

A FORM LOCKING DEVICE FOR INJECTION MOLDING MACHINES

The present invention relates to a form locking device for injection molding machines which device is provided with a fixed form top plate carrying half of a tool, a movable form top plate carrying the second half of the tool, with motion spindles, which spindles are freely rotatable in the fixed form top plate and are located therein in one direction axially supported and are located in the movable form top plate in a spindle nut mounted therein, with a rotary drive for the actuation of the motion spindles for the locking-and opening hub of the movable form top plate and with a hydraulic piston-cylinder unit for the locking power construction being in connection in an effective manner with the motion spindles.

A form locking device of this kind is known from DE 37 18 106 A 1 (embodiment according to Fig. 5). In said known embodiment the movable form top plate is movable by the motion spindles supported in the fixed top plate in the locking- and opening hub and in which the locking pressure construction is obtained by hydraulic piston cylinder units supported in the fixed form top plate and engaging the motion spindles. In said embodiment the spindles take over, besides the opening- and locking hub to be performed quickly, also the entire tensile force in the generation of the locking force by the hydraulic piston-cylinder units. The motion spindles are thus used both for overcoming the motion-and the locking force function. The motion spindles can thus be carried out only with difficulty.

There is known from EP 0 381 107 A2 a further form molding device in which the motion spindles mounted in the fixed form top plate are coupled with the movable form top plate by spindle nuts, which cause by a rotary drive the opening- and locking movement. In view of the fact that the locking pressure construction is obtained via hydraulic piston-cylinder units which are supported by spindle



nuts, also in this case the motion spindles are used for taking over the tension forces resulting from the high locking pressure.

The object of the present invention is thus to design a form locking device (as herein defined) in which in ascertaining the high locking pressure by a hydraulic piston-cylinder unit, the motion drive obtained by motion spindles is only that required for quick opening- and locking movements.

The present invention thus consists in a form locking device (as herein defined), characterized in that the movement- and force transfer of the movable form top plate, in quick motion, in the course of the opening and locking operation is performed only by the motion spindles, and in that the hydraulic piston-cylinder unit consists of one or more pistons and hydraulic cylinders in which the application of hydraulic pressure for the locking force construction is performed by piston-cylinder units actuated by the motion spindles by interconnection of one or more pressure transmission units.

One embodiment of the above form locking device may be characterized in that

two kinds of piston columns units are mounted at the movable form top plate, which columns penetrates through the fixed form plate and are guided therein by pistons in hydraulic cylinders, wherein the piston column units of one kind are provided with a motion spindle device and the piston column units of the other kind are provided with a pressure transmission unit;

the pistons divide the hydraulic cylinders in a locking side cylinder room and in an open side cylinder room;

all locking side cylinder rooms are connected to each other by way of channels;



the pressure transmission units consist each of a pressure transmission piston, a pressure transmission cylinder and a valve unit, the pressure transmission piston dividing the pressure transmission cylinder in a locking side pressure transmission room and an open side pressure transmission room, and the valve body being switchable between a position setting free and closing a passage from the locking side cylinder room to the open side cylinder room;

the motion spindle arrangements consist each of a spindle nut mounted within the piston and a motion spindle being located therein in the thread engagement, which motion spindle dips with one end into a cylindric groove of the piston column unit and with the other end penetrates through the main hydraulic cylinder and is guided with one to a second hydraulic cylinder with a piston unit and with a second penetrates through the second hydraulic cylinder and is coupled with the end part with a drive gear;

the piston unit of each motion spindle divides the second hydraulic piston in a second locking side cylinder room and a second open side cylinder room;

in a first function position (closing movement in quick motion) of a hydraulic system a first multi-path valve is switchable into switching position c, in which the second locking side cylinder room is connectable with a pressure means source, and a second multi-path valve is switchable into switching position b, in which a hydraulic conduit guiding from the second locking side pressure cylinder room to the open side pressure cylinder room is interrupted, wherein the pressure transmission piston and the valve shell are located in a basic position setting a passage free;



in a second function position (locking pressure construction) of the hydraulic system the second locking side cylinder room is connectable with the open side pressure transmission room, wherein the first multi-path valve is in switching position b and the second multi-path valve in switching position a;

in a third function position (pressure reduction) of the hydraulic system the second locking side cylinder room and the open side pressure transmission room are switchable without pressure, wherein the first multi-path valve and the second multi-path valve are each time in switching position a; and in a fourth function position, corresponding to the first function position, (opening movement in quick motion) of the hydraulic system the first multi-path valve is switchable into switching position c and the second multi-path valve is switchable into switching position b.

The previous embodiment may be varied by an embodiment that is characterized in that

the motion spindle arrangements consist each of a spindle nut mounted within the piston and a motion spindle being located therein in the thread engagement, which motion spindle is guided with one end with a spindle piston into a spindle cylinder formed in the piston column unit and with the other end penetrates through the main hydraulic cylinder and is guided with one to a second hydraulic cylinder with a piston unit; and with a second penetrates through the second hydraulic cylinder and is coupled with the end part with a drive gear;

the piston unit of each motion spindle divides the second hydraulic cylinder into a second locking side cylinder room



and into a second side open side cylinder room;
in a first function position (closing movement in quick motion) of a hydraulic system a first multi-path valve is switchable into switching position c, in which the second locking side cylinder room is applicable with a pressure medium of a pressure means source, a second multi-path valve is switchable into switching position a, in which the spindle cylinder is connectable with a tank and a third multi-path valve is switchable into switching position b, with which the hydraulic conduit to the pressure transmission system is interrupted;
in a second function position (locking pressure construction) of the hydraulic system the first multi-path valve is switchable into switching position a, in which the pressure medium being present in the second locking side cylinder room may expand towards said tank, the second multi-path valve is switchable into switching position b and the third multi-path valve is switchable into switching position a, in which the second multi-path valve shuts off the conduit to said tank and the third multi-path valve connects the spindle cylinder with the open side pressure transmission room;
in a third function position (pressure reduction) of the hydraulic system the first multi-path valve is switchable into switching position a, in which the pressure medium being present in the second locking side cylinder room may expand towards said tank, the second multi-path valve and the third multi-path valve being be switchable into switching position a, whereby the pressure from the open side pressure transmission room and of the spindle cylinder may expand towards said tank; and



in a fourth position (corresponding to the first function position, (opening movement in quick motion) the first multi-path valve is switchable into switching position c, in which the second locking side cylinder room is connectable with the pressure means source, the second locking side cylinder room being connectable with the pressure means source, the second multi-path valve being switchable in switching position a, the hydraulic oil may be sucked from the tank into the spindle cylinder, and the third multi-path valve is switchable in the switching position b, in which the hydraulic conduit to the open side pressure transmission room is interrupted.

The previous embodiments may be varied by a further embodiment which is characterized in that

the motion spindle arrangements consist each of a spindle nut mounted within the piston and a motion spindle being located therein in the thread engagement, which motion spindle dips with one end into a cylindric groove of the piston column unit and with the other end penetrates through the hydraulic cylinder and is supported by one by an axial bearing and with the other end part is coupled with a drive gear;

in the first function position (closing movement in quick motion) of a hydraulic system a multi-path valve is switchable into switching position b, in which the open side pressure transmission room is connected with said tank essentially without pressure;

in a second position (locking pressure construction) in which both halves of the tool adjoin each other a multi-path valve is switchable in indexing position c, in which the open side pressure transmission room is connected via the hydraulic conduit to the pressure means source;



in a third function (pressure reduction) of a hydraulic system a multi-path valve is switchable in switching position a, in which the pressure medium may expand to said tank from the open side pressure transmission room via the hydraulic conduits;

in a fourth position (opening movement in quick motion) of the hydraulic system a multi-path valve is switchable into switching position b, in which the pressure transmission device is kept in a position leaving the passage free.

The above embodiments may additionally be characterized in that

in the fixed form top plate are arranged four pistons of piston column units in which each are arranged diagonally each opposite another two motion spindle arrangements and two pressure transmission devices.

Said embodiments may further be characterized in that the pressure transmission piston consists of a piston part having a larger diameter and a piston part having a smaller diameter, wherein on the latter the valve body consisting of a valve shell is axially movable located which is coupled with the pressure transmission piston with the proviso that in the course of the movement of the pressure transmission piston the valve shell is moved simultaneously in a direction opposite to that of the piston which is provided at its circumference with an axial notch over which the pressure medium may be guided from the passage to the ring piston surface of the pressure transmission piston.

The present invention will now be illustrated with reference to the accompanying drawings without being limited by same. Identical parts appearing in various Figs. will be referenced by

the same numerals. In said drawings:

Fig. 1 shows a schematic longitudinal section of a form locking device of an injection molding machine along line I - I of Fig. 4;

Fig. 2 shows a schematical longitudinal section of another embodiment of a form locking device;

Fig. 3 shows a schematical longitudinal section of a further embodiment of a form locking device; and

Fig. 4 shows a cross-section, which is common for all form locking devices of Fig. 1 to 3, along line IV -IV of Fig. 1.

Fig. 1 shows a form locking device for an injection molding machine being provided with fixed form top plate 1 carrying first tool half 2 and movable form top plate 4 carrying second tool half 3. In form top plate 4 are mounted four piston column units 5 to 8, which units 5 to 8 penetrates through form top plate 1 and are movably guided therein in four main hydraulic cylinders 9 to 12 by pistons 13 to 16.

Piston column units 5 to 8 consist of two kinds, in which piston column units 5 and 7 are each provided with a pressure transmission unit; and piston column units 6 and 8 are each provided with a motion spindle arrangement.

The pressure transmission devices of piston column units 5 and 7 consist each of pressure transmission cylinder 17 in which is guided two-step transmission piston 18 which is provided with larger pressure piston 19 which corresponds to the diameter of pressure transmission cylinder 17, and a smaller pressure piston 20, which is surrounded by a valve body constituted by valve shell 21. The circumference diameter of valve shell 21 corresponds essentially to the diameter of pressure transmission cylinder 17 and is axially movable in it as well against pressure piston 20.



Valve shell 21 has at its outer surface at least one axially penetrating notch 22. The axial movement of valve shell 21 is limited in the locking direction by outer ring stop 23 and in the opening direction by stop devices (not shown) acting between the end part of pressure piston 20 and the end part of the inner circumference of valve shell 21 adjoining said stop devices.

Pressure transmission piston 18 divided pressure transmission cylinder 17 in lock side pressure transmission room 24 and in open side pressure transmission room 25.

Open side pressure transmission room 25 is part of passage 26 in piston 13, 15 which divides main hydraulic cylinder 9, 11 in lock side cylinder room 27, 28 and open side cylinder room 31, 32. Passage 26 may be locked by valve shell 21.

In a similar manner pistons 14 and 16 of piston column units 6 and 8 each being provided with a motion spindle arrangement divide main cylinder rooms 10 and 12 in locking side cylinder rooms 29 and 30 and in open side cylinder rooms 33 and 34, respectively.

All locking side cylinder rooms 27, 28 and 29, 30 are connected to each other by channels 35.

The motion spindle arrangements of piston column units 6 and 8 consist each of motion spindle 36, 37, 38 which is located with spindle nut 39 being mounted in piston 14 in the thread engagement and dips into groove 40 of piston column unit 6 and 8.

Motion spindles 36, 37, 38 are also provided with axial bearing 41 and with end part 42, with which the motion spindle is coupled axially movable with a gear drive. Only drive pinion 43 is shown of said gear drive, which pinion 43 may be driven via belt drive 44 with a servo motor having a position regulation. The servo motor is preferably an electro motor.

The above features and devices are identical for all embodi-



ments according to Figs. 1 to 3. Thus hereinafter only the special features of each embodiment will be described.

1. Embodiment according to Fig. 1

1.1 Constructive structure

Motion spindle 36 of the embodiment according to Fig. 1 penetrates through open side cylinder room 32 and extends into adjoining second cylinder room 45 in which motion spindle 36 with axial bearing 41 is located in piston unit 46. Said piston unit 46 divides second cylinder room 45 in second locking side cylinder room 47 and a second open side cylinder room, (not shown in the drawing of piston unit 46).

From second locking side cylinder room 47 hydraulic conduit 48 conducts to first multi-path valve 49 (4/3-path valve) with switching positions a, b and c. Hydraulic conduit 50 branches of hydraulic conduit 48 towards multi-path valve 51 (4/2-path valve) with switching positions a and b over which a connection between second locking side cylinder room 47 and open side pressure cylinder room 25 may be formed or interrupted. Hydraulic conduit 48 is switchable over first multi-path valve 49 optionally either to pressure means source P or via return valve 52 with back pressure (6 bar) to tank T. Hydraulic liquid may be taken from tank T over return valve 53 functioning as secondary suction valve. Open side cylinder room 31 is connected with tank T via hydraulic conduit 54 and return valve 52 with back pressure.

1.2 Function description

1.2.1 Closing of the form locking device in quick motion.

For this purpose second locking side cylinder room 47 is applicable over switching position c of first multi-path valve 49, with pressure medium of pressure means source



P. Thereafter piston unit 46 reaches the stop position illustrated in Fig. 1. Second multi-path valve 51 is in switching

position b, which ascertains that pressure transmission piston 18 holds valve shell 21 in the position illustrated in Fig. 1, in which passage 26 between locking side cylinder room 27 and open side cylinder room 31 is open.

By the rotation of motion spindle 36 tool halves 2 and 3 are moved one toward another until they are stopped by each other. Thus on the basis of the drive of motion spindle 31 via a servo motor with position regulation a precise positioning can be obtained. In the course of the movement of tool halves 2 and 3 one towards another a re-laying of the hydraulic oil from open side cylinder rooms 31 and 33 over passages 26 and channels 35 to locking side cylinder rooms 27 to 30 is performed. Missing quantities of hydraulic oil may be replaced over conduit 54 and return valve 53.

1.2.2. Locking pressure construction.

For this purpose first multi-path valve 49 is brought into switching position b and second multi-path valve 51 into switching position a. By further rotating of motion spindle 51 in the locking side direction piston unit is moved left side in the description according to Fig. 1, whereafter the hydraulic oil being located in second locking side cylinder room 47 reaches via hydraulic conduits 48 and 50 and second multi-path valve 51 open side pressure transmission room 25 and causes a movement of pressure transmission piston 18 and valve shell 21, so that passage 26 is closed by valve shell 26. By further movement of pressure transmission piston 18 there is achieved on the basis of differential pressure



surfaces 19' and 19" an elevated pressure, which extends through notch 22 into valve shell 21 and forms at ring piston surfaces 13' to 16' the required locking pressure.

1.2.3 Pressure reduction.

For the relief of the locking pressure acting on ring piston surfaces 13' to 16' second multi-path valve 51 is brought into switching position a and first multi-path valve 49 into switching position a, whereafter pressure transmission piston 18 is switched without pressure to tank T. Second locking side cylinder room 47 is connected to pressure means source P so that the piston unit is put back into the stop position illustrated in Fig. 1.

1.2.4 Opening of the form locking device in quick motion.

The first and second multi-path valves 49 and 51 are brought into the same switching positions as in the course of the locking operation. The rotation direction of motion spindle 36 is however the reverse direction so that tool halves 2 and 3 are moved from each other.

2. Embodiment according to Fig. 2.

2.1 Constructive structure.

In the embodiment according to Fig. 2 motion spindle 37 is located freely rotatable by axial bearing 41 in housing 55 adjoining hydraulic cylinder 10, but it is not axially movable. The hydraulic system consists of pressure means source P, multi-path valve 56 with switching positions a, b and c, freely switchable return valve 57, return valve 53, return valve 52 with counter pressure, tank T as well as of hydraulic conduits 58 to 61.

2.2 Function description.

2.2.1 Locking of form locking device in quick motion.



Multi-path valve is switched in the position illustrated in Fig. 2 in which it is ascertained that passage 26 in piston 13, 15 is left open. Thus, in the rotation movement of motion spindle 37 and the movement of working tools 2 and 3 one towards the other caused by said movement, the hydraulic oil can flow from both open side cylinder rooms 31 and 33 into locking side cylinder rooms 27 to 30. Missing oil volumes may be sucked by return valve 53 and hydraulic conduit 61. The rotation of motion spindle 37 is stopped when both tool halves touch each other.

2.2.2 Locking force construction

Multi-path valve 56 is brought into switching position c in which the hydraulic oil reaches pressure transmission room 24 from pressure means source P over hydraulic conduit 58 and causes by pressure transmission piston 18 the locking force construction described in 1.2.2.

2.2.3 Pressure reduction

For the relief of the locking pressure acting on ring piston surfaces 13' to 16" multi-path valve 56 is brought into switching position a, in which return valve 57 is switched free over hydraulic conduit 59, so that the pressure acting on pressure transmission piston 18 can expand via hydraulic conduits 58 and 60 towards tank T.

2.2.4 Opening of the form locking device in quick motion.

Multi-path valve 56 is brought into switching position b. By the rotation of motion spindle 37 in the direction in which tool halves move from each other a pressure is formed in locking side cylinder rooms 27 which causes via passage 26 a return movement of pressure transmission piston 18 and valve shell 21 into the position illustrated in Fig. 2, so that



passage 26 between locking side cylinder rooms 27, 29 is completely free, so that in the reverse movement a volume compensation between locking side cylinder rooms 27 to 30 and open side cylinder rooms 31 to 33 may be obtained. Excess hydraulic oil is removed to tank T via hydraulic conduit 61.

3. Embodiment according to Fig. 3

3.1 Constructive structure.

Motion spindle 38 according to Fig. 3 corresponds in the driving side part to motion spindle 36 according to Fig. 1. At the end dipping into piston column unit 6 (8) motion spindle 38 has hydraulic spindle piston 62, which is conducted in spindle cylinder 63. The hydraulic system consists of pressure means source P, first multi-path valve 64 having three switching positions a to c, second multi-path valve 65 having two switching positions a and b and third multi-path valve 66 having switching positions a and b. Said multi-path valves 64 to 66 are connected via hydraulic conduits 67 to 70 to open side transmission room 24, spindle cylinder 63, second locking side cylinder room 47, open side cylinder room 31, 33 and to tank T.

3.2 Function description.

3.2.1 Locking of form locking device in quick motion.

First multi-path valve 64 is switched into switching position c, as the result thereof second locking side cylinder room 47 is applicable with pressure means from pressure means source P and piston unit 46 is in the right stopping position illustrated in Fig.3. Second multi-path valve is switched into switching position a, as the result thereof in the course of the movement of tool halves 2 and 3 one towards another, caused by the spindle rotation the hydraulic oil displaced by



spindle piston 62 out of spindle cylinder 63 can flow to tank T via hydraulic conduit 67. Third multi-path valve 66 is switched into switching position b in order to ascertain that pressure transmission piston 18 and valve shell 21 remain in the position illustrated in Fig. 3, in which, in the cause of moving pistons 13 to 16 into the locking position, an exchange of oil volumes between open side cylinder rooms 31 and 33 and locking side cylinder rooms 27 to 30 may be performed.

