outer body from the prefill source to the outer passageway, and a forward closed position in which it prevents such flow, movement from the open to the closed positions being effected by
95 actuating means provided in the valve body which carries the primary valve.

The preferred arrangement is one in which the primary valve comprises one or more valve elements each movable axially in the valve body at the outer or rearward ends of the inner and outer passageways between a first, rearward, position, in which it or they establish communication with the pressure source only to the inner passageway, the sleeve which
100 forms the secondary valve member being maintained in its rearward open position with respect to the prefill source by biasing means acting to urge the sleeve rearwardly, and a second, forward, position, in which the or
105 each primary valve element co-acts directly or indirectly with the rearward end of the sleeve concurrently to move this forwardly to its closed position and establish communication between the pressure source and the outer
110 passageway through the radial interspace between the inner boundary of the sleeve and the outer boundary of the inner tubular member.

The primary valve element, or each of same, 130

may thus comprise a plunger mounted for axial movement in an associated axially extending bore in the valve body, the bore having port means co-operating with port means in the plunger so that, when the latter is in its rearward position, it closes communication between the pressure source and the rearward end of the outer passageway in the main body, whilst in its forward position it permits of the establishment of such communication.

The or each primary valve element may be operated hydraulically and for this purpose may include a piston head operating in a cylinder formed by a part of the bore in which the valve element concerned is mounted, preferably the rearward end portion of such bore. The valve body may contain a centrally, or approximately centrally, disposed main bore for establishing communication between the pressure source and the inner passageway, and one or more laterally outwardly extending secondary bores leading from the main bore to the or each axially extending subordinate bore in which one of said primary valve elements operates.

The sleeve which forms the secondary valve element is also preferably formed adjacent to its rearward end with a piston head, and the main body is of enlarged internal diameter at this position to accommodate such piston head which, in combination with the outer body, forms a double-acting piston and cylinder assembly, fluid from the prefill source or other suitable lower pressure source being supplied to the interspace between the sleeve and the outer body forwardly of the piston head to act as the biasing means for urging the sleeve in a rearward direction towards its open position with respect to the prefill source.

At its forward end the sleeve includes a valve portion proper co-operating with a valve seating formed in the outer body forwardly of a laterally extending opening therein through which fluid can flow inwardly to the outer passageway from the prefill source.

The invention will now be described, by way of example, with reference to the accompanying drawings wherein:—

FIGURE 1 is a fragmentary view in side elevation and partly in diametral cross-section through one embodiment of die clamping assembly in accordance with the invention;

FIGURE 2 is a view in side elevation and on an enlarged scale in cross-section on the line 2—2 of Figure 3 showing the arrangement of duct means and valve means of the die clamping assembly;

FIGURE 3 is a view in end elevation of the parts shown in Figure 2;

FIGURE 4 is a fragmentary view in diametral longitudinal cross-section through one of the primary valves;

FIGURE 5 is a fragmentary plan view of one of the primary valve plungers; and

FIGURE 6 is a schematic view showing

a hydraulic fluid supply circuit for the die clamping assembly.

Referring firstly to Figure 1, the die clamping assembly is shown, by way of example, in combination with a pair of dies 1 and 2 shown in the open position in Figure 1 in full lines. The die 1 is supported by a fixed cross head 3 carried by spaced parallel guide rods 4, and the movable die 2 is supported by a movable cross head 5 slidably mounted on the guide rods 4 and movable to the right as viewed in Figure 1 to bring the movable die 2 into a closed position, as indicated in chain lines at 2a.

Movement of the cross head 5 is effected by connection thereof to the piston part 6 of a hydraulic ram means indicated generally at 7, while the guide rods 4 are connected to a cylinder 8 of the ram means which is secured to the chamber defining part 9 of the ram means.

Internally the ram means is formed with an inner chamber 6a which operates as the closure chamber hereinbefore mentioned, and from which extends a tubular member 12 extending through a gland or sealing structure (not shown) at the mouth of the subordinate chamber 6a.

