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(54) DIE-CASTING MACHINE

(71) We, IDRA-PRESSEN GmbH, a Body corporate organised and existing under the laws of the Federal Republic of Germany, of Azenbergstrasse 31, D-7000 Stuttgart, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a die casting machine, comprising a working cylinder accomodating a displaceable working piston, and a multiplier cylinder, linking to the working cylinder, accomodating a displaceable multiplier piston, there being enclosed between the working piston and the multiplier piston a working chamber which is connected to a pressure-medium line, which can be shut off by a check valve, for feeding a pressure medium, acting on the working piston, during a first and a second work phase of the die-casting machine, and in which there if provided on that side of the multiplier piston which is remote from the working chamber a pressure chamber into which can be introduced a pressure medium for driving the multiplier piston during a third work phase.

In a conventional construction of this kind of die-casting machine, the check valve is arranged in the multiplier piston. This check valve closes automatically upon hydraulic pressure rise in the working cylinder towards the end of the mould-filling phase and thus makes movement of the multiplier piston possible.

What is disadvantageous in this construction is the fact that the check valve is accessible only with difficulty and that the multiplier piston is weakened. This weakening can, for example, be the cause of piston cracks. A further disadvantage lies in the fact, that the transition from the second to the third working phase is not always free of pressure peaks, since after the closing of the check valve the mass of the multiplier piston must be accelerated before the pressure rise starts.

An object of the present invention is to provide a die-casting machine wherein this weakening of the multiplier piston is abolished, wherein the check valve is easily accessible and wherein during the transition from the second to the third working phase pressure peaks may be avoided.

The invention provides a die-casting machine, comprising a working cylinder accomodating a displaceable working piston, and a multiplier cylinder, linking to the working cylinder, accommodating a displaceable multiplier piston, there being enclosed between the working piston and the multiplier piston a working chamber which is connected to a pressure-medium line, which can be shut off by a check valve, for feeding a pressure medium, acting on the working piston, during a first and a second work phase of the die-casting machine, and in which there is provided on that side of the multiplier piston which is remote from the working chamber a pressure chamber into which can be introduced a pressure medium for driving the multiplier piston during a third work phase, wherein the pressure-medium line extends outside the multiplier piston, the check valve is arranged on a wall portion bounding the working chamber and the supply of pressure medium to the pressure chamber of the muliplier cylinder is controllable by a valve arrangement which is actuatable independently of the check valve.

Through the invention, the check valve is separated from the multiplier piston and can be built-on to the outside of the press-in part of the die-casting machine. Thus the weakening of the multiplier piston is abolished, and at the same time the check valve becomes easily accessible. Since the multi-

plier piston can be started independently of the check valve, the latter is closed by the pressure rise created by the multiplier piston and the multiplication of the pressure starts without delay and pressure peaks.

Through the invention, furthermore, the design is made such that the multiplier piston can be acted upon at the beginning of the second phase with the pressure medium, which serves for its adjustment, but nevertheless remains at rest.

This is achieved by a controllable second check valve disposed in a conduit connecting a pressure store to a prestressing chamber formed in the multiplicator cylinder on the multiplicator piston side facing the working chamber.

Advantageously, a valve is used for controlling the second check valve so that as a function of its position, it connects the prestressing chamber either to an atmosphere-loaded tank or to the pressure store associated with the multiplier piston.

In many instances it can be advisable to make the valve serving for the control of the second check valve actuatable, without temporal delay, by the same impulse which causes the switching-on of a second of the pressing phases.

In order to reduce the pressure peaks which occur at the end of the third phase and which arise through the sudden deceleration of the moved masses, it is advantageous if the annular chamber of the working cylinder is connected, in the region of its end face remote from the working piston, via a quantity regulating device, to an atmosphere-loaded tank. In this respect it is advisable to use a quantity regulating device which is digitally adjustable.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows substantially the press-in part of three-phase cold-chamber die-casting machine of the invention;

Figure 2 shows a modified embodiment of the press-in part represented in Figure 1.

Figure 3 is a graph showing the pressure in the mould during casting on a three-phase die-casting machine;

Figure 4 is another graph similar to that of Figure 3.