3.2.2 Locking pressure construction.

First multi-path valve 64 is switched into switching position a, as the result thereof the hydraulic oil being within in locking side cylinder room 47 may flow to tank T via hydraulic conduit 69, when motion spindle 38 is rotated further while pistons 13 to 16 are in the locking position, so that spindle piston 62 may penetrate further into spindle cylinder 63 in order to form hydraulic pressure for the application of pressure transmission piston 18. As pistons 13 to 16 are in the locking position, in which tool halves 2 and 3 adjoin each other, the rotation of motion spindle 38 causes a movement 46 left side to the extent that spindle piston 62 penetrates into spindle cylinder 63. Second multi-path valve 65 is then switched into switching position a and third multi-path valve 66 is switched into switching position a, so that the hydraulic pressure formed in spindle cylinder 63 may be transferred via conduits 68 and 67 to pressure transmission piston 18. By pressure transmission 18 the elevation of the pressure appropriate for the locking force construction according to the function description of 1.2.2 is achieved.

3.2.3 Pressure reduction



First multi-path valve 64 is switched into switching position a in order to relief the locking pressure acting on ring piston surfaces 13' to 16", thus second locking side cylinder room 47 is in return sucking connection with tank T. Second multi-path valve 65 and third multi-path valve 66 are both switched into switching positions a, so that the pressure from open side pressure transmission room 25 and spindle cylinder 63 may expand to tank T.

3.2.4 Opening movement of the form locking device in quick motion.

First multi-path valve 64 is switched into switching position c in which second locking side cylinder room 47 is applicable with pressure means from pressure means source P as the result of which piston unit 46 is moved into the stopping position illustrated in Fig. 3. Therefore a simultaneous rotation of motion spindle 38 is performed in order to enable the return positioning of piston unit 46 and after stopping thereof to enable the opening movement. Second multi-path valve 65 is switched into switching position a, so that hydraulic oil can be sucked from tank T into spindle cylinder 63 via hydraulic conduits 68 and 67. Third multi-path valve 66 is switched into switching position b, in which it is ascertained that pressure transmission piston 18 and valve shell 21 in back drawn position setting free passage 26 so that in the course of the opening movement an uninterrupted exchange between the oil volumes of locking side cylinder rooms 27 to 30 and open side cylinder rooms 31 and 33 may be achieved. Excess oil volume may be removed to tank T via hydraulic conduit 61.



Claims

1. A form locking device for injection molding machines which device is provided with a fixed form top plate carrying half of a tool, a movable form top plate carrying the second half of the tool, with motion spindles, which spindles are freely rotatable in the fixed form top plate and are located therein in one direction axially supported and are located in the movable form top plate in a spindle nut mounted therein, with a rotary drive for the actuation of the motion spindles for the locking-and opening hub of the movable form top plate and with a hydraulic piston-cylinder unit for the locking power construction being in connection in an effective manner with the motion spindles, characterized in that the movement- and force transfer of the movable form top plate, in quick motion, in the course of the opening and locking operation is performed only by the motion spindles, and in that the hydraulic piston-cylinder unit consists of one or more pistons and hydraulic cylinders in which the application of hydraulic pressure for the locking force construction is performed by piston-cylinder units actuated by the motion spindles by interconnection of one or more pressure transmission units.
2. A form locking device according to Claim 1, characterized in that

two kinds of piston columns units are mounted at the movable form top plate, which columns penetrates through the fixed form plate and are guided therein by pistons in hydraulic cylinders, wherein the piston column units of one kind are provided with a motion spindle device and the piston column units of the other kind are provided with a pressure transmission unit;





the pistons divide the hydraulic cylinders in a locking side cylinder room and in an open side cylinder room;

all locking side cylinder rooms are connected to each other by way of channels;

the pressure transmission units consist each of a pressure transmission piston, a pressure transmission cylinder and a valve unit, the pressure transmission piston dividing the pressure transmission cylinder in a locking side pressure transmission room and an open side pressure transmission room, and the valve body being switchable between a position setting free and closing a passage from the locking side cylinder room to the open side cylinder room;

the motion spindle arrangements consist each of a spindle nut mounted within the piston and a motion spindle being located therein in the thread engagement, which motion spindle dips with one end into a cylindric groove of the piston column unit and with the other end penetrates through the main hydraulic cylinder and is guided with one to a second hydraulic cylinder with a piston unit and with a second penetrates through the second hydraulic cylinder and is coupled with the end part with a drive gear;

the piston unit of each motion spindle divides the second hydraulic piston in a second locking side cylinder room and a second open side cylinder room;

in a first function position (closing movement in quick motion) of a hydraulic system a first multi-path valve is switchable into switching position c, in which the second locking side cylinder room is connectable with a pressure means source, and a second multi-path valve is switchable into switching position b, in which a hydraulic conduit guiding





from the second locking side pressure cylinder room to the open side pressure cylinder room is interrupted, wherein the pressure transmission piston and the valve shell are located in a basic position setting a passage free;

in a second function position (locking pressure construction) of the hydraulic system the second locking side cylinder room is connectable with the open side pressure transmission room, wherein the first multi-path valve is in switching position b and the second multi-path valve in switching position a;

in a third function position (pressure reduction) of the hydraulic system the second locking side cylinder room and the open side pressure transmission room are switchable without pressure, wherein the first multi-path valve and the second multi-path valve are each time in switching position a; and in a fourth function position, corresponding to the first function position, (opening movement in quick motion) of the hydraulic system the first multi-path valve is switchable into switching position c and the second multi-path valve is switchable into switching position b.

3. A form locking device according to Claim 1 characterized in that

two kinds of piston columns units are mounted at the movable form top plate, which columns penetrates through the fixed form plate and are guided therein by pistons in hydraulic cylinders, wherein the piston column units of one kind are provided with a motion spindle device and the piston column units of the other kind are provided with a pressure transmission unit;

the pistons divide the hydraulic cylinders in a locking side



cylinder room and in an open side cylinder room;

all locking side cylinder rooms are connected to each other by way of channels;

the pressure transmission units consist each of a pressure transmission piston, a pressure transmission cylinder and a valve unit, the pressure transmission piston dividing the pressure transmission cylinder in a locking side pressure transmission room and an open side pressure transmission room, and the valve body being switchable between a position setting free and closing a passage from the locking side cylinder room to the open side cylinder room;

the motion spindle arrangements consist each of a spindle nut mounted within the piston and a motion spindle being located therein in the thread engagement, which motion spindle dips with one end into a cylindric groove of the piston column unit and with the other end penetrates through the main hydraulic cylinder and is guided with one to a second hydraulic cylinder with a piston unit and with a second penetrates through the second hydraulic cylinder and is coupled with the end part with a drive gear;

the piston unit of each motion spindle divides the second hydraulic piston in a second locking side cylinder room and a second open side cylinder room;

in a first function position (closing movement in quick motion) of a hydraulic system a first multi-path valve is switchable into switching position c, in which the second locking side cylinder room is connectable with a pressure means source, and a second multi-path valve is switchable into switching position b, in which a hydraulic conduit guiding from the second locking side pressure cylinder room to the



open side pressure cylinder room is interrupted, wherein the pressure transmission piston and the valve shell are located in a basic position setting a passage free;

in a second function position (locking pressure construction) of the hydraulic system the second locking side cylinder room is connectable with the open side pressure transmission room, wherein the first multi-path valve is in switching position b and the second multi-path valve in switching position a;

in a third function position (pressure reduction) of the hydraulic system the second locking side cylinder room and the open side pressure transmission room are switchable without pressure, wherein the first multi-path valve and the second multi-path valve are each time in switching position a;

the motion spindle arrangements consist each of a spindle nut mounted within the piston and a motion spindle being located therein in the thread engagement, which motion spindle is guided with one end with a spindle piston into a spindle cylinder formed in the piston column unit and with the other end penetrates through the main hydraulic cylinder and is guided with one to a second hydraulic cylinder with a piston unit; and with a second penetrates through the second hydraulic cylinder and is coupled with the end part with a drive gear;

the piston unit of each motion spindle divides the second hydraulic cylinder into a second locking side cylinder room and into a second side open side cylinder room;

in a first function position (closing movement in quick motion) of a hydraulic system a first multi-path valve is switchable into switching position c, in which the second



locking side cylinder room is applicable with a pressure medium of a pressure means source, a second multi-path valve is switchable into switching position a, in which the spindle cylinder is connectable with a tank and a third multi-path valve is switchable into switching position b, with which the hydraulic conduit to the pressure transmission system is interrupted;

in a second function position (locking pressure construction) of the hydraulic system the first multi-path valve is switchable into switching position a, in which the pressure medium being present in the second locking side cylinder room may expand towards said tank, the second multi-path valve is switchable into switching position b and the third multi-path valve is switchable into switching position a, in which the second multi-path valve shuts off the conduit to said tank and the third multi-path valve connects the spindle cylinder with the open side pressure transmission room;

in a third function position (pressure reduction) of the hydraulic system the first multi-path valve is switchable into switching position a, in which the pressure medium being present in the second locking side cylinder room may expand towards said tank, the second multi-path valve and the third multi-path valve being be switchable into switching position a, whereby the pressure from the open side pressure transmission room and of the spindle cylinder may expand towards said tank; and

in a fourth position (corresponding to the first function position, (opening movement in quick motion) the first multi-path valve is switchable into switching position c, in which the second locking side cylinder room is connectable with the



pressure means source, the second locking side cylinder room being connectable with the pressure means source, the second multi-path valve being switchable in switching position a, the hydraulic oil may be sucked from the tank into the spindle cylinder, and the third multi-path valve is switchable in the switching position b, in which the hydraulic conduit to the open side pressure transmission room is interrupted.

4. A form locking device for injection molding machines which device is provided with a fixed form top plate carrying half of a tool, a movable form top plate carrying the second half of the tool, with motion spindles, which spindles are freely rotatable in the fixed form top plate and are located therein in one direction axially supported and are located in the movable form top plate in a spindle nut mounted therein, with a rotary drive for the actuation of the motion spindles for the locking-and opening hub of the movable form top plate and with a hydraulic piston-cylinder unit for the locking power construction being in connection in an effective manner with the motion spindles,

characterized in that

two kinds of piston columns units are mounted at the movable form top plate, which columns penetrates through the fixed form plate and are guided therein by pistons in hydraulic cylinders, wherein the piston column units of one kind are provided with a motion spindle device and the piston column units of the other kind are provided with a pressure transmission unit;

the pistons divide the hydraulic cylinders in a locking side cylinder room and in an open side cylinder room;

all locking side cylinder rooms are connected to each other by



way of channels;

the pressure transmission units consist each of a pressure transmission piston, a pressure transmission cylinder and a valve unit, the pressure transmission piston dividing the pressure transmission cylinder in a locking side pressure transmission room and an open side pressure transmission room, and the valve body being switchable between a position setting free and closing a passage from the locking side cylinder room to the open side cylinder room;

the motion spindle arrangements consist each of a spindle nut mounted within the piston and a motion spindle being located therein in the thread engagement, which motion spindle dips with one end into a cylindric groove of the piston column unit and with the other end penetrates through the hydraulic cylinder and is supported by one by an axial bearing and with the other end part is coupled with a drive gear;

in the first function position (closing movement in quick motion) of a hydraulic system a multi-path valve is switchable into switching position b, in which the open side pressure transmission room is connected with said tank essentially without pressure;

in a second position (locking pressure construction) in which both halves of the tool adjoin each other a multi-path valve is switchable in indexing position c, in which the open side pressure transmission room is connected via the hydraulic conduit to the pressure means source;

in a third function (pressure reduction) of a hydraulic system a multi-path valve is switchable in switching position a, in which the pressure medium may expand to said tank from the open side pressure transmission room via the hydraulic



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conduits;

in a fourth position (opening movement in quick motion) of the hydraulic system a multi-path valve is switchable into switching position b, in which the pressure transmission device is kept in a position leaving the passage free.

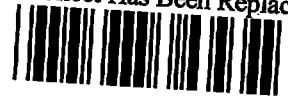
5. A form locking device according to any of Claims 1 to 4 characterized in that

in the fixed form top plate are arranged four pistons of piston column units in which each are arranged diagonally each opposite another two motion spindle arrangements and two pressure transmission devices.

6. A form locking device according to any of Claims 1 to 5 characterized in that

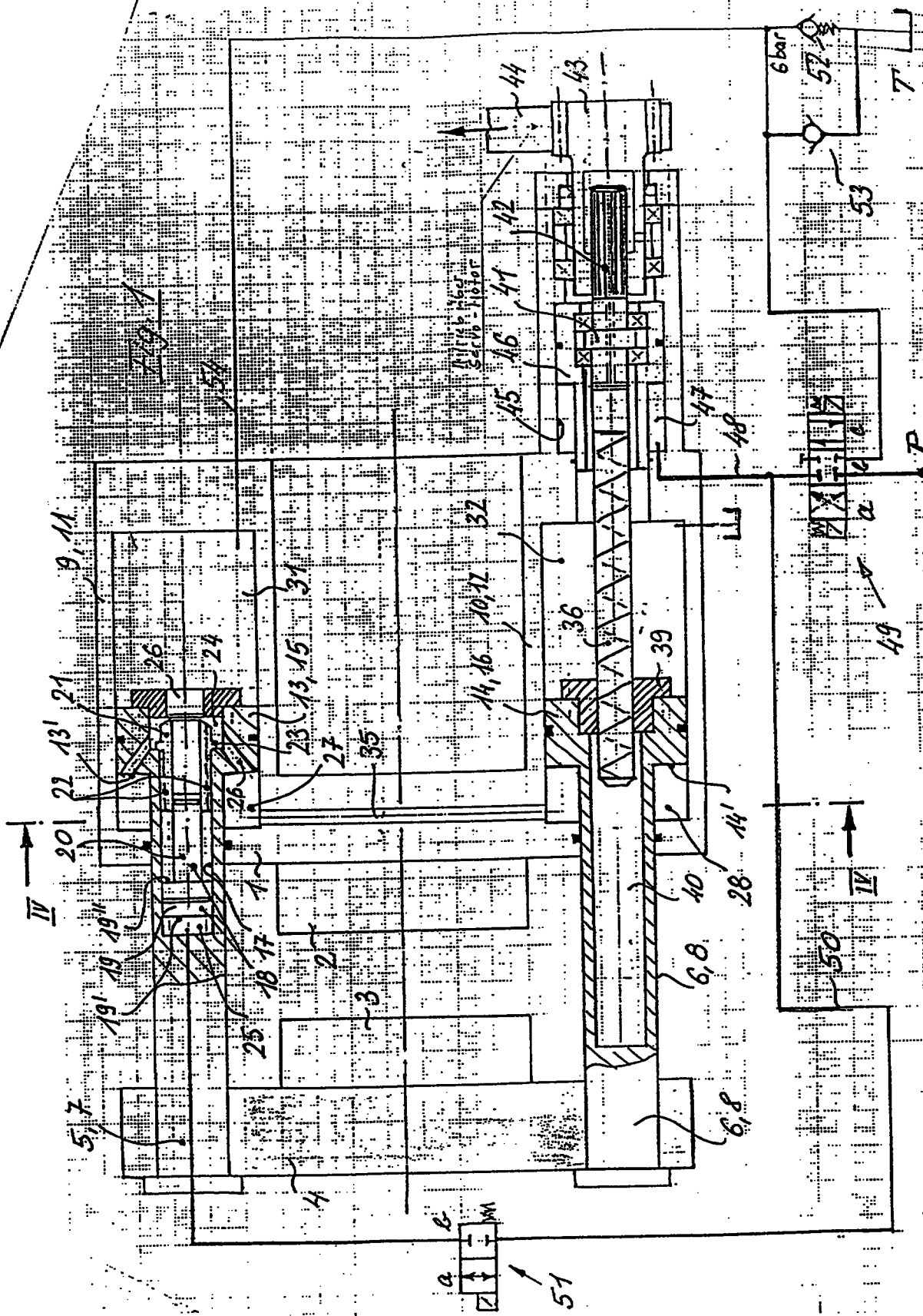
the pressure transmission piston consists of a piston part having a larger diameter and a piston part having a smaller diameter, wherein on the latter the valve body consisting of a valve shell is axially movable located which is coupled with the pressure transmission piston with the proviso that in the course of the movement of the pressure transmission piston the valve shell is moved simultaneously in a direction opposite to that of the piston which is provided at its circumference with an axial notch over which the pressure medium may be guided from the passage to the ring piston surface of the pressure transmission piston.

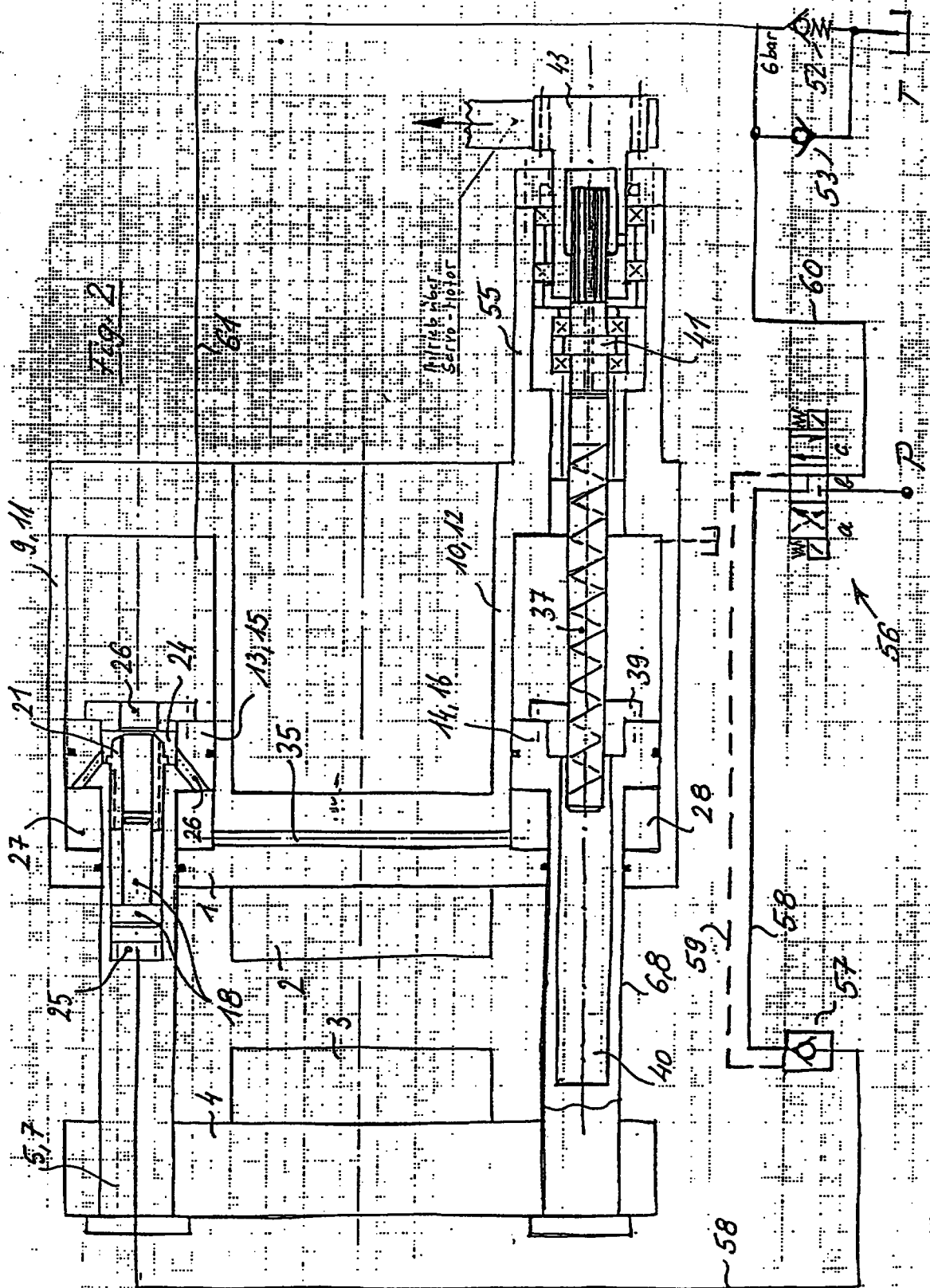
For the Applicant:

**ABSTRACT****A Form Locking Device for Injection Molding Machines**

In the case of a form locking device for an injection moulding machine, there are mounted in the fixed and in the movable mould clamping plates screw drives which are freely rotatable in the fixed mould clamping plate and are axially braced in one direction and which are mounted in the movable mould clamping plate in spindle nuts which are mounted therein. To actuate the screw drives for the closing and opening strokes of the movable mould clamping plate, a rotary drive is provided and similarly, for building up the closure force, a hydraulic piston-cylinder unit which is operatively connected to the screw drives. In order to ensure that while guaranteeing a high closure pressure by the hydraulic piston-cylinder unit, the propulsion drive of the drive screws need only be designed essentially to meet the demands of a rapid opening and closing movement, it is proposed that the hydraulic piston-cylinder unit consist of one or a plurality of pistons and hydraulic cylinders, pressurised medium being applied to it, in order to build up closure pressure, by piston-cylinder units adapted to be driven by drive screws, through the interposition of pressure transmitting means.