The ram means 7 also has an outer chamber 9a which acts as the clamping chamber hereinbefore mentioned.

The piston area afforded by the inner closure chamber 6a is substantially smaller than that afforded by the outer clamping chamber 9a, a typical ratio being 1:20, and this permits fluid to be supplied in moderate quantity from a pressure source to the closure chamber for effecting rapid closure of the dies by movement of the piston 6 to the right, as seen in Figure 1, into the position shown in chain lines without demanding an excessive quantity of hydraulic fluid to be supplied at high pressure. The outer clamping chamber 9a during this stage is required to be kept full of hydraulic fluid, such, however, being drawn conveniently by gravity from a separate source (not shown) such as a tank, herein referred to as the prefill source, through an inlet 18 by a pipe 18a. The clamping chamber 9a is required to be placed in communication with a pressure source only after the dies have reached, or just before the dies have reached, the closed position.

Thereafter a large clamping force is exerted, as a result of the fluid under pressure in the outer clamping chamber 9a, on the piston 6 to maintain a good sealing relationship between the abutting or mating faces of the dies 1 and 2, notwithstanding the possibly high internal pressure of the casting or moulding material fed or injected into the die cavity defined between the dies.

To enable this sequence of operations to be effected, the present invention provides

a die clamping assembly having a certain arrangement of duct means and valve means for the supply of fluid to the chambers 6a and 9a as hereinafter described.

5 The chamber defining part 9 of the ram means is conveniently formed integrally with a main outer body 10, although the latter may be formed, if desired, as a structurally
10 separate part and secured in any suitable manner to the chamber defining part 9. The body part 10, which is seen in more detail in Figure 2, is sub-divided internally by a rearward extension of the tubular member 12 previously referred to, so as to form an inner
15 passageway 13 leading to the closure chamber 6a and an outer annular passageway 14 leading to the clamping chamber 9a.

As mentioned it will be evident that the tubular member 12 serves also to sub-divide
20 the piston 6 into two areas, namely an inner area which is that afforded by the right-hand or blind end of the closure chamber 6a of the ram means, and an outer annular area bounded internally and externally by the outer
25 surface 15 of the tubular member 12 and the inner surface of the cylinder 8 of the ram means, this latter area constituting the effective piston area of the clamping ram.

The rearward end of the body 10 is closed
30 by a valve body 19 which centrally is formed with a main bore 20 leading from an inlet 17 to the inner passageway 13 and thence to the closure chamber 6a of the ram means. The valve body 19 is also provided with one
35 or more primary valves, two such being illustrated at 21a and 21b. These valves are of identical construction and are disposed at approximately diametrically opposed positions, the former being shown in the open position
40 and the latter in the closed position.

The primary valves are identical and one of these is shown in more detail in Figures 4 and 5. The primary valves comprise valve
45 liners 22a, 22b which are fluid-tight fits in corresponding axial bores in the valve body 19 and are formed in the mid regions of their length with inlet ports 23a, 23b communicating with radial bores 24a, 24b leading
50 outwardly from the central main axial bore 20.

The bores 24a, 24b are continued radially outwardly of the valve liners merely for convenience in the formation of these bores, the
55 continuations 25a, 25b, however, being closed by screw-threaded socketed flush fitting plugs 26a, 26b.

The valve liners contain respective valve
60 plungers 27a, 27b formed adjacent to their rearward ends with inlet ports communicating with axial bores 29a, 29b in the plungers which are blind at their forward ends and terminate in portions forming thrust elements
30a, 30b.

The bores 24a, 24b, and the ports 23a,
65 23b communicate with annular grooves such

as those seen at 24a and 23a in Figure 4, in each case to provide some tolerance as to the axial position of the liner or plunger, and to allow the device to operate properly
70 regardless of the rotational positions of the liner or plunger about their own axes.