Installed so as to be displaceable in a working cylinder 1 (Figure 1) of a press-in part of a preferred die-casting machine of the invention is a working piston 2 having a piston rod 3. Connected securely to the piston rod 3 is a press piston (not shown) by means of which metal is forced into a mould of the machine. Consecutive to the working cylinder 1 is a multiplier cylinder 4, which contains a displaceable multiplier piston 5. Adjacent to the multiplier piston 5 a multiplier prestressing chamber 6 is disposed which is connected via a line 7 to a bubble store 8.

A pressure-medium feed pipe 9, into which a first check valve 10 is incorporated, opens on the piston side of the working piston 2, into a working cylinder chamber 11. Connecting to that portion of the pressure-medium feed pipe 9 which lies in fron of the check valve 10 is a connection line 13 coming from a pump line 12.

In a first phase of casting, hydraulic medium is conveyed from the pump via the lines 12 and 13. Consequently, a closure member 14 of the check valve 10 is forced, against the pressure of a spring 15, into an open position and the working piston 2 is shifted in the direction of the arrow P.

After the pushing-forward of the metal into the mould during the 1st phase, after covering of a fixed distance by the piston rod 3 in a manner which is not shown, a switch (also not shown) is actuated, which triggers a valve 16 controlling the flow of pressure medium. Consequently, in accordance with the previously-effected digital preselection for the second phase the corresponding valve combination 16.1 .... 16.5 is actuated. Thus for the valve cone 17 of a quantity-regulating device 24 the opening distance and thus the speed of the second phase is fixed. The hydraulic medium prestressed in the piston store 18 now flows also via the line 13, opens the closure member 14 and acts on the working piston 2.

At the end of the second phase, the third phase can be initiated by a valve 19 which is controlled in time-dependent, pressure-dependent or path-dependent manner. As soon as the valve 19 is in the work position, the desired opening path for the valve cone 20 of a quantity-regulating device 25 is suddenly freed, since the corresponding valve combination at the pre-control valves 20.1....20.5 has already been actuated at the beginning of the second phase.

The hydraulic medium for this phase flows from the piston store 18 via a line 21, acts upon the multiplier piston 5, and this latter leaves its position of rest.

As soon as the pressure behind the working piston 2 rises towards the end of the mould filling, the spring 15 forces the closure member 14 onto the valve seat, and the multiplication of the pressure starts immediately without a pressure peak.

In order to set the desired end pressure of the multiplication, the corresponding combination of the pre-control or servo valves 20.1 ... 20.5 together with a valve 22 is actuated by the machine control in accordance with a digital preselection on a control board of the die-casting machine and thus the loading pressure is fixed by a pressure regulating device 23.

The flow of hydraulic medium from the

piston store 18 and therewith the speed for the second and third pressing phase is set by the digital quantity-regulting device 24 or 25 respectively in accordance with the values preselected for this in the switching cupboard, whereas the loading pressure for the bubble store 8 and therewith the end pressure emerging upon the multiplication is called-up in accordance with the preselection on the control board by the digital pressure-regulating device 23.

The described embodiment offers additionally the further advantage that via the quantity regulating device 25 as may be required a greater amount of oil per unit of time can be called-up for the third press-in phase than was the case with the second press-in phase. Thus, a faster presure build-up can be achieved even with a slow mould filling phase.

Through the incorporation of a spring-loaded sensing pin 26, in conjunction with an end switch 27 it can be exactly ascertained when the multiplier piston 5 leaves its position of rest.

When a pressure receiver 28 is incorporated behind the working piston 2, furthermore upon each casting cycle it can be accurately measured and controlled as to whether and to what extend the multiplier piston 5 has left its position of rest, before the hydraulic system pressure occurs in the press-in cylinder. Thus the possibility is offered of realising a multiplier use control which is very important for the die-casting production and has so far not been possible without great expenditure.

In the case of the embodiment in accordance with Figure 2, a working cylinder 31 receives a working piston 32 so as to be displaceable in the direction of, and in the opposite direction to, the arrow A. Connected securely to the working piston 32 is a piston rod 33, which carries at the end which is not shown the pressure piston which pushes the metal into the mould hollow space which is likewise not shown.

Connecting (or linking) to the working cylinder 31 on the piston side of the working piston 32 is a multiplier cylinder 34, in which a multiplier piston 35 is arranged so as to be displaceable in the direction of, and in the opposite direction to, the arrow A. Connected securely to the working piston 32 is a piston rod 33, which carries at the end which is not shown the pressure piston which pushes the metal into the mould hollow space which is likewise not shown.