Fig. 1





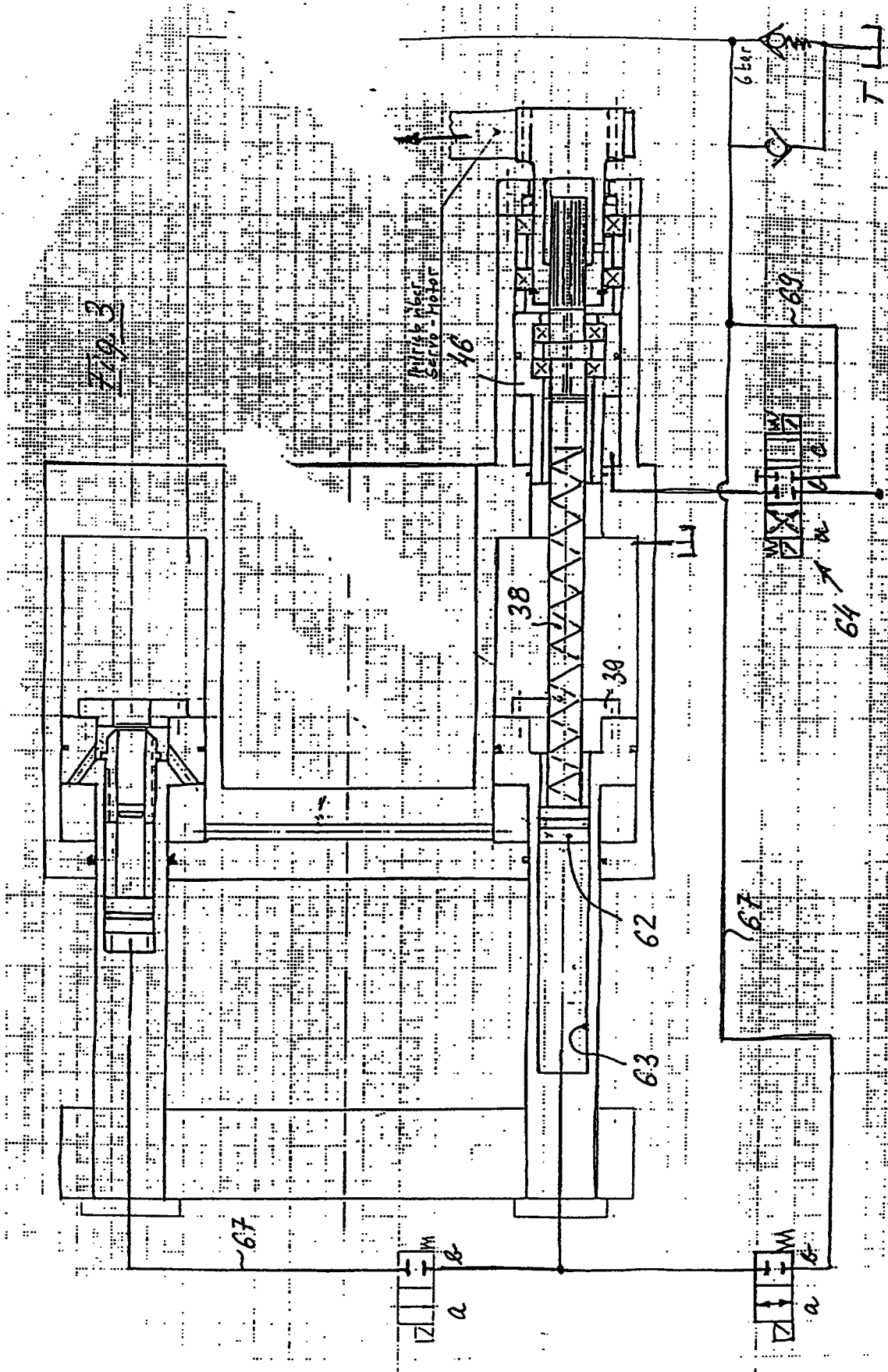
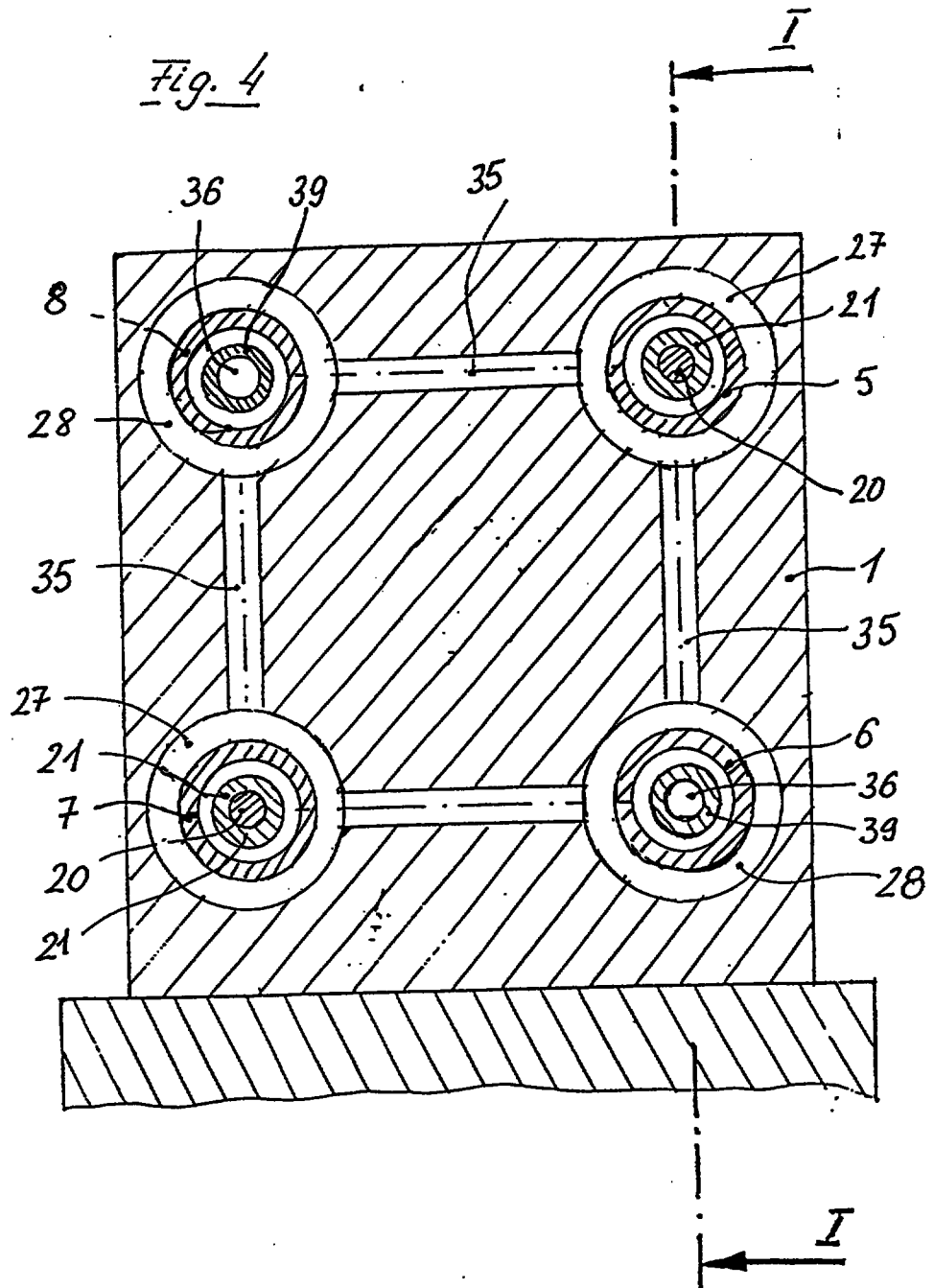




Fig. 4



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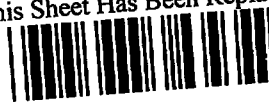


A mould closing device for an injection moulding machine

Patent claims

1. A mould closing device for an injection moulding machine and comprising a fixed mould clamping plate supporting one tool half, a movable mould clamping plate carrying the other tool half, with screw drives which are axially supported in one direction and are freely rotatable in the fixed mould clamping plate and are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive for actuating the screw drives for the closing and opening travels of the movable mould clamping plate and with, operatively connected to the screw drives, a hydraulic piston-cylinder unit for building up the closing force, characterised in that the movement of and transmission of force for the movable mould clamping plate during opening and closing is provided during rapid movement solely by the screw drives (36, 38) and in that the hydraulic piston-cylinder unit consists of one or a plurality of pistons (13, 14, 15, 16) and hydraulic cylinders (9, 10, 11, 12), to which, for the build-up of closing force, pressurised medium is applied by piston-cylinder units (45, 46; 62, 63) adapted to be driven by the screw drives (36, 38) through one or a plurality of interposed pressure transmitting means.

2. A mould closing device according to claim 1, characterised in that



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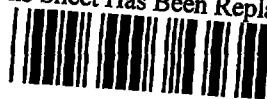
- there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,
- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure-side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19"), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the



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- piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),
- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
 - in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),
 - in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
 - in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25)



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can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and

- in a fourth function position corresponding to the first function position (opening movement, rapid speed) of the hydraulic system the first multi-way valve (49) can be switched into position c and the second multi-way valve (51) into position b.

3. A mould closing device according to claim 1, characterised in that there are fixed on the movable mould clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,

- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (331, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19''), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting



cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),

- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),
- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),

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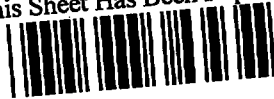


- in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
- in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25) can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a drive screw (38) disposed in screw threaded engagement therein, having one end guided by a spindle piston (62) in a spindle cylinder (63) constructed in the piston-column unit (6, 8), the other end traversing the main hydraulic cylinder (10, 12) and being guided on the one hand through a piston unit (46) in a second hydraulic cylinder (45) and on the other traversing the second hydraulic cylinder (45) and being coupled by its end part (42) to a rotary drive,
- the piston unit (46) of each drive screw (38) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closure movement, rapid movement) of the hydraulic system the first multi-way valve (64) can be switched to a position c in which the



second closure-side cylinder space (47) can be subjected to pressurised medium from the source P, a second multi-way valve (65) can be switched into position a in which the spindle cylinder (63) can be connected to the tank T and a third multi-way valve (66) can be switched into position b with which the hydraulic line (67) to the pressure transmitting system is interrupted,

- in a second function position (closure pressure build-up) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded to the tank T, the second multi-way valve (65) can be switched to position b and the third multi-way valve (66) can be switched to position a in which the multi-way valve (65) blocks the line to the tank T and the multi-way valve (66) connects the spindle cylinder (63) to the opening-side pressure transmitting space (25),
- in a third function position (pressure dissipation) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded and passed to the tank T, the second multi-way valve (65) and the third multi-way valve (66) can be switched in each case to the position a so that the pressure from the opening-side pressure transmitting space (25) and the spindle cylinder (63) can be expanded and passed to the tank T, and
- in a fourth function position corresponding to the first function position (open in rapid movement), the first multi-way valve (64) can be switched to position c in



which the second closure-side cylinder space (47) can be connected to the pressurised medium source P, the second multi-way valve (65) can be switched to the position a in which hydraulic fluid can be drawn from the tank T and pass into the spindle cylinder (63) and the third multi-way valve (66) can be switched to position b in which the hydraulic line (67) to the opening-side pressure transmitting space (25) is interrupted.

4. A mould closure device for an injection moulding machine having a fixed mould clamping plate carrying one tool half, a movable mould clamping plate carrying the other tool half, with drive screws which are mounted to be axially supported in one direction and to be freely rotatable in the fixed mould clamping plate and which are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive to actuate the drive screws for the closing and opening travels of the movable mould clamping plate and with a hydraulic piston-cylinder unit which is operatively connected to the drive screws for building-up the closure pressure, characterised in that

there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,



- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19"), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston-column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by means of an axial bearing (41) and on the other is coupled to a rotary drive via the end part (42),
- in a first function position (closure movement in rapid speed) of a hydraulic system a multi-way valve (56) can be switched to a position b in which the opening-side



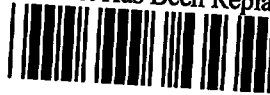
pressure transmitting space (25) is connected to the tank T in a substantially pressureless state,

- in a second function position (closure force build-up) of the hydraulic system in which the tool halves (2 and 3) rest on each other, the multi-way valve (56) can be switched to a position in which via the hydraulic line (58) the opening-side pressure transmitting space (25) of the pressure transmitting means is connected to the source P of pressurised medium,
- in a third function position (pressure dissipation) of the hydraulic system the multi-way valve (56) can be switched to a position a in which the pressurised medium can expand out of the opening-side pressure transmitting space (25) via hydraulic lines (58 and 60) to the tank T, and
- in a fourth function position (opening movement in rapid speed) of the hydraulic system the multi-way valve (56) can be switched to a position b in which the pressure transmitting means is maintained in a position which keeps the port (26) open.

5. A mould closing device according to one of claims 1 to 4, characterised in that there are in the fixed mould clamping plate (1) four pistons (13, 14, 15, 16) of piston-column units (5, 6, 7, 8) in which there are in each case diagonally oppositely disposed two drive screw arrangements and two pressure transmitting means.

6. A mould closing device according to one of claims 1 to 5, characterised in that the pressure transmitting piston (18) consists of a piston part (19) of a larger diameter and

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a piston part (20) of a smaller diameter, whereby there is mounted on this latter for axial displacement the valve body which consists of a valve sleeve (21) and which is coupled to the pressure transmitting piston (18) with the proviso that upon displacement of the pressure transmitting piston (18) in a direction opposite to the piston (13, 15) there is an entraining of the valve sleeve (21) and which has on its periphery an axial groove (22) via which it is possible to pass pressurised medium from the port (26) to the annular piston surface (19") of the pressure transmitting piston (18).



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A mould closing device for an injection moulding machine

The invention relates to a mould closing device for injection moulding machines in accordance with the preamble to claim 1.

A mould closing device of this type is known from DE 37 18 106 A 1 (construction as shown in Fig. 5), in which the movable mould clamping plate can be propelled in the closing and opening directions by means of screw drives supported in the fixed mould clamping plate and in which the closing pressure is built up by means of hydraulic piston-cylinder units which are supported in the fixed mould clamping plate and which act upon the screw drives. Where this arrangement is concerned, in addition to the opening and closing travels which have to be performed rapidly, the spindles also assume the full tractive force when the closing force is generated by the hydraulic piston-cylinder units. Therefore, the screw drives have to be designed to handle the movement as well as the closing force function, which means that they have to be made relatively heavy.

Furthermore, known from EP 0 381 107 A2 is a mould closing device in which screw drives mounted in the fixed mould clamping plate are coupled to the movable mould clamping plate by means of spindle nuts which produce the opening and closing movements via a rotary drive. Since the closing pressure is built up via hydraulic piston-cylinder units which are braced on the spindle nuts, then here, too, the screw drives have to be designed so that they can absorb the tractive forces resulting from the high closing pressure.



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Therefore, the invention is based on the problem of so further developing a mould closing device of the aforementioned type that while ensuring the high closing pressure by a hydraulic piston-cylinder unit, the movement drive by means of screw drives only has to be designed to meet the demands for rapid opening and closing movements.

This problem is resolved by the characterising features of the subordinate claims 1 and 4.

Advantageous further developments and measures according to the invention are indicated in the sub-claims.

The invention is explained in greater detail hereinafter with reference to three embodiments shown in the accompanying drawings, in which:

Fig.1 shows a diagrammatic longitudinal section through a mould closing device of an injection moulding machine and taken along the line I-I in Fig. 4;

Fig.2 is a diagrammatic longitudinal section through another embodiment of mould closing device;

Fig.3 is a diagrammatic longitudinal section through a further embodiment of mould closing device, and

Fig.4 shows a cross-section taken on the line IV-IV in Fig.1 and jointly applicable to the mould closing devices shown in Figs. 1 to 3.

Fig.1 shows a mould closing device for an injection moulding machine and comprising a fixed mould clamping plate 1 with a first tool half 2 and with a movable mould clamping plate 4 carrying the second tool half 3 and in which are fixed four piston-column units 5 to 8 which pass through the fixed



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mould clamping plate 1 by being guided for displacement in this latter in four main hydraulic cylinders 9 to 12 with pistons 13 to 16.

The four piston-column units 5 to 8 consist of two types, of which the piston-column units 5 and 7 are equipped in each case with a pressure transmitting means while the piston-column units 6 and 8 are in each case equipped with a screw drive arrangement.

The pressure transmitting means of the piston-column units 5 and 7 consist in each case of a pressure transmitting cylinder 17 in which is guided a two-stage pressure transmitting piston 18 comprising a larger thrust piston 17 corresponding to the diameter of the pressure transmitting cylinder 19 and a smaller thrust piston 20 enclosed by a valve body consisting of a valve sleeve 21. In its outside diameter, the valve sleeve 21 corresponds substantially to the diameter of the pressure transmitting cylinder 17 and is guided for axial displacement in this latter as well as in respect of the smaller thrust piston 20. The valve sleeve 21 has on its outer surface at least one axially continuous groove 22. The axial displaceability of the valve sleeve 21 is limited in the direction of closure by the outer ring abutment 23 and in the opening direction by abutment means (not shown) acting between the end part of the smaller thrust piston 20 and the end part on the inner periphery of the valve sleeve 21.