The inlet ports of the plungers are of such form or configurations as to provide, in combination with the inlet ports 23a, 23b, con-
75 striction to the flow of fluid from the bores 24a, 24b to the interiors of the plungers and thence via ports 31a, 31b to interspace 49 and chamber 9a. Thus the ports may, as shown, each comprise axially spaced holes or groups thereof, with the holes of each set
80 being of respectively increasing diameters from right to left as seen in Figures 2 and 4, and with the axial spacing such that as the plunger moves to the right the effective area of overlap with the ports 23a, 23b is increased.
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Thus, as seen in Figures 2 and 4, there may be two groups of axially spaced holes, one indicated at 28a₁, 28a₂, and being typically 1/2 inch in diameter, and the other
90 being indicated at 28a₂, 28b₂, and being 1/4 inch in diameter spaced axially from the first group by approximately 3/8 inches between hole centres. The number of holes in each group, the diameter of the holes, and the number of groups may be varied as
95 required. As shown there are two holes in each group.

Alternatively the inlet ports of the plungers may be of appropriate non-circular shape
100 selected to provide the required rate of diminution in the constriction, for example of triangular or other longitudinally tapering form with the narrow end nearest the ports 31a, 31b. At the forward ends of the bores 29a, 29b these communicate with outlet ports 31a,
105 31b which in the open position of the primary valve, as shown in the valve 21a, allow fluid under pressure from the inlet 17 to the outer chamber 14, and which in the closed position, as shown in respect of the valve
110 21b, prevent such delivery of fluid from the pressure source.

For operating the valve plungers these are formed with piston heads 32a, 32b and the
115 rearward end portions of valve liners 22a, 22b form cylinders 33a, 33b communicating with an inlet 35a by way of a transverse bore 35 in the valve body 19. If desired the piston heads may be made of somewhat larger diameter than the remainder of the plungers,
120 the liners 22a, 22b being correspondingly enlarged internally. Alternatively, or in addition, the plungers could be spring loaded for forward movement, e.g. by coiled compression springs in cylinders 33a, 33b. The
125 bores in which the liners 22a, 22b are mounted are closed by plugs 50a, 50b which may, as shown, be castellated or otherwise so formed at their inner ends to act as rearward stops for the piston heads without obstructing
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delivery of fluid to the cylinders formed by the rear portions of the liners.

The valve body 19, as shown, is formed as a structurally separate part from the body 10 and is secured thereto by screws 36, but the valve body could be formed wholly, or in part, as an integral portion of the main cylinder body or may be formed of two more structurally separate components if such is convenient for manufacturing purposes.

In addition to accommodating the primary valves 21a, 21b the inner face of the valve body 19 is formed with a cylindrical recess 37 in which a terminal portion of enlarged external diameter at the rearward end of the tubular member 12 is received and which serves to maintain this in the required coaxial relation with the main body 10.

The valve means further comprises a secondary valve in the form of a sleeve 38 which is slidable axially in contact with the inner surface of the main body 10 of the cylinder and is equipped with sealing rings 39 providing fluid-tight relationship between these two parts.

The rearward end of the sleeve 38 is of enlarged diameter to form a piston head 40 operating in a portion of the rearward end of the main cylinder which is of enlarged internal diameter and in combination therewith forms a double-acting piston and cylinder unit. Fluid can be admitted at inlet 43a and through a bore 43 to apply pressure to one end of the piston head, and pressure is applied to the other end of the piston head when the outer chamber 14 is pressurised.

The relative areas of space 41 on the one hand and that of both the piston heads 32a and 32b on the other hand are such that, when hydraulic fluid at the same pressure is fed in at inlets 35a and 43a, the sleeve 38 is biased to be retained in the rearward direction, i.e. to the left as shown in Figure 2, the plungers 27a, 27b being then in contact with piston head 40.

At its forward end the sleeve 38 is formed with a valve portion proper having a surface 44 of frusto-conical form co-operative with a complementary valve seating 45 formed at a shoulder 46 afforded at the entrance to the outer clamping chamber.