An annular space 36 in the multiplier cylinder 34 forms a prestressing chamber in which there can be built up a counter-pressure which acts on the multiplier piston 35 in the opposite direction to the arrow A. The prestressing chamber 36 is connected via a line 37 to the pressure store 38 which is designed as a bubble store, in which connection a controllable check valve 39 is incorporated in the line 37.

The inner space of the working cylinder 31 is connected in front of the piston side of the working piston 32 via a line 40 to a first check valve 41 which is arranged on the outside of the multiplier cylinder 34 and which is connected, for its part, to a line 42 which leads to a pump (not shown) and which is shut-off relative to the pump by a second check valve 43.

Between the second check valve 43 and the first check valve 41, a line 44 opens into the line 42. This line 44 connects to the down stream side of a quantity regulating apparatus 45 which serves for the adjustable regulation of the volume flow of the hydraulic medium which leads via a line 46 to a line 47 which is connected via a line 48 to a pressure store 49 which is designed as a piston store.

Forming part of the quantity regulating apparatus 45, in the case of the exemplified embodiment shown, are five valves which can be actuated magnetically and which are designated by 50.1 to 50.5 and are switchable by an electrical selection switch which is not shown. The individual valves 50.1....50.5 are so stepped or graduated that the respectively following valve frees the respectively doubled amount of pressure medium. Thus $2^5 = 32$ different amounts of pressure medium can be set with the quantity regulation apparatus 45 shown.

The calling-up of the amounts of pressure medium set via electrical selector switches (not shown) and therewtith via the valves 50.1...50.5 is effected by actuation of the valve 50. With the calling-up of the digitally-preselected amount of pressure medium the opening path of the valve cone 51 of the quantity regulating apparatus 45 is fixed.

The space 52 in front of the multiplier piston 35 is connected via a line 53 and a line 54 to the flow-off side of a quantity regulation apparatus 55, which is connected on the flow-in side via the lines 56, 47 and 48 likewise to the pressure store 49. The quantity regulation apparatus 55 can, like the quantity regulation apparatus 45, be set digitally.

Forming part of the quantity regulation apparatus 55 are additionally the preselection or servo valves 27.1 to 27.5, which correspond with the valves 50.1...50.5 and the quantities of flow of which are presettable via an electrical selector switch (not shown). The calling-up of the set amount is effected via a valve 57. In accordance with the selected setting, upon the actuation of the valve 57 the desired opening path of the valve cone 58 of quantity regulating apparatus 55 is freed.

The loading pressure for the pressure

store 38 is set via a pressure regulation device 59 in accordance with the digital preselection (not shown) by means of an electrical switch 77.

In the region of the end face 60, the annular chamber 61 of working cylinder 31 is connected via a line 62 to a quantity regulating apparatus 63, which corresponds to the quantity regulating apparatus 45. The quantity regulating apparatus 63 blocks or opens the flow-off of the pressure medium from the annular chamber 61 via a line 64 to an atmosphere-loaded tank 65. Via a line 66, into which additionally a check valve 67 is incorporated, the annular chamber 61 can be connected, for the pushing-back of the working piston 32 in the opposite direction to the arrow A, to the pump (not shown).

The opening path of the valve cone 68 of quantity regulating apparatus 63 can be determined by corresponding setting of a electrical selector switch (not shown) which forms part of the quantity regulating apparatus 63.

By incorporating a, for example, spring-loaded sensing pin 71, which co-operates with a limit switch 72, it can be accurately ascertained when the multiplier piston 35 leaves its position of rest.

Connected to the line 40 is additionally, via a line 69, a pressure receiver (or absorber) 70 which makes it possible to monitor, upon each casting cycle, whether or to what extent the multiplier piston 35 has left its position of rest, before the hydraulic system pressure occurs in the working cylinder 31.

In this way a multiplier use control is obtained, which is very important for the die-casting production and has so far not been possible without great expenditure.

It will be assumed that the casting cycle proceeds in 3 phases, in which respect the pressure piston proceeds slowly in the 1st phase and more quickly in the 2nd phase and, in the 3rd phase, secondarily compresses the metal in the mould hollow space.

For the initiation of the 1st phase, by opening the prerun (or recuperator) valve (not shown), hydraulic fluid is conveyed from the pump (not shown) through a line 73 via the check valve 43 into the line 42. Caused by the pressure of the hydraulic fluid, a valve cone 74 of the check valve 41 is pushed against the pressure of a spring 75 into the open position. The hydraulic fluid passes via the line 40 in front of the working piston 32, so that this latter is advanced slowly in the direction of the arrow A. The forwardrun speed during the 1st phase of the press-in procedure can be set by regulating the amount of fluid conveyed by the fluid pump.