The pressure transmitting piston 18 sub-divides the pressure transmitting cylinder 17 into a closure-side pressure transmitting space 24 and an opening-side pressure transmitting space 25.

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The pressure transmitting space 25 on the opening-side is a constituent part of a port 26 in the piston 13, 15 which sub-divides the main hydraulic cylinder 9, 11 into a closure-side cylinder space 27, 28 and an opening-side cylinder space 31, 32. The port 26 can be closed by the valve sleeve 21.

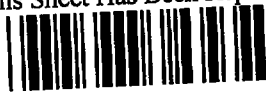
In the same way, the pistons 14 and 16 of the piston-column units 6 and 8 each of which is equipped with a screw drive arrangement, sub-divide these main cylinder spaces 10 and 12 into closure-side cylinder spaces 29 and 30 and opening-side cylinder spaces 33 and 34.

All the closure-side cylinder spaces 27, 28 and 29, 30 are connected to one another by ports 35.

The screw drive arrangements of the piston-column units 6 and 8 consist in each case of a screw drive 36, 37, 38 which is in screw threaded engagement with a spindle nut 39 fixed in the piston 14, 16 and which fits into a recess 40 in the piston-column arrangement 6 and 8.

The screw drives 36, 37, 38 further comprise an axial bearing 41 and an end part 42 by which the screw drive is axially displaceably coupled to a rotary drive, of which only one drive pinion 43 is shown but which is adapted to be driven by a belt transmission 44 with a servomotor and with a positioning adjusting means. Preferably, the servomotor is an electric motor.

The aforescribed features and means are identically in the three embodiments shown in Figs. 1 to 3. Hereinafter, therefore, only the peculiarities of the respective embodiments are described.



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1. Embodiment shown in Fig. 1

1.1 Design

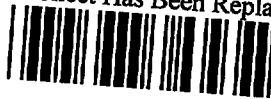
The screw drive 36 in the embodiment shown in Fig. 1 passes through the opening-side cylinder space 32 and projects into a adjacent second cylinder space 45 in which the axial bearing 41 of the screw drive 36 is mounted in a piston unit 46 which sub-divides the second cylinder space 45 into a second closure-side cylinder space 47 and a second opening-side cylinder space (not present in the switched position of the piston unit 46 as illustrated).

From the second closure-side cylinder space 47, a hydraulic line 48 leads to a first multi-way valve 49 (4/3-way valve) with switching positions a, be and c. From the hydraulic line 48, a hydraulic line 50 branches off to a second multi-way valve 51 (4/2-way valve) with switching positions a and b by which a connection can be made or broken between the second closure-side cylinder space 47 and the opening-side thrust cylinder space 25. Via the first multi-way valve 49, the hydraulic line 48 can be switched optionally to a pressurised medium source P or via a non-return valve 52 with back pressure (6 bars) to the tank T. Via a second non-return valve 53 which functions as a secondary section valve, hydraulic fluid can be drawn from the tank T. The opening-side cylinder space 31 is connected by a hydraulic line 54 and the non-return valve 52 with back pressure to the tank T

1.2 Functional description

1.2.1 Closure of the mould closing device, rapid movement

For this, the second closure-side cylinder space 47 is



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subjected to pressurised medium from the source 'P' via the position c of the first multi-way valve 49, whereupon the piston unit 46 assumes the right-hand position of abutment shown in Fig. 1. The second multi-way valve 51 is in switched position b, ensuring that the pressure transmitting piston 18 maintains the valve sleeve 21 in the position shown in Fig. 1 in which the passage or port 26 between the closure-side cylinder space 27 and the opening-side cylinder space 31 is open.

By rotation of the screw drive 36, the two halves 2 and 3 of the tool are moved towards each other until they abut each other. Due to the fact that the screw drive 31 is driven by an electric servomotor with a position adjustment facility, precised positioning is possible. During the movement of the tool halves 2 and 3 towards each other, there is a redistribution of the hydraulic fluid from the opening-side cylinder spaces 31 and 33 via the ports 26 and passages 35 to the closure-side cylinder spaces 27 to 30, any shortage of hydraulic fluid being replaced via the line 54 and the secondary suction valve 53.

1.2.2 Closure pressure build-up

For this, the first multi-way valve 49 is moved to position b and the second multi-way valve 51 to position a. Upon further rotation of the screw drive 36 in the closure direction, the piston unit 46 (in the illustration in Fig.1) is displaced leftwardly whereupon the hydraulic fluid contained in the second closure-side cylinder space 47 passes through the hydraulic lines 48 and 50 and the second multi-way valve 51 and into the opening-side pressure transmitting space 25 and causes a



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displacement of the pressure transmitting piston 18 and of the valve sleeve 21 so that at first the valve sleeve 21 closes the port 26. Further displacement of the pressure transmitting piston 18 produces, by virtue of the differential pressure surfaces 19' and 19" an increase in pressure which becomes propagated via the continuous groove 22 in the valve sleeve 21 and generates the required closure pressure at the annular piston surfaces 13' to 16'.

1.2.3 Pressure dissipation

In order to relieve the closure pressure acting on the annular piston surfaces 13' to 16', the second multi-way valve 51 is moved to switched position a and the first multi-way valve 49 to switched position a, whereupon the pressure transmitting piston 18 is switched to the tank T in a pressureless condition. The second closure-side cylinder space 47 is connected to the pressurised medium source P so that the piston unit is reset in the abutment position shown in Fig. 1.

1.2.4 Opening of the mould closing device, rapid movement

For this stage, the first and the second multi-way valves 49 and 51 are moved into the same switched position as when carrying out the closure process but the direction of rotation of the screw drives 36 is reversed, so that the tool halves 2 and 3 move away from each other.

2. Embodiment shown in Fig. 2

2.1 Design

Where the embodiment shown in Fig. 2 is concerned, the screw drive 37 is, by means of an axial bearing 41,



freely rotatably but axially non-displaceably mounted in a housing 55 adjacent the main hydraulic cylinder 10. The hydraulic system consists of a pressurised medium source P, a multi-way valve 56 with switched positions a, b and c, a freely switchable non-return valve 57, a secondary suction valve 53, a non-return valve 52 with back pressure, a tank T and hydraulic lines 58 to 61.

2.2 Functional description

2.2.1 Closure of the mould closing device, rapid movement

For this, the multi-way valve 56 is switched to the position b shown in Fig. 2 ensuring that the passage 26 in the piston 13, 15 remains open so that upon rotation of the screw drive 37 and of the movement of the tool halves 2 and 3 towards each other which this produces, the hydraulic fluid is able to flow out of the two opening-side cylinder spaces 31 and 33 into the closure side cylinder spaces 27 to 30, any lack of fluid being drawn in via the secondary suction valve 53 and the hydraulic line 61. Rotation of the screw drive 37 is stopped when the two halves 2 and 3 of the tool have come to rest on each other.

2.2.2 Closure pressure build-up

To achieve this, the multi-way valve 56 is moved to position c in which the hydraulic fluid passes from the pressurised medium source P through the hydraulic line 58 and into the closure-side pressure transmitting space 24 producing, by means of the pressure transmitting piston 18, the build-up of closure pressure which is described with reference to 1.2.2.

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2.2.3 Pressure dissipation

To relieve the closure pressure acting on the annular piston surfaces 12' to 16', the multi-way valve 56 is moved to switch position a in which, via the hydraulic line 59, the non-return valve 57 is cleared, whereupon the pressure biasing the pressure reducing (sic') piston 18 is able to expand to the tank T via the hydraulic lines 58 and 60.

2.2.4 Opening of the mould closing device, rapid movement

For this phase, the multi-way valve 56 is moved to switch position b. By rotation of the screw drive 37 so that the tool halves 2, 3 move apart, a pressure is generated in the closure-side cylinder spaces 27 which, via the port 26, produces a resetting of the pressure transmitting piston 18 and of the valve sleeve 21 into the position shown in Fig. 2 so that the port 26 between the closure-side cylinder spaces 27, 29 is completely clear so that upon the movement apart, it is possible for the volumes between the closure-side cylinder spaces 27 to 30 and the opening-side cylinder spaces 31 to 33 to become equalised. Excess hydraulic fluid is discharged to the tank T via the hydraulic line 61.

3. Embodiment shown in Fig. 3

3.1 Design

The drive-side part of the screw drive 38 in Fig. 3 corresponds to the screw drive 36 in Fig. 1. At the end which fits into the piston-column unit 6 (8) the screw drive 38 has a hydraulic spindle piston 62 guided in a spindle cylinder 63. The hydraulic system consists of a pressurised medium source P, a first multi-way valve 64



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with three switch positions a to c, a second multi-way valve 65 with switch positions a and b and a third multi-way valve 66 with switch positions a and b.

The aforescribed multi-way valves 64 to 66 are connected by hydraulic lines 67 to 70 to the opening-side pressure transmitting space 24, the spindle cylinder 63, the second closure-side cylinder space 47, the opening-side cylinder space 31, 33 and the tank T.

3.2 Functional description

3.2.1 Closure of the mould closing device, rapid movement

For this, the first multi-way valve 64 is switched to position c, causing the second closure-side cylinder space 47 to be exposed to pressurised medium from the pressurised medium source P and the piston unit 46 assumes the right-hand abutment position shown in Fig.3. The second multi-way valve 65 is switched to position a whereby, upon the movement together of the two halves 2 and 3 caused by rotation of the spindle, the hydraulic fluid displaced from the spindle cylinder 63 by the spindle piston 62 is able to flow through the hydraulic line 67 to the tank T. The third multi-way valve 66 is switched to position b, ensuring that the pressure transmitting space 18 and the valve sleeve 21 remain in the position shown in Fig. 3 in which, when the pistons 13 to 16 travel into the closed position, there is an exchange of fluids between the opening-side cylinder spaces 31 and 33 and the closure-side cylinder spaces 27 to 30.

3.2.2 Closure pressure build-up

For this, the first multi-way valve 64 is switched to

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position a so that the hydraulic fluid contained in the second closure-side cylinder space 47 is able to flow through the hydraulic line 69 to the tank T when the screw drive 38 is further rotated while the pistons 13 to 16 are in the closed position, so that the spindle piston 62 can penetrate farther into the spindle cylinder 63 in order to generate hydraulic pressure which is to be applied to the pressure transmitting piston 18. Since the pistons 13 to 16 are in the closed position, in which the tool halves 2 and 3 rest on each other, rotation of the screw drive 38 produces a displacement of the piston unit 46 to the left by the amount by which the spindle piston 62 penetrates the spindle cylinder 63. The second multi-way valve 65 is then switched to position b and the third multi-way valve 66 is switched to position a so that the hydraulic pressure generated in the spindle cylinder 63 can be conveyed via the lines 68 and 67 to the pressure transmitting piston 18. By means of the pressure transmitting piston 18, there is then an increase in pressure appropriate to the build-up of closure force, in accordance with the functional description under 1.2.2.

3.2.3 Pressure dissipation

In order to relieve the closure pressure acting on the annular piston surfaces 13' to 16', the first multi-way valve 64 is switched to position a so that the second closure-side cylinder space 47 is in a secondary suction state of communication with the tank T. The second multi-way valve 65 and the third multi-way valve 66 are both switched to position a so that the pressure from the opening-side pressure transmitting space 25 and the spindle cylinder 63 is able to expand to the tank T.



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3.2.4 Opening of the mould closing device, rapid movement

For this, the first multi-way valve 64 is switched to position c in which the second closure side cylinder space 47 is exposed to the action of pressurised medium from the pressurised medium source P, so that the piston unit 46 is pushed into the abutment position shown in Fig. 3. To this end, there is at the same time a rotation of the screw drive 38 to allow a resetting of the piston unit 46 so that after this reaches its abutment, the opening movement can be performed. The second multi-way valve 65 is switched to position a so that hydraulic fluid can be drawn through the hydraulic lines 68 and 67 from the tank T and passed into the spindle cylinder 63. The third multi-way valve 66 is switched to position b, ensuring that the pressure transmitting piston 18 and the valve sleeve 21 are in the retracted position, opening the port 26 so that during the opening movement there is an unhindered exchange of fluids between the closure-side cylinder spaces 27 to 30 and the opening-side cylinder spaces 31 and 33, excess fluid being capable of being discharged to the tank T via hydraulic line 61.

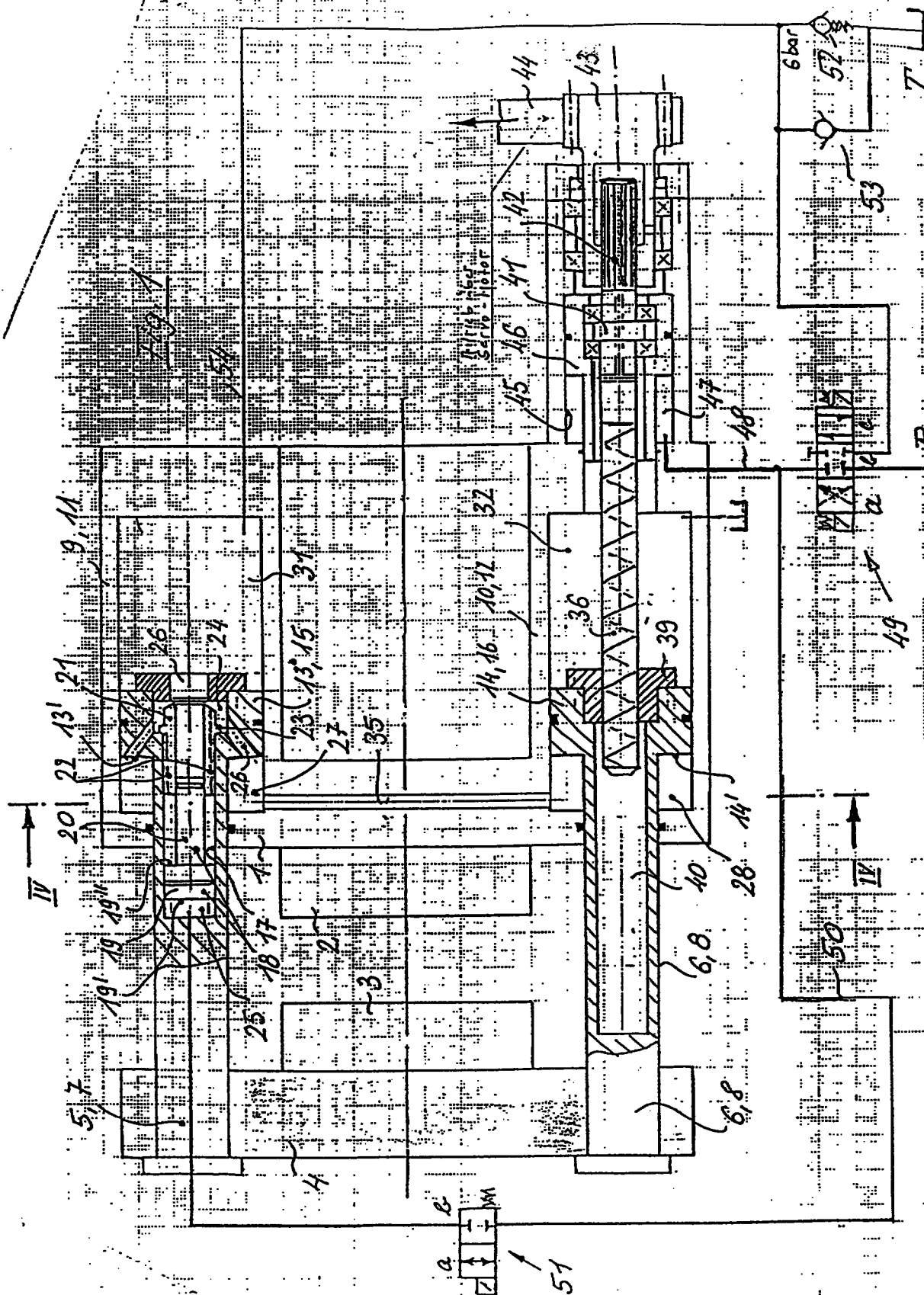
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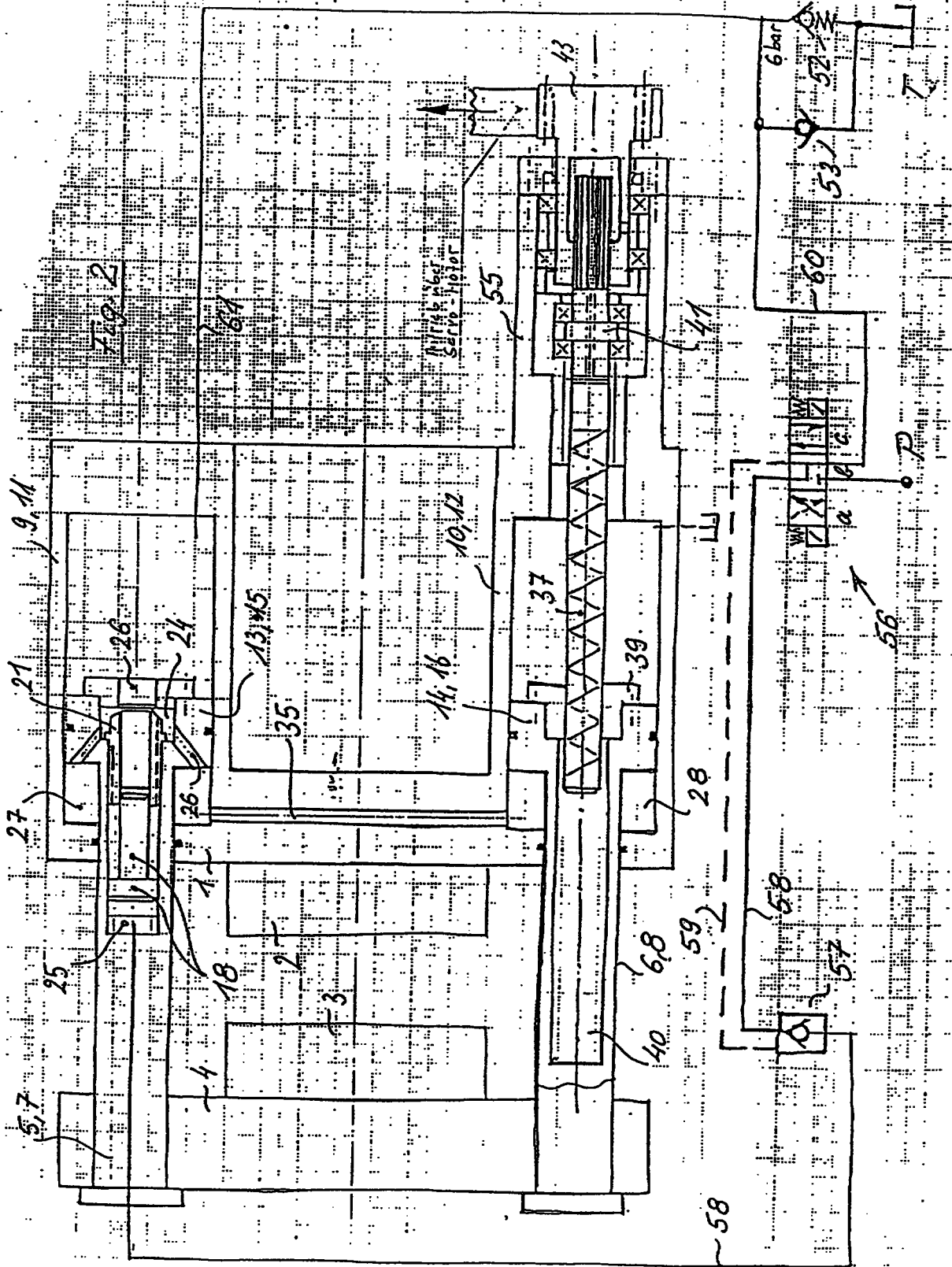
A mould closing device for an injection moulding machine

Abstract

In the case of a mould closing device for an injection moulding machine, there are mounted in the fixed and in the movable mould clamping plates screw drives which are freely rotatable in the fixed mould clamping plate and are axially braced in one direction and which are mounted in the movable mould clamping plate in spindle nuts which are mounted therein. To actuate the screw drives for the closing and opening strokes of the movable mould clamping plate, a rotary drive is provided and similarly, for building up the closure force, a hydraulic piston-cylinder unit which is operatively connected to the screw drives. In order to ensure that while guaranteeing a high closure pressure by the hydraulic piston-cylinder unit, the propulsion drive of the drive screws need only be designed essentially to meet the demands of a rapid opening and closing movement, it is proposed that the hydraulic piston-cylinder unit consist of one or a plurality of pistons and hydraulic cylinders, pressurised medium being applied to it, in order to build up closure pressure, by piston-cylinder units adapted to be driven by drive screws, through the interposition of pressure transmitting means.