When the sleeve 38 is in its rearward position it is open with respect to the inlet 18a connected to the prefill source and fluid therefrom can enter the outer chamber 9a, as indicated by the arrow 48, whereas when the sleeve is in its forward or closed position, as seen in the lower half of the drawing, the closed relation between the valve face 44 and seating 45 shuts off communication between the prefill source and the clamping chamber.

The various sources of hydraulic fluid, the manner in which these are effectively connected to the assembly, and the operation of

the latter will be best understood by describing the sequence of operation which is as follows.

Starting at the stage at which the die-carrying cross heads 5 are in the fully open position, and the parts are in the position shown in the upper half of Figure 2, hydraulic pumps PL (low volume) and PH (high volume) driven from respective electric motors, are both running. The high volume pump PH delivers fluid through pipes 51 and 52 to the unloading valve V1.

The unloading valve V1 is controlled by a solenoid valve D1 having a small bore connection to the reservoir tank. When D1 is closed the unloading valve acts as a relief valve which lifts according to spring tension, e.g. 2400 p.s.i. when it discharges back to the tank, while when D1 is open V1 opens and permits fluid to flow at near zero pressure back to the tank (a small quantity concurrently passing through pipe 53 and valve D1).

At this time the low volume pump PL discharges to the tank by way of solenoid valve D3 which is open to the tank and closed with respect to pipe 62. Fluid passes through pipes 54 and 50, containing a restrictor valve R, a non-return valve N2 and then via pipes 56 and 61 to solenoid valve D3. By virtue of the pressure drop occurring through the restrictor valve R, pressure in the pipe 54, and hence in the pipe 58, is maintained at a suitable low pressure (e.g. 400 p.s.i.).

A non-return valve N1 connected between pipes 59 and 60 prevents fluid delivered from the pump PL passing to the unloading valve V1.

Fluid from the pipe 58 passes by way of solenoid valve D2 from inlet port P thereof to outlet ports A and B which are connected respectively to inlets 43a and 35a of the valve assembly.

The relative areas of the right hand end of the piston head 40 and the left hand ends of the plungers 27a and 27b are such that when an equal pressure of hydraulic fluid (400 p.s.i.), is supplied to both the chamber 41 and against the left-hand ends of the plungers 27a and 27b, the sleeve 38 is held in its leftward or open position.

To effect rapid closure of the dies the solenoid valve D3 is operated to open the pipe 61 to the pipe 62 and to close it with respect to the tank. The solenoid valve D1 is closed, thus closing the unloading valve V1. This causes fluid to be supplied from both pumps PH and PL through pipes 61 and 62 to inlet 17. Accordingly the fluid flows along the inner passageway 13 to the inner closure chamber 6a causing the piston 6 to be moved rapidly to the right.

At the same time prefill fluid from the tank can gravitationally enter inlet 18a, and pass into the outer chamber 9a as the piston 6 travels to the right.

The pressure at this time at inlet 17 can rise to the value set by the unloading valve V1, namely 2400 p.s.i.

To effect slow closure of the dies, (for example in the terminal portion of the closure stroke) the high volume pump PH is unloaded by opening of the valve D1. The piston 6 then continues to travel to the right at a speed corresponding to the output of the low volume pump PL only.

To establish the required clamping pressure after the dies have closed, solenoid valve D2 is operated so that the inlet P is connected to outlet B, while outlet A is connected to outlet T, feeding back to the tank. Under these conditions the pressure of fluid maintained at inlet 35a, and hence on the left-hand ends of the plungers 27a, 27b, allows these to prevail over the piston 40 (chamber 41 being then only at exhaust pressure to the tank). The plungers thus displace the sleeve 38 to the right, so that the parts then take up the position shown in the lower half of Figure 2. The plungers 27a, 27b exert sufficient thrust on the rear end of the piston head 40 to ensure satisfactory closure of the valve face 44 with respect to the seating 45. At this stage the solenoid valve D1 is closed so that the pressure of the fluid delivered from the high volume pump PH rises rapidly until the high volume pump PH is unloaded by a pressure switch (not shown) controlling the solenoid valve D1 to cause the latter, and hence the unloading valve V1, to open to the tank at a pressure of about 2400 p.s.i. The low volume pump PL continues to deliver fluid and pressure continues to rise to a level typically of about 3000 p.s.i. determined by the relief valve V2. The high pressure fluid is thus supplied to both inlets 17 and 35a. Hydraulic fluid from the inlet 17 can pass through bores 24a, 24b and ports 28a, 28b, along the axial bores 29a, 29b of the plungers for delivery from ports 31a, 31b to the interspace 14 and chamber 9a. Simultaneously the fluid at 17 passes directly to chamber 6a, so that the whole of the piston area presented by piston 6 is pressurised at the high pressure.