At the end of the 1st phase, a member (not shown) connected to the piston rod 33 actuates a switch (a so not shown) the switching impulse of which brings about the actuation of the way-valve 50. Consequently, the amount of pressure medium arising in accordance with the digital selection of the quantity regulating apparatus 45 and thus of the provided valve combination 50.1...50.5 is called-up. Thus the opening path for the valve cone 51 is set. Accordingly, at this stage pressure fluid passes from the pressure store 49 to the quantity regulating apparatus 45, opens here the valve cone 51 and flows via the lines 44, 42 as well as the check valve 41 in front of the working piston 32. Because the pressure of the pressure fluid coming from the pressure store 49 has a higher value than the pressure of the pressure fluid conveyed by the pump (not shown) to the line 42, on the one hand automatically the check valve 43 is closed and, on the other hand, the working piston 32 is now, in the 2nd press-in phase, advanced more rapidly in the direction of the arrow A.

Towards the end of the 2nd phase, in time- or pressure- or path-dependent manner the way-valve 57 can be actuated and thus the 3rd phase of the press-in procedure can be initiated. Through the actuation of the way-valve 57, the desired opening path for the valve cone 58 is suddenly freed, since the corresponding combination of the way-valves 27.1...27.5 has been set already with the beginning of the 2nd phase. The hydraulic fluid for the 3rd phase flows from the pressure store 49 via the line 54 to the chamber 52 in front of the multiplier piston 35. This is acted upon and leaves its position of rest in the direction of the arrow A. As soon as the pressure on the piston side of the working piston 32 rises towards the end of the mould filling, the spring 75 forces the valve cone 74 onto its valve seat and the multiplication of the pressure in the working cylinder 31 starts in delay-free manner without a pressure peak.

Through the incorporation of the controlled check valve 39 into the line 37, already with the beginning of the 2nd phase the digital pressure quantity regulating apparatus 55 can be connected in (or switched on), without the multiplier piston 35 travelling forward. This becomes possible in that the pressure fluid in the prestressing chamber 36 on account of the blocked check valve 39 cannot escape. The counter-pressure exerted by the pressure fluid in the prestressing chamber 36 on the multiplier piston 35 suffices to fetter the multiplier piston despite the action of pressure fluid on its piston side in the position of rest. When, at the end of the 2nd phase, the way-valve 76 is actuated in time-, pressure- or path-dependent manner, the check valve 39 is opened by the pressure in the line 47, so that now the 3rd phase is freed.

In order to be able to set the charging pressure and therewith the desired end pressure of the multiplication, the corresponding combination of the way-valves 27.1...37.5 (together with the way-valve 77) is called-up by the control of the die-casting machine in accordance with the digital preselection i.e. the charging pressure is fixed by the pressure regulation device 59.

In order to reduce the pressure peaks which occur at the end of the mould filling and which are designated in Figures 3 and 4 by S and S1, at the beginning of the 2nd phase the digital quantity regulation device 63 opens the valve cone 68 entirely, so that the entire valve cross-section is open. Consequently, the hydraulic medium displaced by the forwardly-running working piston 32 can flow off unhindered from the working cylinder 31. Towards the end of the 2nd phase, controlled in time-, path- or pressure-dependent manner, the opening cross-section of the quantity regulating device 63 is then reduced. In this way, the speed of the moved (or moving) masses is dampened, and the previously occurring pressure peaks are largely eliminated. Then a pressure course emerges approximately (or for instance) in accordance with the broken lines in Figures 3 and 4.

WHAT WE CLAIM IS:-

1. A die-casting machine, comprising a working cylinder accomodating a displaceable working piston, and a multiplier cylinder, linking to the working cylinder, accomodating a displaceable multiplier piston, there being enclosed between the working piston and the multiplier piston a working chamber which is connected to a pressure-medium line, which can be shut off by a check valve, for feeding a pressure medium, acting on the working piston, during a first and a second work phase of the die-casting machine, and in which there is provided on that side of the multiplier piston which is remote from the working chamber a pressure chamber into which can be introduced a pressure medium for driving the multiplier piston during a third work phase, wherein the pressure-medium line extends outside the multiplier piston, the check valve is arranged on a wall portion bounding the working chamber and the supply of pressure to the pressure chamber of the multiplier cylinder is controllable by a valve arrangement which is actuatable independently of the check valve.