Fig. 1





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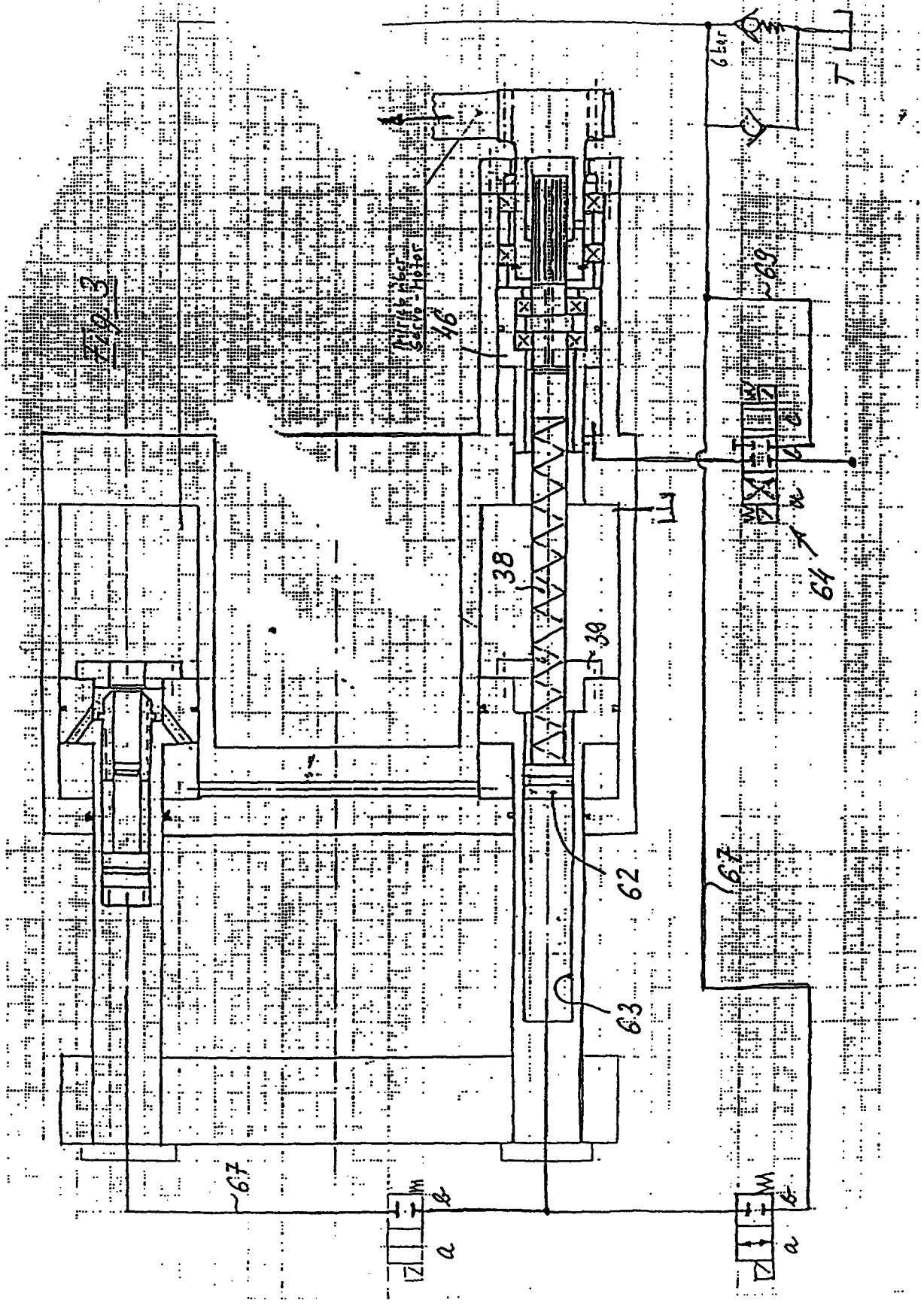
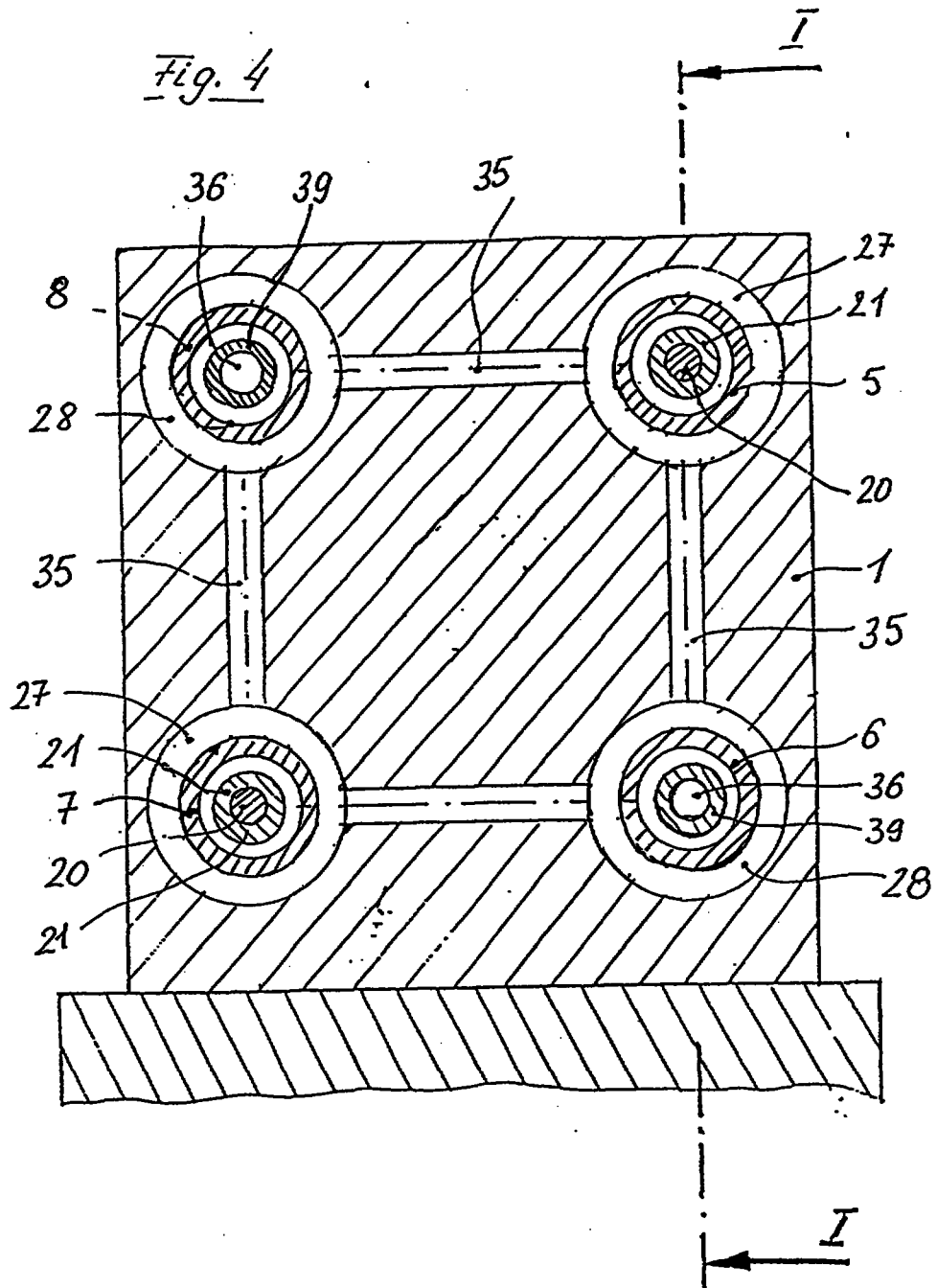




Fig. 4





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A mould closing device for an injection moulding machine

Patent claims

1. A mould closing device for an injection moulding machine and comprising a fixed mould clamping plate supporting one tool half, a movable mould clamping plate carrying the other tool half, with screw drives which are axially supported in one direction and are freely rotatable in the fixed mould clamping plate and are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive for actuating the screw drives for the closing and opening travels of the movable mould clamping plate and with, operatively connected to the screw drives, a hydraulic piston-cylinder unit for building up the closing force, characterised in that the movement of and transmission of force for the movable mould clamping plate during opening and closing is provided during rapid movement solely by the screw drives (36, 38) and in that the hydraulic piston-cylinder unit consists of one or a plurality of pistons (13, 14, 15, 16) and hydraulic cylinders (9, 10, 11, 12), to which, for the build-up of closing force, pressurised medium is applied by piston-cylinder units (45, 46; 62, 63) adapted to be driven by the screw drives (36, 38) through one or a plurality of interposed pressure transmitting means.

2. A mould closing device according to claim 1, characterised in that



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- there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,
- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure-side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19''), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the



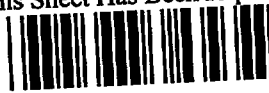
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- piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),
- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
 - in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),
 - in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
 - in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25)



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can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and

- in a fourth function position corresponding to the first function position (opening movement, rapid speed) of the hydraulic system the first multi-way valve (49) can be switched into position c and the second multi-way valve (51) into position b.

3. A mould closing device according to claim 1, characterised in that there are fixed on the movable mould clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,

- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19''), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting



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cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),

- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),
- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),



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- in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
- in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25) can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a drive screw (38) disposed in screw threaded engagement therein, having one end guided by a spindle piston (62) in a spindle cylinder (63) constructed in the piston-column unit (6, 8), the other end traversing the main hydraulic cylinder (10, 12) and being guided on the one hand through a piston unit (46) in a second hydraulic cylinder (45) and on the other traversing the second hydraulic cylinder (45) and being coupled by its end part (42) to a rotary drive,
- the piston unit (46) of each drive screw (38) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closure movement, rapid movement) of the hydraulic system the first multi-way valve (64) can be switched to a position c in which the



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second closure-side cylinder space (47) can be subjected to pressurised medium from the source P, a second multi-way valve (65) can be switched into position a in which the spindle cylinder (63) can be connected to the tank T and a third multi-way valve (66) can be switched into position b with which the hydraulic line (67) to the pressure transmitting system is interrupted,

- in a second function position (closure pressure build-up) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded to the tank T, the second multi-way valve (65) can be switched to position b and the third multi-way valve (66) can be switched to position a in which the multi-way valve (65) blocks the line to the tank T and the multi-way valve (66) connects the spindle cylinder (63) to the opening-side pressure transmitting space (25),
- in a third function position (pressure dissipation) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded and passed to the tank T, the second multi-way valve (65) and the third multi-way valve (66) can be switched in each case to the position a so that the pressure from the opening-side pressure transmitting space (25) and the spindle cylinder (63) can be expanded and passed to the tank T, and
- in a fourth function position corresponding to the first function position (open in rapid movement), the first multi-way valve (64) can be switched to position c in



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which the second closure-side cylinder space (47) can be connected to the pressurised medium source P, the second multi-way valve (65) can be switched to the position a in which hydraulic fluid can be drawn from the tank T and pass into the spindle cylinder (63) and the third multi-way valve (66) can be switched to position b in which the hydraulic line (67) to the opening-side pressure transmitting space (25) is interrupted.

4. A mould closure device for an injection moulding machine having a fixed mould clamping plate carrying one tool half, a movable mould clamping plate carrying the other tool half, with drive screws which are mounted to be axially supported in one direction and to be freely rotatable in the fixed mould clamping plate and which are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive to actuate the drive screws for the closing and opening travels of the movable mould clamping plate and with a hydraulic piston-cylinder unit which is operatively connected to the drive screws for building-up the closure pressure, characterised in that

there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,

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- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19"), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston-column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by means of an axial bearing (41) and on the other is coupled to a rotary drive via the end part (42),
- in a first function position (closure movement in rapid speed) of a hydraulic system a multi-way valve (56) can be switched to a position b in which the opening-side

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pressure transmitting space (25) is connected to the tank T in a substantially pressureless state,

- in a second function position (closure force build-up) of the hydraulic system in which the tool halves (2 and 3) rest on each other, the multi-way valve (56) can be switched to a position in which via the hydraulic line (58) the opening-side pressure transmitting space (25) of the pressure transmitting means is connected to the source P of pressurised medium,
- in a third function position (pressure dissipation) of the hydraulic system the multi-way valve (56) can be switched to a position a in which the pressurised medium can expand out of the opening-side pressure transmitting space (25) via hydraulic lines (58 and 60) to the tank T, and
- in a fourth function position (opening movement in rapid speed) of the hydraulic system the multi-way valve (56) can be switched to a position b in which the pressure transmitting means is maintained in a position which keeps the port (26) open.

5. A mould closing device according to one of claims 1 to 4, characterised in that there are in the fixed mould clamping plate (1) four pistons (13, 14, 15, 16) of piston-column units (5, 6, 7, 8) in which there are in each case diagonally oppositely disposed two drive screw arrangements and two pressure transmitting means.

6. A mould closing device according to one of claims 1 to 5, characterised in that the pressure transmitting piston (18) consists of a piston part (19) of a larger diameter and

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a piston part (20) of a smaller diameter, whereby there is mounted on this latter for axial displacement the valve body which consists of a valve sleeve (21) and which is coupled to the pressure transmitting piston (18) with the proviso that upon displacement of the pressure transmitting piston (18) in a direction opposite to the piston (13, 15) there is an entraining of the valve sleeve (21) and which has on its periphery an axial groove (22) via which it is possible to pass pressurised medium from the port (26) to the annular piston surface (19") of the pressure transmitting piston (18).



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A mould closing device for an injection moulding machine

The invention relates to a mould closing device for injection moulding machines in accordance with the preamble to claim 1.

A mould closing device of this type is known from DE 37 18 106 A 1 (construction as shown in Fig. 5), in which the movable mould clamping plate can be propelled in the closing and opening directions by means of screw drives supported in the fixed mould clamping plate and in which the closing pressure is built up by means of hydraulic piston-cylinder units which are supported in the fixed mould clamping plate and which act upon the screw drives. Where this arrangement is concerned, in addition to the opening and closing travels which have to be performed rapidly, the spindles also assume the full tractive force when the closing force is generated by the hydraulic piston-cylinder units. Therefore, the screw drives have to be designed to handle the movement as well as the closing force function, which means that they have to be made relatively heavy.

Furthermore, known from EP 0 381 107 A2 is a mould closing device in which screw drives mounted in the fixed mould clamping plate are coupled to the movable mould clamping plate by means of spindle nuts which produce the opening and closing movements via a rotary drive. Since the closing pressure is built up via hydraulic piston-cylinder units which are braced on the spindle nuts, then here, too, the screw drives have to be designed so that they can absorb the tractive forces resulting from the high closing pressure.



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Therefore, the invention is based on the problem of so further developing a mould closing device of the aforementioned type that while ensuring the high closing pressure by a hydraulic piston-cylinder unit, the movement drive by means of screw drives only has to be designed to meet the demands for rapid opening and closing movements.

This problem is resolved by the characterising features of the subordinate claims 1 and 4.

Advantageous further developments and measures according to the invention are indicated in the sub-claims.

The invention is explained in greater detail hereinafter with reference to three embodiments shown in the accompanying drawings, in which:

Fig.1 shows a diagrammatic longitudinal section through a mould closing device of an injection moulding machine and taken along the line I-I in Fig. 4;

Fig.2 is a diagrammatic longitudinal section through another embodiment of mould closing device;

Fig.3 is a diagrammatic longitudinal section through a further embodiment of mould closing device, and

Fig.4 shows a cross-section taken on the line IV-IV in Fig.1 and jointly applicable to the mould closing devices shown in Figs. 1 to 3.

Fig.1 shows a mould closing device for an injection moulding machine and comprising a fixed mould clamping plate 1 with a first tool half 2 and with a movable mould clamping plate 4 carrying the second tool half 3 and in which are fixed four piston-column units 5 to 8 which pass through the fixed

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mould clamping plate 1 by being guided for displacement in this latter in four main hydraulic cylinders 9 to 12 with pistons 13 to 16.

The four piston-column units 5 to 8 consist of two types, of which the piston-column units 5 and 7 are equipped in each case with a pressure transmitting means while the piston-column units 6 and 8 are in each case equipped with a screw drive arrangement.

The pressure transmitting means of the piston-column units 5 and 7 consist in each case of a pressure transmitting cylinder 17 in which is guided a two-stage pressure transmitting piston 18 comprising a larger thrust piston 17 corresponding to the diameter of the pressure transmitting cylinder 19 and a smaller thrust piston 20 enclosed by a valve body consisting of a valve sleeve 21. In its outside diameter, the valve sleeve 21 corresponds substantially to the diameter of the pressure transmitting cylinder 17 and is guided for axial displacement in this latter as well as in respect of the smaller thrust piston 20. The valve sleeve 21 has on its outer surface at least one axially continuous groove 22. The axial displaceability of the valve sleeve 21 is limited in the direction of closure by the outer ring abutment 23 and in the opening direction by abutment means (not shown) acting between the end part of the smaller thrust piston 20 and the end part on the inner periphery of the valve sleeve 21.