Continuance of the high pressure at inlet 17 ensures maintenance of the sleeve 38 in its right-hand closed position, by virtue of the greater area presented by the piston head 40, in comparison with that presented by the forward end of the sleeve 38 inwardly of the surface 44.

To return the parts of the machine to the initial position the fluid is exhausted from chamber 9a through a separate valve controlled exhaust duct (not shown). Exhausts of chamber 6a takes place via pipe 62 and valve D3.

It will be noted that during movement of the plungers 27a and 27b to the right, the initial admission of fluid from inlet 17 through

bores 24a, 24b takes place through the smaller diameter portions or elements of the ports 28a, 28b, and consequently controls the rate of build-up of pressure.

All of the components of the primary valves 21a, 21b are readily accessible for maintenance and replacement merely by unscrewing plugs 50a, 50b. Further, the valve body 19 can be withdrawn with the primary valves as a unit by removal of screws 36, and it is then possible very simply to withdraw the primary valves as required.

Any adjustments upon assembly and which are required to be carried out with respect to the inlet ports 28a, 28a₂, 28b, 28b₂ for the purpose of ensuring proper rapid but shockless operation of the device as a whole, can readily be made.

Sealing or cutting-off of the fluid admitted at inlet 17 during the initial stages of closure of the dies is effected by virtue of the sealing relation between the outer surface of the plungers 27a, 27b and the inner surfaces of the liners 22a, 22b. These components are of relatively small diameter and can, therefore, be machined economically to a high accuracy.

WHAT WE CLAIM IS:—

1. A hydraulically operated die clamping assembly of the kind specified wherein firstly the duct means is defined by a main outer body connected or adapted for connection to one of the relatively movable parts of the ram means and affording a longitudinally extending main chamber which is sub-divided internally by a co-axial inner tubular member into an inner passageway communicating with the inner chamber of the ram means, and an outer generally annular chamber communicating with the outer chamber of the ram means, and wherein secondly the valve means comprises a valve body disposed at the outer end of the main body and formed with ducts through which fluid can be supplied to the outer ends of said inner and outer passageways and containing a primary valve settable in alternative positions, in one of which it permits of the flow of fluid from said pressure source to the inner passageway only and in the other of which positions it permits of flow of fluid to the outer passageway, a secondary valve in the form of a sleeve assembled co-axially with the main body in the main chamber thereof but with radial clearance with respect to the inner tubular member, and slidable axially between a rearward open position in which it permits of inflow of fluid through a way in the main outer body from the prefill source to the outer passageway, and a forward closed position in which it prevents such flow, movement from the open to the closed positions being effected by actuating means provided in the valve body which carries the primary valve.