The pressure transmitting piston 18 sub-divides the pressure transmitting cylinder 17 into a closure-side pressure transmitting space 24 and an opening-side pressure transmitting space 25.



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The pressure transmitting space 25 on the opening-side is a constituent part of a port 26 in the piston 13, 15 which sub-divides the main hydraulic cylinder 9, 11 into a closure-side cylinder space 27, 28 and an opening-side cylinder space 31, 32. The port 26 can be closed by the valve sleeve 21.

In the same way, the pistons 14 and 16 of the piston-column units 6 and 8 each of which is equipped with a screw drive arrangement, sub-divide these main cylinder spaces 10 and 12 into closure-side cylinder spaces 29 and 30 and opening-side cylinder spaces 33 and 34.

All the closure-side cylinder spaces 27, 28 and 29, 30 are connected to one another by ports 35.

The screw drive arrangements of the piston-column units 6 and 8 consist in each case of a screw drive 36, 37, 38 which is in screw threaded engagement with a spindle nut 39 fixed in the piston 14, 16 and which fits into a recess 40 in the piston-column arrangement 6 and 8.

The screw drives 36, 37, 38 further comprise an axial bearing 41 and an end part 42 by which the screw drive is axially displaceably coupled to a rotary drive, of which only one drive pinion 43 is shown but which is adapted to be driven by a belt transmission 44 with a servomotor and with a positioning adjusting means. Preferably, the servomotor is an electric motor.

The aforescribed features and means are identically in the three embodiments shown in Figs. 1 to 3. Hereinafter, therefore, only the peculiarities of the respective embodiments are described.



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1. Embodiment shown in Fig. 1

1.1 Design

The screw drive 36 in the embodiment shown in Fig. 1 passes through the opening-side cylinder space 32 and projects into a adjacent second cylinder space 45 in which the axial bearing 41 of the screw drive 36 is mounted in a piston unit 46 which sub-divides the second cylinder space 45 into a second closure-side cylinder space 47 and a second opening-side cylinder space (not present in the switched position of the piston unit 46 as illustrated).

From the second closure-side cylinder space 47, a hydraulic line 48 leads to a first multi-way valve 49 (4/3-way valve) with switching positions a, be and c. From the hydraulic line 48, a hydraulic line 50 branches off to a second multi-way valve 51 (4/2-way valve) with switching positions a and b by which a connection can be made or broken between the second closure-side cylinder space 47 and the opening-side thrust cylinder space 25. Via the first multi-way valve 49, the hydraulic line 48 can be switched optionally to a pressurised medium source P or via a non-return valve 52 with back pressure (6 bars) to the tank T. Via a second non-return valve 53 which functions as a secondary section valve, hydraulic fluid can be drawn from the tank T. The opening-side cylinder space 31 is connected by a hydraulic line 54 and the non-return valve 52 with back pressure to the tank T

1.2 Functional description

1.2.1 Closure of the mould closing device, rapid movement

For this, the second closure-side cylinder space 47 is



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subjected to pressurised medium from the source P via the position c of the first multi-way valve 49, whereupon the piston unit 46 assumes the right-hand position of abutment shown in Fig. 1. The second multi-way valve 51 is in switched position b, ensuring that the pressure transmitting piston 18 maintains the valve sleeve 21 in the position shown in Fig. 1 in which the passage or port 26 between the closure-side cylinder space 27 and the opening-side cylinder space 31 is open.

By rotation of the screw drive 36, the two halves 2 and 3 of the tool are moved towards each other until they abut each other. Due to the fact that the screw drive 31 is driven by an electric servomotor with a position adjustment facility, precised positioning is possible. During the movement of the tool halves 2 and 3 towards each other, there is a redistribution of the hydraulic fluid from the opening-side cylinder spaces 31 and 33 via the ports 26 and passages 35 to the closure-side cylinder spaces 27 to 30, any shortage of hydraulic fluid being replaced via the line 54 and the secondary suction valve 53.

1.2.2 Closure pressure build-up

For this, the first multi-way valve 49 is moved to position b and the second multi-way valve 51 to position a. Upon further rotation of the screw drive 36 in the closure direction, the piston unit 46 (in the illustration in Fig.1) is displaced leftwardly whereupon the hydraulic fluid contained in the second closure-side cylinder space 47 passes through the hydraulic lines 48 and 50 and the second multi-way valve 51 and into the opening-side pressure transmitting space 25 and causes a



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displacement of the pressure transmitting piston 18 and of the valve sleeve 21 so that at first the valve sleeve 21 closes the port 26. Further displacement of the pressure transmitting piston 18 produces, by virtue of the differential pressure surfaces 19' and 19" an increase in pressure which becomes propagated via the continuous groove 22 in the valve sleeve 21 and generates the required closure pressure at the annular piston surfaces 13' to 16'.

1.2.3 Pressure dissipation

In order to relieve the closure pressure acting on the annular piston surfaces 13' to 16', the second multi-way valve 51 is moved to switched position a and the first multi-way valve 49 to switched position a, whereupon the pressure transmitting piston 18 is switched to the tank T in a pressureless condition. The second closure-side cylinder space 47 is connected to the pressurised medium source P so that the piston unit is reset in the abutment position shown in Fig. 1.

1.2.4 Opening of the mould closing device, rapid movement

For this stage, the first and the second multi-way valves 49 and 51 are moved into the same switched position as when carrying out the closure process but the direction of rotation of the screw drives 36 is reversed, so that the tool halves 2 and 3 move away from each other.

2. Embodiment shown in Fig. 2

2.1 Design

Where the embodiment shown in Fig. 2 is concerned, the screw drive 37 is, by means of an axial bearing 41,



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freely rotatably but axially non-displaceably mounted in a housing 55 adjacent the main hydraulic cylinder 10. The hydraulic system consists of a pressurised medium source P, a multi-way valve 56 with switched positions a, b and c, a freely switchable non-return valve 57, a secondary suction valve 53, a non-return valve 52 with back pressure, a tank T and hydraulic lines 58 to 61.

2.2 Functional description

2.2.1 Closure of the mould closing device, rapid movement

For this, the multi-way valve 56 is switched to the position b shown in Fig. 2 ensuring that the passage 26 in the piston 13, 15 remains open so that upon rotation of the screw drive 37 and of the movement of the tool halves 2 and 3 towards each other which this produces, the hydraulic fluid is able to flow out of the two opening-side cylinder spaces 31 and 33 into the closure side cylinder spaces 27 to 30, any lack of fluid being drawn in via the secondary suction valve 53 and the hydraulic line 61. Rotation of the screw drive 37 is stopped when the two halves 2 and 3 of the tool have come to rest on each other.

2.2.2 Closure pressure build-up

To achieve this, the multi-way valve 56 is moved to position c in which the hydraulic fluid passes from the pressurised medium source P through the hydraulic line 58 and into the closure-side pressure transmitting space 24 producing, by means of the pressure transmitting piston 18, the build-up of closure pressure which is described with reference to 1.2.2.



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2.2.3 Pressure dissipation

To relieve the closure pressure acting on the annular piston surfaces 12' to 16', the multi-way valve 56 is moved to switch position a in which, via the hydraulic line 59, the non-return valve 57 is cleared, whereupon the pressure biasing the pressure reducing (sic') piston 18 is able to expand to the tank T via the hydraulic lines 58 and 60.

2.2.4 Opening of the mould closing device, rapid movement

For this phase, the multi-way valve 56 is moved to switch position b. By rotation of the screw drive 37 so that the tool halves 2, 3 move apart, a pressure is generated in the closure-side cylinder spaces 27 which, via the port 26, produces a resetting of the pressure transmitting piston 18 and of the valve sleeve 21 into the position shown in Fig. 2 so that the port 26 between the closure-side cylinder spaces 27, 29 is completely clear so that upon the movement apart, it is possible for the volumes between the closure-side cylinder spaces 27 to 30 and the opening-side cylinder spaces 31 to 33 to become equalised. Excess hydraulic fluid is discharged to the tank T via the hydraulic line 61.

3. Embodiment shown in Fig. 3

3.1 Design

The drive-side part of the screw drive 38 in Fig. 3 corresponds to the screw drive 36 in Fig. 1. At the end which fits into the piston-column unit 6 (8) the screw drive 38 has a hydraulic spindle piston 62 guided in a spindle cylinder 63. The hydraulic system consists of a pressurised medium source P, a first multi-way valve 64



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with three switch positions a to c, a second multi-way valve 65 with switch positions a and b and a third multi-way valve 66 with switch positions a and b.

The aforescribed multi-way valves 64 to 66 are connected by hydraulic lines 67 to 70 to the opening-side pressure transmitting space 24, the spindle cylinder 63, the second closure-side cylinder space 47, the opening-side cylinder space 31, 33 and the tank T.

3.2 Functional description

3.2.1 Closure of the mould closing device, rapid movement

For this, the first multi-way valve 64 is switched to position c, causing the second closure-side cylinder space 47 to be exposed to pressurised medium from the pressurised medium source P and the piston unit 46 assumes the right-hand abutment position shown in Fig.3. The second multi-way valve 65 is switched to position a whereby, upon the movement together of the two halves 2 and 3 caused by rotation of the spindle, the hydraulic fluid displaced from the spindle cylinder 63 by the spindle piston 62 is able to flow through the hydraulic line 67 to the tank T. The third multi-way valve 66 is switched to position b, ensuring that the pressure transmitting space 18 and the valve sleeve 21 remain in the position shown in Fig. 3 in which, when the pistons 13 to 16 travel into the closed position, there is an exchange of fluids between the opening-side cylinder spaces 31 and 33 and the closure-side cylinder spaces 27 to 30.

3.2.2 Closure pressure build-up

For this, the first multi-way valve 64 is switched to



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position a so that the hydraulic fluid contained in the second closure-side cylinder space 47 is able to flow through the hydraulic line 69 to the tank T when the screw drive 38 is further rotated while the pistons 13 to 16 are in the closed position, so that the spindle piston 62 can penetrate farther into the spindle cylinder 63 in order to generate hydraulic pressure which is to be applied to the pressure transmitting piston 18. Since the pistons 13 to 16 are in the closed position, in which the tool halves 2 and 3 rest on each other, rotation of the screw drive 38 produces a displacement of the piston unit 46 to the left by the amount by which the spindle piston 62 penetrates the spindle cylinder 63. The second multi-way valve 65 is then switched to position b and the third multi-way valve 66 is switched to position a so that the hydraulic pressure generated in the spindle cylinder 63 can be conveyed via the lines 68 and 67 to the pressure transmitting piston 18. By means of the pressure transmitting piston 18, there is then an increase in pressure appropriate to the build-up of closure force, in accordance with the functional description under 1.2.2.

3.2.3 Pressure dissipation

In order to relieve the closure pressure acting on the annular piston surfaces 13' to 16', the first multi-way valve 64 is switched to position a so that the second closure-side cylinder space 47 is in a secondary suction state of communication with the tank T. The second multi-way valve 65 and the third multi-way valve 66 are both switched to position a so that the pressure from the opening-side pressure transmitting space 25 and the spindle cylinder 63 is able to expand to the tank T.



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3.2.4 Opening of the mould closing device, rapid movement

For this, the first multi-way valve 64 is switched to position c in which the second closure side cylinder space 47 is exposed to the action of pressurised medium from the pressurised medium source P, so that the piston unit 46 is pushed into the abutment position shown in Fig. 3. To this end, there is at the same time a rotation of the screw drive 38 to allow a resetting of the piston unit 46 so that after this reaches its abutment, the opening movement can be performed. The second multi-way valve 65 is switched to position a so that hydraulic fluid can be drawn through the hydraulic lines 68 and 67 from the tank T and passed into the spindle cylinder 63. The third multi-way valve 66 is switched to position b, ensuring that the pressure transmitting piston 18 and the valve sleeve 21 are in the retracted position, opening the port 26 so that during the opening movement there is an unhindered exchange of fluids between the closure-side cylinder spaces 27 to 30 and the opening-side cylinder spaces 31 and 33, excess fluid being capable of being discharged to the tank T via hydraulic line 61.

**ABSTRACT****A MOULD CLOSING DEVICE FOR AN INJECTION MOULDING MACHINE**

In the mould closing device for an injection moulding machine, in the fixed (1) and movable (4) clamping plate are fitted movement spindles (36) which can rotate freely in the fixed clamping plate (1) and are axially supported in one direction and borne in spindle nuts (39) secured in the movable clamping plate (4). For actuating the movement spindles (36) for the closing and opening stroke of the movable clamping plate (4) there is a belt transmission (44) and a hydraulic piston-cylinder unit (45, 46) in operative connection with the movement spindles for accumulating the closing force. To ensure that, while maintaining a high closing pressure exerted by the hydraulic piston-cylinder unit, the actuating drive of the movement spindles is to be designed only in accordance with the requirements for fast opening and closing movements, it is proposed that the hydraulic piston-cylinder unit consist of one or more piston and hydraulic cylinders, to which pressurising agent is applied, for accumulating the closing pressure, by the piston-cylinder unit drivable by the movement spindles with the insertion of pressure transmission devices (19).

(Figure 1)

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A mould closing device for an injection moulding machine

Patent claims



1. A mould closing device for an injection moulding machine and comprising a fixed mould clamping plate supporting one tool half, a movable mould clamping plate carrying the other tool half, with screw drives which are axially supported in one direction and are freely rotatable in the fixed mould clamping plate and are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive for actuating the screw drives for the closing and opening travels of the movable mould clamping plate and with, operatively connected to the screw drives, a hydraulic piston-cylinder unit for building up the closing force, characterised in that the movement of and transmission of force for the movable mould clamping plate during opening and closing is provided during rapid movement solely by the screw drives (36, 38) and in that the hydraulic piston-cylinder unit consists of one or a plurality of pistons (13, 14, 15, 16) and hydraulic cylinders (9, 10, 11, 12), to which, for the build-up of closing force, pressurised medium is applied by piston-cylinder units (45, 46; 62, 63) adapted to be driven by the screw drives (36, 38) through one or a plurality of interposed pressure transmitting means.

2. A mould closing device according to claim 1, characterised in that

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- there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,
- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure-side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19''), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the



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piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),

- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),
- in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
- in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25)



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can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and

- in a fourth function position corresponding to the first function position (opening movement, rapid speed) of the hydraulic system the first multi-way valve (49) can be switched into position c and the second multi-way valve (51) into position b.

3. A mould closing device according to claim 1, characterised in that there are fixed on the movable mould clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,

- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (33, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19''), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting



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cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),

- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),
- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),

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- in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
- in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25) can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a drive screw (38) disposed in screw threaded engagement therein, having one end guided by a spindle piston (62) in a spindle cylinder (63) constructed in the piston-column unit (6, 8), the other end traversing the main hydraulic cylinder (10, 12) and being guided on the one hand through a piston unit (46) in a second hydraulic cylinder (45) and on the other traversing the second hydraulic cylinder (45) and being coupled by its end part (42) to a rotary drive,
- the piston unit (46) of each drive screw (38) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closure movement, rapid movement) of the hydraulic system the first multi-way valve (64) can be switched to a position c in which the

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second closure-side cylinder space (47) can be subjected to pressurised medium from the source P, a second multi-way valve (65) can be switched into position a in which the spindle cylinder (63) can be connected to the tank T and a third multi-way valve (66) can be switched into position b with which the hydraulic line (67) to the pressure transmitting system is interrupted,

- in a second function position (closure pressure build-up) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded to the tank T, the second multi-way valve (65) can be switched to position b and the third multi-way valve (66) can be switched to position a in which the multi-way valve (65) blocks the line to the tank T and the multi-way valve (66) connects the spindle cylinder (63) to the opening-side pressure transmitting space (25),
- in a third function position (pressure dissipation) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded and passed to the tank T, the second multi-way valve (65) and the third multi-way valve (66) can be switched in each case to the position a so that the pressure from the opening-side pressure transmitting space (25) and the spindle cylinder (63) can be expanded and passed to the tank T, and
- in a fourth function position corresponding to the first function position (open in rapid movement), the first multi-way valve (64) can be switched to position c in



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which the second closure-side cylinder space (47) can be connected to the pressurised medium source P, the second multi-way valve (65) can be switched to the position a in which hydraulic fluid can be drawn from the tank T and pass into the spindle cylinder (63) and the third multi-way valve (66) can be switched to position b in which the hydraulic line (67) to the opening-side pressure transmitting space (25) is interrupted.

4. A mould closing device according to one of claims 1 to 3, characterised in that there are in the fixed mould clamping plate (1) four pistons (13, 14, 15, 16) of piston-column units (5, 6, 7, 8) in which there are in each case diagonally oppositely disposed two drive screw arrangements and two pressure transmitting means.

5. A mould closing device according to one of claims 1 to 4, characterised in that the pressure transmitting piston (18) consists of a piston part (19) of a larger diameter and a piston part (20) of a smaller diameter, whereby there is mounted on this latter for axial displacement the valve body which consists of a valve sleeve (21) and which is coupled to the pressure transmitting piston (18) with the proviso that upon displacement of the pressure transmitting piston (18) in a direction opposite to the piston (13, 15) there is an entraining of the valve sleeve (21) and which has on its periphery an axial groove (22) via which it is possible to pass pressurised medium from the port (26) to the annular piston surface (19") of the pressure transmitting piston (18).

6. A mould closing device for an injection moulding machine having a fixed mould clamping plate carrying one tool half, a movable mould clamping plate carrying the other

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tool half, with drive screws which are mounted to be axially supported in one direction and to be freely rotatable in the fixed mould clamping plate and which are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive to actuate the drive screws for the closing and opening travels of the movable mould clamping plate and with a hydraulic piston-cylinder unit which is operatively connected to the drive screws for building-up the closure pressure, characterised in that

there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,

- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19"), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space



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- (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston-column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by means of an axial bearing (41) and on the other is coupled to a rotary drive via the end part (42),
 - in a first function position (closure movement in rapid speed) of a hydraulic system a multi-way valve (56) can be switched to a position b in which the opening-side pressure transmitting space (25) is connected to the tank T in a substantially pressureless state,
 - in a second function position (closure force build-up) of the hydraulic system in which the tool halves (2 and 3) rest on each other, the multi-way valve (56) can be switched to a position in which via the hydraulic line (58) the opening-side pressure transmitting space (25) of the pressure transmitting means is connected to the source P of pressurised medium,
 - in a third function position (pressure dissipation) of the hydraulic system the multi-way valve (56) can be switched to a position a in which the pressurised medium can expand out of the opening-side pressure transmitting space (25) via hydraulic lines (58 and 60) to the tank T, and



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- in a fourth function position (opening movement in rapid speed) of the hydraulic system the multi-way valve (56) can be switched to a position b in which the pressure transmitting means is maintained in a position which keeps the port (26) open.

7. A mould closing device according to claim 6, characterised in that there are in the fixed mould clamping plate (1) four pistons (13, 14, 15, 16) of piston-column units (5, 6, 7, 8) in which there are in each case diagonally oppositely disposed two drive screw arrangements and two pressure transmitting means.

8. A mould closing device according to one of claims 6 or 7, characterised in that the pressure transmitting piston (18) consists of a piston part (19) of a larger diameter and a piston part (20) of a smaller diameter, whereby there is mounted on this latter for axial displacement the valve body which consists of a valve sleeve (21) and which is coupled to the pressure transmitting piston (18) with the proviso that upon displacement of the pressure transmitting piston (18) in a direction opposite to the piston (13, 15) there is an entraining of the valve sleeve (21) and which has on its periphery an axial groove (22) via which it is possible to pass pressurised medium from the port (26) to the annular piston surface (19") of the pressure transmitting piston (18).

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A mould closing device for an injection moulding machine

The invention relates to a mould closing device for injection moulding machines in accordance with the preamble to claim 1.

A mould closing device of this type is known from DE 37 18 106 A 1 (construction as shown in Fig. 5), in which the movable mould clamping plate can be propelled in the closing and opening directions by means of screw drives supported in the fixed mould clamping plate and in which the closing pressure is built up by means of hydraulic piston-cylinder units which are supported in the fixed mould clamping plate and which act upon the screw drives. Where this arrangement is concerned, in addition to the opening and closing travels which have to be performed rapidly, the spindles also assume the full tractive force when the closing force is generated by the hydraulic piston-cylinder units. Therefore, the screw drives have to be designed to handle the movement as well as the closing force function, which means that they have to be made relatively heavy.

Furthermore, known from EP 0 381 107 A2 is a mould closing device in which screw drives mounted in the fixed mould clamping plate are coupled to the movable mould clamping plate by means of spindle nuts which produce the opening and closing movements via a rotary drive. Since the closing pressure is built up via hydraulic piston-cylinder units which are braced on the spindle nuts, then here, too, the screw drives have to be designed so that they can absorb the tractive forces resulting from the high closing pressure.

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Therefore, the invention is based on the problem of so further developing a mould closing device of the aforementioned type that while ensuring the high closing pressure by a hydraulic piston-cylinder unit, the movement drive by means of screw drives only has to be designed to meet the demands for rapid opening and closing movements.

This problem is resolved by the characterising features of the subordinate claims 1 and 4.

Advantageous further developments and measures according to the invention are indicated in the sub-claims.

The invention is explained in greater detail hereinafter with reference to three embodiments shown in the accompanying drawings, in which:

- Fig.1 shows a diagrammatic longitudinal section through a mould closing device of an injection moulding machine and taken along the line I-I in Fig. 4;
- Fig.2 is a diagrammatic longitudinal section through another embodiment of mould closing device;
- Fig.3 is a diagrammatic longitudinal section through a further embodiment of mould closing device, and
- Fig.4 shows a cross-section taken on the line IV-IV in Fig.1 and jointly applicable to the mould closing devices shown in Figs. 1 to 3.

Fig.1 shows a mould closing device for an injection moulding machine and comprising a fixed mould clamping plate 1 with a first tool half 2 and with a movable mould clamping plate 4 carrying the second tool half 3 and in which are fixed four piston-column units 5 to 8 which pass through the fixed

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mould clamping plate 1 by being guided for displacement in this latter in four main hydraulic cylinders 9 to 12 with pistons 13 to 16.

The four piston-column units 5 to 8 consist of two types, of which the piston-column units 5 and 7 are equipped in each case with a pressure transmitting means while the piston-column units 6 and 8 are in each case equipped with a screw drive arrangement.

The pressure transmitting means of the piston-column units 5 and 7 consist in each case of a pressure transmitting cylinder 17 in which is guided a two-stage pressure transmitting piston 18 comprising a larger thrust piston 17 corresponding to the diameter of the pressure transmitting cylinder 19 and a smaller thrust piston 20 enclosed by a valve body consisting of a valve sleeve 21. In its outside diameter, the valve sleeve 21 corresponds substantially to the diameter of the pressure transmitting cylinder 17 and is guided for axial displacement in this latter as well as in respect of the smaller thrust piston 20. The valve sleeve 21 has on its outer surface at least one axially continuous groove 22. The axial displaceability of the valve sleeve 21 is limited in the direction of closure by the outer ring abutment 23 and in the opening direction by abutment means (not shown) acting between the end part of the smaller thrust piston 20 and the end part on the inner periphery of the valve sleeve 21.

The pressure transmitting piston 18 sub-divides the pressure transmitting cylinder 17 into a closure-side pressure transmitting space 24 and an opening-side pressure transmitting space 25.

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The pressure transmitting space 25 on the opening-side is a constituent part of a port 26 in the piston 13, 15 which sub-divides the main hydraulic cylinder 9, 11 into a closure-side cylinder space 27, 28 and an opening-side cylinder space 31, 32. The port 26 can be closed by the valve sleeve 21.

In the same way, the pistons 14 and 16 of the piston-column units 6 and 8 each of which is equipped with a screw drive arrangement, sub-divide these main cylinder spaces 10 and 12 into closure-side cylinder spaces 29 and 30 and opening-side cylinder spaces 33 and 34.

All the closure-side cylinder spaces 27, 28 and 29, 30 are connected to one another by ports 35.

The screw drive arrangements of the piston-column units 6 and 8 consist in each case of a screw drive 36, 37, 38 which is in screw threaded engagement with a spindle nut 39 fixed in the piston 14, 16 and which fits into a recess 40 in the piston-column arrangement 6 and 8.

The screw drives 36, 37, 38 further comprise an axial bearing 41 and an end part 42 by which the screw drive is axially displaceably coupled to a rotary drive, of which only one drive pinion 43 is shown but which is adapted to be driven by a belt transmission 44 with a servomotor and with a positioning adjusting means. Preferably, the servomotor is an electric motor.

The aforescribed features and means are identically in the three embodiments shown in Figs. 1 to 3. Hereinafter, therefore, only the peculiarities of the respective embodiments are described.

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1. Embodiment shown in Fig. 1

1.1 Design

The screw drive 36 in the embodiment shown in Fig. 1 passes through the opening-side cylinder space 32 and projects into a adjacent second cylinder space 45 in which the axial bearing 41 of the screw drive 36 is mounted in a piston unit 46 which sub-divides the second cylinder space 45 into a second closure-side cylinder space 47 and a second opening-side cylinder space (not present in the switched position of the piston unit 46 as illustrated).

From the second closure-side cylinder space 47, a hydraulic line 48 leads to a first multi-way valve 49 (4/3-way valve) with switching positions a, be and c. From the hydraulic line 48, a hydraulic line 50 branches off to a second multi-way valve 51 (4/2-way valve) with switching positions a and b by which a connection can be made or broken between the second closure-side cylinder space 47 and the opening-side thrust cylinder space 25. Via the first multi-way valve 49, the hydraulic line 48 can be switched optionally to a pressurised medium source P or via a non-return valve 52 with back pressure (6 bars) to the tank T. Via a second non-return valve 53 which functions as a secondary section valve, hydraulic fluid can be drawn from the tank T. The opening-side cylinder space 31 is connected by a hydraulic line 54 and the non-return valve 52 with back pressure to the tank T

1.2 Functional description

1.2.1 Closure of the mould closing device, rapid movement

For this, the second closure-side cylinder space 47 is

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subjected to pressurised medium from the source P via the position c of the first multi-way valve 49, whereupon the piston unit 46 assumes the right-hand position of abutment shown in Fig. 1. The second multi-way valve 51 is in switched position b, ensuring that the pressure transmitting piston 18 maintains the valve sleeve 21 in the position shown in Fig. 1 in which the passage or port 26 between the closure-side cylinder space 27 and the opening-side cylinder space 31 is open.

By rotation of the screw drive 36, the two halves 2 and 3 of the tool are moved towards each other until they abut each other. Due to the fact that the screw drive 31 is driven by an electric servomotor with a position adjustment facility, precised positioning is possible. During the movement of the tool halves 2 and 3 towards each other, there is a redistribution of the hydraulic fluid from the opening-side cylinder spaces 31 and 33 via the ports 26 and passages 35 to the closure-side cylinder spaces 27 to 30, any shortage of hydraulic fluid being replaced via the line 54 and the secondary suction valve 53.

1.2.2 Closure pressure build-up

For this, the first multi-way valve 49 is moved to position b and the second multi-way valve 51 to position a. Upon further rotation of the screw drive 36 in the closure direction, the piston unit 46 (in the illustration in Fig.1) is displaced leftwardly whereupon the hydraulic fluid contained in the second closure-side cylinder space 47 passes through the hydraulic lines 48 and 50 and the second multi-way valve 51 and into the opening-side pressure transmitting space 25 and causes a

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displacement of the pressure transmitting piston 18 and of the valve sleeve 21 so that at first the valve sleeve 21 closes the port 26. Further displacement of the pressure transmitting piston 18 produces, by virtue of the differential pressure surfaces 19' and 19" an increase in pressure which becomes propagated via the continuous groove 22 in the valve sleeve 21 and generates the required closure pressure at the annular piston surfaces 13' to 16'.

1.2.3 Pressure dissipation

In order to relieve the closure pressure acting on the annular piston surfaces 13' to 16', the second multi-way valve 51 is moved to switched position a and the first multi-way valve 49 to switched position a, whereupon the pressure transmitting piston 18 is switched to the tank T in a pressureless condition. The second closure-side cylinder space 47 is connected to the pressurised medium source P so that the piston unit is reset in the abutment position shown in Fig. 1.

1.2.4 Opening of the mould closing device, rapid movement

For this stage, the first and the second multi-way valves 49 and 51 are moved into the same switched position as when carrying out the closure process but the direction of rotation of the screw drives 36 is reversed, so that the tool halves 2 and 3 move away from each other.

2. Embodiment shown in Fig. 2

2.1 Design

Where the embodiment shown in Fig. 2 is concerned, the screw drive 37 is, by means of an axial bearing 41,

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freely rotatably but axially non-displaceably mounted in a housing 55 adjacent the main hydraulic cylinder 10. The hydraulic system consists of a pressurised medium source P, a multi-way valve 56 with switched positions a, b and c, a freely switchable non-return valve 57, a secondary suction valve 53, a non-return valve 52 with back pressure, a tank T and hydraulic lines 58 to 61.

2.2 Functional description

2.2.1 Closure of the mould closing device, rapid movement

For this, the multi-way valve 56 is switched to the position b shown in Fig. 2 ensuring that the passage 26 in the piston 13, 15 remains open so that upon rotation of the screw drive 37 and of the movement of the tool halves 2 and 3 towards each other which this produces, the hydraulic fluid is able to flow out of the two opening-side cylinder spaces 31 and 33 into the closure side cylinder spaces 27 to 30, any lack of fluid being drawn in via the secondary suction valve 53 and the hydraulic line 61. Rotation of the screw drive 37 is stopped when the two halves 2 and 3 of the tool have come to rest on each other.

2.2.2 Closure pressure build-up

To achieve this, the multi-way valve 56 is moved to position c in which the hydraulic fluid passes from the pressurised medium source P through the hydraulic line 58 and into the closure-side pressure transmitting space 24 producing, by means of the pressure transmitting piston 18, the build-up of closure pressure which is described with reference to 1.2.2.

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2.2.3 Pressure dissipation

To relieve the closure pressure acting on the annular piston surfaces 12' to 16', the multi-way valve 56 is moved to switch position a in which, via the hydraulic line 59, the non-return valve 57 is cleared, whereupon the pressure biasing the pressure reducing (sic') piston 18 is able to expand to the tank T via the hydraulic lines 58 and 60.

2.2.4 Opening of the mould closing device, rapid movement

For this phase, the multi-way valve 56 is moved to switch position b. By rotation of the screw drive 37 so that the tool halves 2, 3 move apart, a pressure is generated in the closure-side cylinder spaces 27 which, via the port 26, produces a resetting of the pressure transmitting piston 18 and of the valve sleeve 21 into the position shown in Fig. 2 so that the port 26 between the closure-side cylinder spaces 27, 29 is completely clear so that upon the movement apart, it is possible for the volumes between the closure-side cylinder spaces 27 to 30 and the opening-side cylinder spaces 31 to 33 to become equalised. Excess hydraulic fluid is discharged to the tank T via the hydraulic line 61.

3. Embodiment shown in Fig. 3

3.1 Design

The drive-side part of the screw drive 38 in Fig. 3 corresponds to the screw drive 36 in Fig. 1. At the end which fits into the piston-column unit 6 (8) the screw drive 38 has a hydraulic spindle piston 62 guided in a spindle cylinder 63. The hydraulic system consists of a pressurised medium source P, a first multi-way valve 64

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with three switch positions a to c, a second multi-way valve 65 with switch positions a and b and a third multi-way valve 66 with switch positions a and b.

The aforescribed multi-way valves 64 to 66 are connected by hydraulic lines 67 to 70 to the opening-side pressure transmitting space 24, the spindle cylinder 63, the second closure-side cylinder space 47, the opening-side cylinder space 31, 33 and the tank T.

3.2 Functional description

3.2.1 Closure of the mould closing device, rapid movement

For this, the first multi-way valve 64 is switched to position c, causing the second closure-side cylinder space 47 to be exposed to pressurised medium from the pressurised medium source P and the piston unit 46 assumes the right-hand abutment position shown in Fig.3. The second multi-way valve 65 is switched to position a whereby, upon the movement together of the two halves 2 and 3 caused by rotation of the spindle, the hydraulic fluid displaced from the spindle cylinder 63 by the spindle piston 62 is able to flow through the hydraulic line 67 to the tank T. The third multi-way valve 66 is switched to position b, ensuring that the pressure transmitting space 18 and the valve sleeve 21 remain in the position shown in Fig. 3 in which, when the pistons 13 to 16 travel into the closed position, there is an exchange of fluids between the opening-side cylinder spaces 31 and 33 and the closure-side cylinder spaces 27 to 30.

3.2.2 Closure pressure build-up

For this, the first multi-way valve 64 is switched to

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position a so that the hydraulic fluid contained in the second closure-side cylinder space 47 is able to flow through the hydraulic line 69 to the tank T when the screw drive 38 is further rotated while the pistons 13 to 16 are in the closed position, so that the spindle piston 62 can penetrate farther into the spindle cylinder 63 in order to generate hydraulic pressure which is to be applied to the pressure transmitting piston 18. Since the pistons 13 to 16 are in the closed position, in which the tool halves 2 and 3 rest on each other, rotation of the screw drive 38 produces a displacement of the piston unit 46 to the left by the amount by which the spindle piston 62 penetrates the spindle cylinder 63. The second multi-way valve 65 is then switched to position b and the third multi-way valve 66 is switched to position a so that the hydraulic pressure generated in the spindle cylinder 63 can be conveyed via the lines 68 and 67 to the pressure transmitting piston 18. By means of the pressure transmitting piston 18, there is then an increase in pressure appropriate to the build-up of closure force, in accordance with the functional description under 1.2.2.

3.2.3 Pressure dissipation

In order to relieve the closure pressure acting on the annular piston surfaces 13' to 16', the first multi-way valve 64 is switched to position a so that the second closure-side cylinder space 47 is in a secondary suction state of communication with the tank T. The second multi-way valve 65 and the third multi-way valve 66 are both switched to position a so that the pressure from the opening-side pressure transmitting space 25 and the spindle cylinder 63 is able to expand to the tank T.

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3.2.4 Opening of the mould closing device, rapid movement

For this, the first multi-way valve 64 is switched to position c in which the second closure side cylinder space 47 is exposed to the action of pressurised medium from the pressurised medium source P, so that the piston unit 46 is pushed into the abutment position shown in Fig. 3. To this end, there is at the same time a rotation of the screw drive 38 to allow a resetting of the piston unit 46 so that after this reaches its abutment, the opening movement can be performed. The second multi-way valve 65 is switched to position a so that hydraulic fluid can be drawn through the hydraulic lines 68 and 67 from the tank T and passed into the spindle cylinder 63. The third multi-way valve 66 is switched to position b, ensuring that the pressure transmitting piston 18 and the valve sleeve 21 are in the retracted position, opening the port 26 so that during the opening movement there is an unhindered exchange of fluids between the closure-side cylinder spaces 27 to 30 and the opening-side cylinder spaces 31 and 33, excess fluid being capable of being discharged to the tank T via hydraulic line 61.

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A mould closing device for an injection moulding machine

Patent claims

1. A mould closing device for an injection moulding machine and comprising a fixed mould clamping plate supporting one tool half, a movable mould clamping plate carrying the other tool half, with screw drives which are axially supported in one direction and are freely rotatable in the fixed mould clamping plate and are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive for actuating the screw drives for the closing and opening travels of the movable mould clamping plate and with, operatively connected to the screw drives, a hydraulic piston-cylinder unit for building up the closing force, characterised in that the movement of and transmission of force for the movable mould clamping plate during opening and closing is provided during rapid movement solely by the screw drives (36, 38) and in that the hydraulic piston-cylinder unit consists of one or a plurality of pistons (13, 14, 15, 16) and hydraulic cylinders (9, 10, 11, 12), to which, for the build-up of closing force, pressurised medium is applied by piston-cylinder units (45, 46; 62, 63) adapted to be driven by the screw drives (36, 38) through one or a plurality of interposed pressure transmitting means.

2. A mould closing device according to claim 1, characterised in that

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- there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,
- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure-side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19"), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the

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piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),

- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),
- in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
- in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25)

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can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and

- in a fourth function position corresponding to the first function position (opening movement, rapid speed) of the hydraulic system the first multi-way valve (49) can be switched into position c and the second multi-way valve (51) into position b.