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10 To establish the required clamping pressure after the dies have closed, solenoid valve D2 is operated so that the inlet P is connected to outlet B, while outlet A is connected to outlet T, feeding back to the tank. Under these conditions the pressure of fluid maintained at inlet 35a, and hence on the left-hand ends of the plungers 27a, 27b, allows these to prevail over the piston 40 (chamber 41 being then only at exhaust pressure to the tank).
20 The plungers thus displace the sleeve 38 to the right, so that the parts then take up the position shown in the lower half of Figure 2. The plungers 27a, 27b exert sufficient thrust on the rear end of the piston head 40 to ensure satisfactory closure of the valve face 44 with respect to the seating 45. At this stage the solenoid valve D1 is closed so that the pressure of the fluid delivered from the high volume pump PH rises rapidly until the high volume pump PH is unloaded by a pressure switch (not shown) controlling the solenoid valve D1 to cause the latter, and hence the unloading valve V1, to
30 open to the tank at a pressure of about 2400 p.s.i. The low volume pump PL continues to deliver fluid and pressure continues to rise to a level typically of about 3000 p.s.i. determined by the relief valve V2. The high pressure fluid is thus supplied to both inlets 17 and 35a. Hydraulic fluid from the inlet 17 can pass through bores 24a, 24b and ports 28a, 28a, along the axial bores 29a, 29b of the plungers for delivery from
45 ports 31a, 31b to the interspace 14 and chamber 9a. Simultaneously the fluid at 17 passes directly to chamber 6a, so that the whole of the piston area presented by piston 6 is pressurised at the high pressure.

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110 alternative positions, in one of which it permits of the flow of fluid from said pressure source to the inner passageway only and in the other of which positions it permits of flow of fluid to the outer passageway, a secondary valve in the form of a sleeve assembled co-axially with the main body in the main chamber thereof but with radial clearance with respect to the inner tubular member, and slidable axially between a rearward open position in which it permits of inflow of fluid through a way in the main outer body from the prefill source to the outer passageway, and a forward closed position in which it prevents such flow, movement from the open to the closed positions being effected by actuating means provided in the valve body which carries the primary valve.
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2. An assembly according to claim 1 in which the primary valve comprises one or more valve elements each movable axially in the valve body at the outer or rearward ends of the inner and outer passageways between a first, rearward, position, in which it or they establish communication with the pressure source only to the inner passageway, the sleeve which forms the secondary valve member being maintained in its rearward open position with respect to the prefill source by biasing means acting to urge the sleeve rearwardly, and a second, forward position, in which the or each primary valve element coacts directly or indirectly with the rearward end of the sleeve concurrently to move this forwardly to its closed position and establish communication between the pressure source and the outer passageway through the radial interspace between the inner boundary of the sleeve and the outer boundary of the inner tubular member.

3. An assembly according to claim 2 wherein the primary valve element, or each of same, comprises a plunger mounted for axial movement in an associated axially extending bore in the valve body, the bore having port means co-operating with port means in the plunger so that, when the latter is in its rearward position, it closes communication between the pressure source and the rearward end of the outer passageway in the main body, whilst in its forward position it permits of the establishment of such communication.

4. An assembly according to either of claims 2 and 3 wherein the or each primary valve element is operated hydraulically and for this purpose includes a piston head operating in a cylinder formed by a part of the bore in which the valve element concerned is mounted, preferably the rearward end portion of such bore.

5. An assembly according to claim 4 wherein the valve body contains a centrally,

or approximately centrally, disposed main bore for establishing communication between the pressure source and the inner passageway, and one or more laterally outwardly extending secondary bores leading from the main bore to the or each axially extending subordinate bore in which one of said primary valve elements operates.

6. An assembly according to any one of the preceding claims wherein the sleeve which forms the secondary valve element is formed adjacent to its rearward end with a piston head, and the main body is of enlarged internal diameter at this position to accommodate such piston head which, in combination with the outer body, forms a piston and cylinder assembly, fluid from the prefill source or other suitable lower pressure source being supplied to the interspace between the sleeve and the outer body forwardly of the piston head to act as the biasing means for urging the sleeve in a rearward direction towards its open position with respect to the prefill source.

7. An assembly according to any one of the preceding claims wherein at its forward end the sleeve includes a valve portion proper co-operating with a valve seating formed in the outer body forwardly of a laterally extending opening therein through which fluid can flow inwardly to the outer passageway from the prefill source.

8. A hydraulically operated die clamping assembly of the kind specified substantially as hereinbefore described with reference to and as shown in Figures 1 to 4 of the accompanying drawings.

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