3. A mould closing device according to claim 1, characterised in that there are fixed on the movable mould clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,

- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (331, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19"), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting

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cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space (25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),

- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by a piston unit (46) in a second hydraulic cylinder (45) and on the other passes through the second hydraulic cylinder (45) and has a rotary drive coupled to the end part (42),
- the piston unit (46) of each screw drive (36) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closing movement, rapid speed) of a hydraulic system a first multi-way valve (49) can be switched into a position c in which the second closure-side cylinder space (47) can be connected to a source P of pressurised medium, and a second multi-way valve (51) can be switched into a position b in which a hydraulic line (50) leading from the second closure-side cylinder space (47) to the opening-side pressure cylinder space (25) is interrupted, the pressure transmitting piston (18) and the valve casing (21) being in a basic position which opens the port (26),

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- in a second function position (closure pressure build-up) of the hydraulic system the second closure-side cylinder space (47) can be connected to the opening side pressure transmitting space (25), the first multi-way valve (49) being in the position b and the second multi-way valve (51) being in position a,
- in a third function position (pressure dissipation) of the hydraulic system the second closure-side cylinder space (47) and the opening side pressure transmitting space (25) can be switched to be pressureless, the first multi-way valve (49) and the second multi-way valve (51) being in each case in the switched position a, and
- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a drive screw (38) disposed in screw threaded engagement therein, having one end guided by a spindle piston (62) in a spindle cylinder (63) constructed in the piston-column unit (6, 8), the other end traversing the main hydraulic cylinder (10, 12) and being guided on the one hand through a piston unit (46) in a second hydraulic cylinder (45) and on the other traversing the second hydraulic cylinder (45) and being coupled by its end part (42) to a rotary drive,
- the piston unit (46) of each drive screw (38) sub-divides the second hydraulic cylinder (45) into a second closure-side cylinder space (47) and a second opening-side cylinder space,
- in a first function position (closure movement, rapid movement) of the hydraulic system the first multi-way valve (64) can be switched to a position c in which the



second closure-side cylinder space (47) can be subjected to pressurised medium from the source P, a second multi-way valve (65) can be switched into position a in which the spindle cylinder (63) can be connected to the tank T and a third multi-way valve (66) can be switched into position b with which the hydraulic line (67) to the pressure transmitting system is interrupted,

- in a second function position (closure pressure build-up) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded to the tank T, the second multi-way valve (65) can be switched to position b and the third multi-way valve (66) can be switched to position a in which the multi-way valve (65) blocks the line to the tank T and the multi-way valve (66) connects the spindle cylinder (63) to the opening-side pressure transmitting space (25),
- in a third function position (pressure dissipation) of the hydraulic system the first multi-way valve (64) can be switched to position a in which the pressurised medium contained in the second closure-side cylinder space (47) can be expanded and passed to the tank T, the second multi-way valve (65) and the third multi-way valve (66) can be switched in each case to the position a so that the pressure from the opening-side pressure transmitting space (25) and the spindle cylinder (63) can be expanded and passed to the tank T, and
- in a fourth function position corresponding to the first function position (open in rapid movement), the first multi-way valve (64) can be switched to position c in



which the second closure-side cylinder space (47) can be connected to the pressurised medium source P, the second multi-way valve (65) can be switched to the position a in which hydraulic fluid can be drawn from the tank T and pass into the spindle cylinder (63) and the third multi-way valve (66) can be switched to position b in which the hydraulic line (67) to the opening-side pressure transmitting space (25) is interrupted.

4. A mould closing device according to one of claims 1 to 3, characterised in that there are in the fixed mould clamping plate (1) four pistons (13, 14, 15, 16) of piston-column units (5, 6, 7, 8) in which there are in each case diagonally oppositely disposed two drive screw arrangements and two pressure transmitting means.

5. A mould closing device according to one of claims 1 to 4, characterised in that the pressure transmitting piston (18) consists of a piston part (19) of a larger diameter and a piston part (20) of a smaller diameter, whereby there is mounted on this latter for axial displacement the valve body which consists of a valve sleeve (21) and which is coupled to the pressure transmitting piston (18) with the proviso that upon displacement of the pressure transmitting piston (18) in a direction opposite to the piston (13, 15) there is an entraining of the valve sleeve (21) and which has on its periphery an axial groove (22) via which it is possible to pass pressurised medium from the port (26) to the annular piston surface (19") of the pressure transmitting piston (18).

6. A mould closing device for an injection moulding machine having a fixed mould clamping plate carrying one tool half, a movable mould clamping plate carrying the other



tool half, with drive screws which are mounted to be axially supported in one direction and to be freely rotatable in the fixed mould clamping plate and which are mounted in the movable mould clamping plate in a spindle nut fixed therein, with a rotary drive to actuate the drive screws for the closing and opening travels of the movable mould clamping plate and with a hydraulic piston-cylinder unit which is operatively connected to the drive screws for building-up the closure pressure, characterised in that

there are fixed on the movable moulding clamping plate (4) two types of piston-column units (5, 6, 7, 8) which pass through the fixed mould clamping plate (1) in which they are guided by means of pistons (13, 14, 15, 16) in hydraulic cylinders (9, 10, 11, 12), the piston-column units (6, 8) of one type comprising one screw drive device while the piston-column unit (5, 7) of the other type comprises a pressure transmitting means,

- the pistons (13, 14, 15, 16) sub-divide the hydraulic cylinders (9, 10, 11, 12) in each case into a closure-side cylinder space (27, 28, 29, 30) and an opening-side cylinder space (31, 32, 33, 34),
- all closure side cylinder spaces (27, 28, 29, 30) are connected to one another via ducts (35),
- the pressure transmitting means consist in each case of a pressure transmitting piston (18) having differential piston surfaces (19' and 19"), a pressure transmitting cylinder (17) and a valve body (21), the valve transmitting piston (18) sub-dividing the pressure transmitting cylinder (17) into a closure-side pressure transmitting space (24) and an opening-side pressure transmitting space



(25), the valve body (21) being adapted to be switched between positions which open and close a port (26) from the closure-side cylinder space (27, 28, 29, 30) to the opening-side cylinder space (31, 33),

- the drive screw arrangements in each case consist of a spindle nut (39) fixed in the piston (14, 16) and a screw drive (36) in screw threaded engagement therein and which has one end immersed in a cylindrical recess (40) in the piston-column means (6, 8) while the other end passes through the main hydraulic cylinder (10, 12) and is guided on the one hand by means of an axial bearing (41) and on the other is coupled to a rotary drive via the end part (42),
- in a first function position (closure movement in rapid speed) of a hydraulic system a multi-way valve (56) can be switched to a position b in which the opening-side pressure transmitting space (25) is connected to the tank T in a substantially pressureless state,
- in a second function position (closure force build-up) of the hydraulic system in which the tool halves (2 and 3) rest on each other, the multi-way valve (56) can be switched to a position in which via the hydraulic line (58) the opening-side pressure transmitting space (25) of the pressure transmitting means is connected to the source P of pressurised medium,
- in a third function position (pressure dissipation) of the hydraulic system the multi-way valve (56) can be switched to a position a in which the pressurised medium can expand out of the opening-side pressure transmitting space (25) via hydraulic lines (58 and 60) to the tank T, and



- in a fourth function position (opening movement in rapid speed) of the hydraulic system the multi-way valve (56) can be switched to a position b in which the pressure transmitting means is maintained in a position which keeps the port (26) open.

7. A mould closing device according to claim 6, characterised in that there are in the fixed mould clamping plate (1) four pistons (13, 14, 15, 16) of piston-column units (5, 6, 7, 8) in which there are in each case diagonally oppositely disposed two drive screw arrangements and two pressure transmitting means.

8. A mould closing device according to one of claims 6 or 7, characterised in that the pressure transmitting piston (18) consists of a piston part (19) of a larger diameter and a piston part (20) of a smaller diameter, whereby there is mounted on this latter for axial displacement the valve body which consists of a valve sleeve (21) and which is coupled to the pressure transmitting piston (18) with the proviso that upon displacement of the pressure transmitting piston (18) in a direction opposite to the piston (13, 15) there is an entraining of the valve sleeve (21) and which has on its periphery an axial groove (22) via which it is possible to pass pressurised medium from the port (26) to the annular piston surface (19") of the pressure transmitting piston (18).

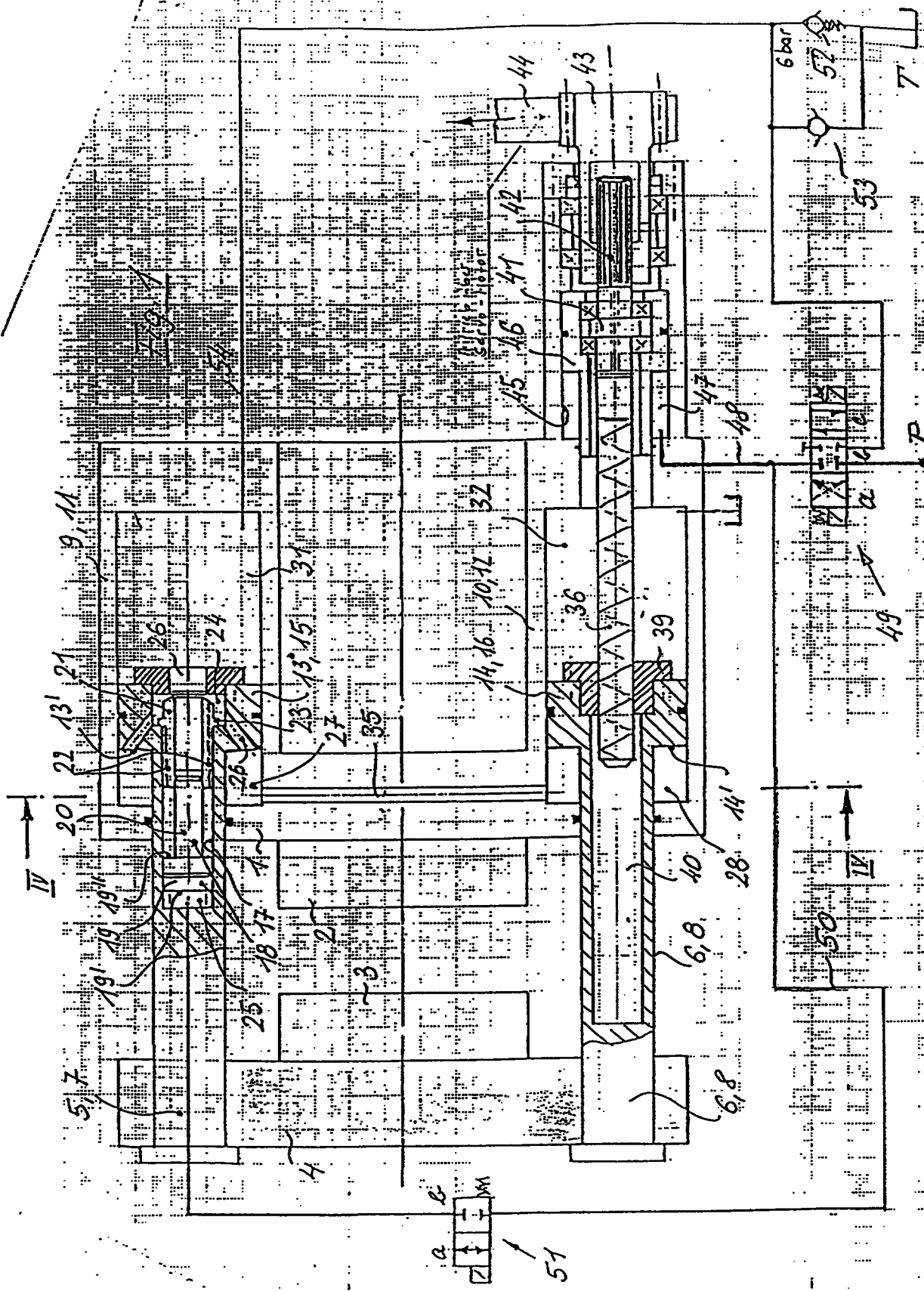
ABSTRACT**A MOULD CLOSING DEVICE FOR AN INJECTION MOULDING MACHINE**

In the mould closing device for an injection moulding machine, in the fixed (1) and movable (4) clamping plate are fitted movement spindles (36) which can rotate freely in the fixed clamping plate (1) and are axially supported in one direction and borne in spindle nuts (39) secured in the movable clamping plate (4). For actuating the movement spindles (36) for the closing and opening stroke of the movable clamping plate (4) there is a belt transmission (44) and a hydraulic piston-cylinder unit (45, 46) in operative connection with the movement spindles for accumulating the closing force. To ensure that, while maintaining a high closing pressure exerted by the hydraulic piston-cylinder unit, the actuating drive of the movement spindles is to be designed only in accordance with the requirements for fast opening and closing movements, it is proposed that the hydraulic piston-cylinder unit consist of one or more piston and hydraulic cylinders, to which pressurising agent is applied, for accumulating the closing pressure, by the piston-cylinder unit drivable by the movement spindles with the insertion of pressure transmission devices (19).

(Figure 1)

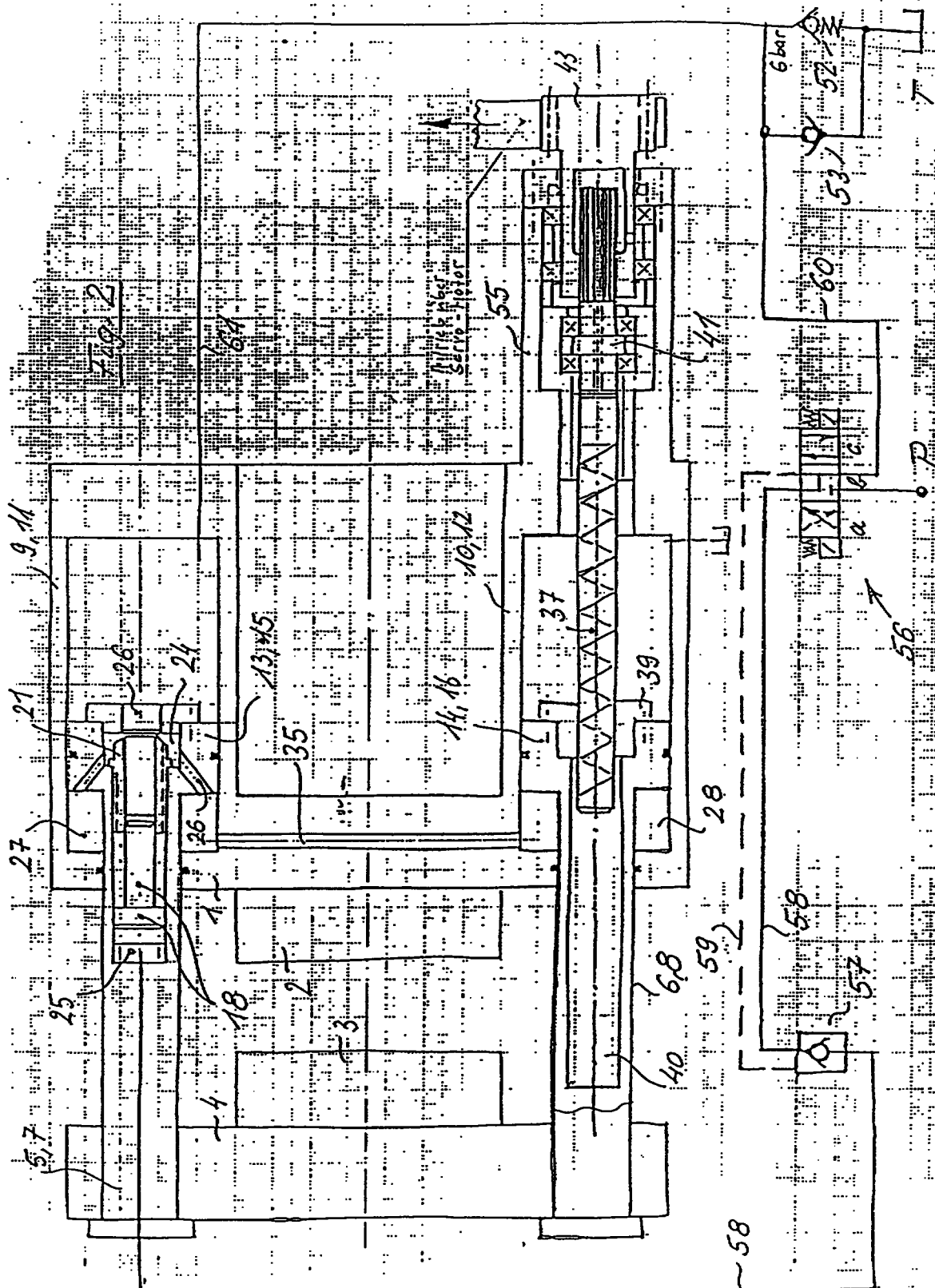
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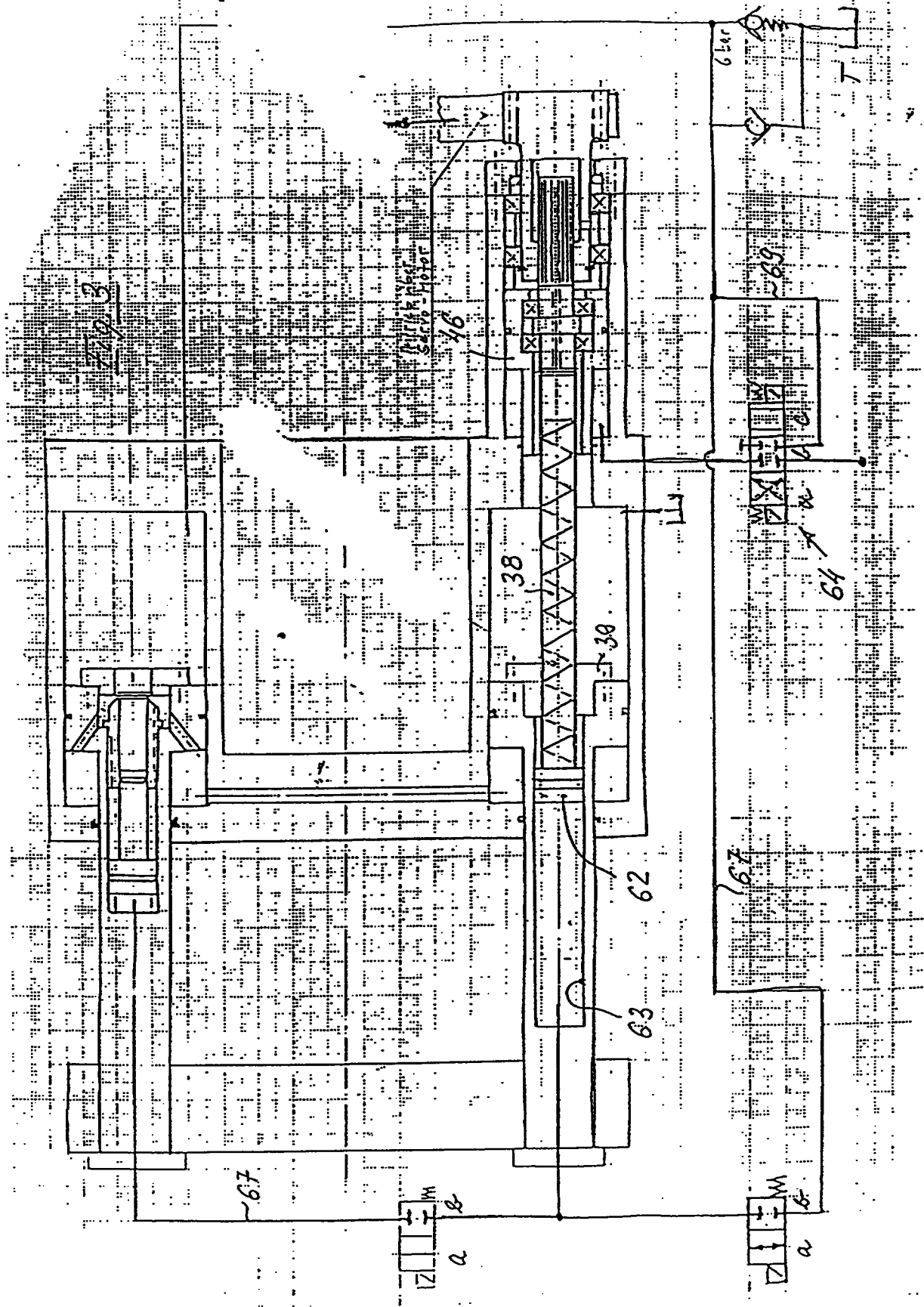
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Fig. 4