2. A die-casting machine as claimed in claim 1, wherein the valve arrangement comprises a quantity control device whose cross-section of passage for the pressure medium is pre-selectable, and a control valve which controls the quantity control device and which is actuatable in pressure-dependent, time-dependent or path-dependent manner.

3. A die-casting machine as claimed in claim 1 or 2, in which there is provided on the side, remote from the pressure chamber, of the multiplier piston in the multiplier cylinder an initial stressing chamber which is connected to a pressure store by way of a line, the charging pressure in the pressure store and the initial stressing chamber being adjustable by way of a pressure regulating device.

4. A die-casting machine as claimed in claim 3, wherein a controllable second check valve is arranged in the line between the initial stressing chamber and the pressure store.

5. A die-casting machine as claimed in claim 4, wherein serving to control the second check valve is a valve which, as a function of its position, connects the initial stressing chamber either to an atmosphere loaded tank or to the pressure store which is associated wtih the multiplier piston.

6. A die-casting machine as claimed in claim 5, wherein the valve serving to control the second check valve is actuable without a time delay as a function of a control impulse which also causes the commencement of the second work phase.

7. A die-casting machine as claimed in any of claims 1 to 6, wherein an annular chamber, lying on that side of the working piston which is remote from the work chamber, of the working cylinder is connectd, in the region of its end face remote from the working piston, by way of a quantity regulating device to an atmosphere-loaded tank.

8. A die-casting machine as claimed in claim 7, wherein the quantity regulating device is designed to be digitally adjustable.

9. A die-casting machine as claimed in any of claims 1 to 8, wherein that side of the multiplier piston remote from the work chamber is acted upon by a spring-loaded sensing pin, the other end of which actuates a limit switch which serves to indicate the position of the multiplier piston.

10. A die-casting machine as claimed in any of claims 1 to 9, wherein a pressure receiver or absorber is arranged in the path of the pressure medium between the working piston and the check valve.

11. A die-casting machine substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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1582533 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

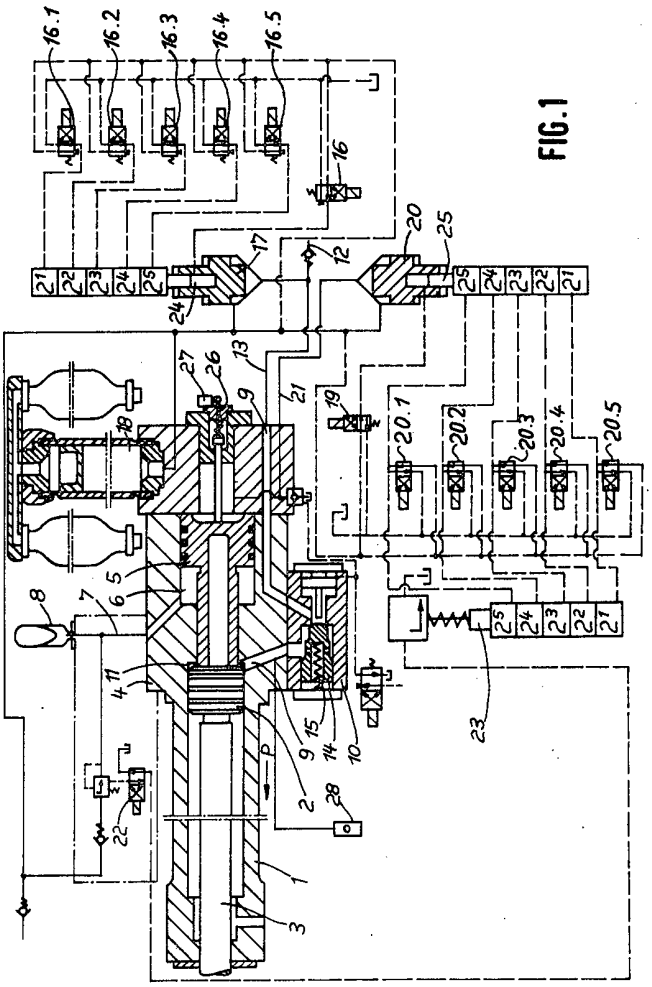

FIG.1

1582533 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

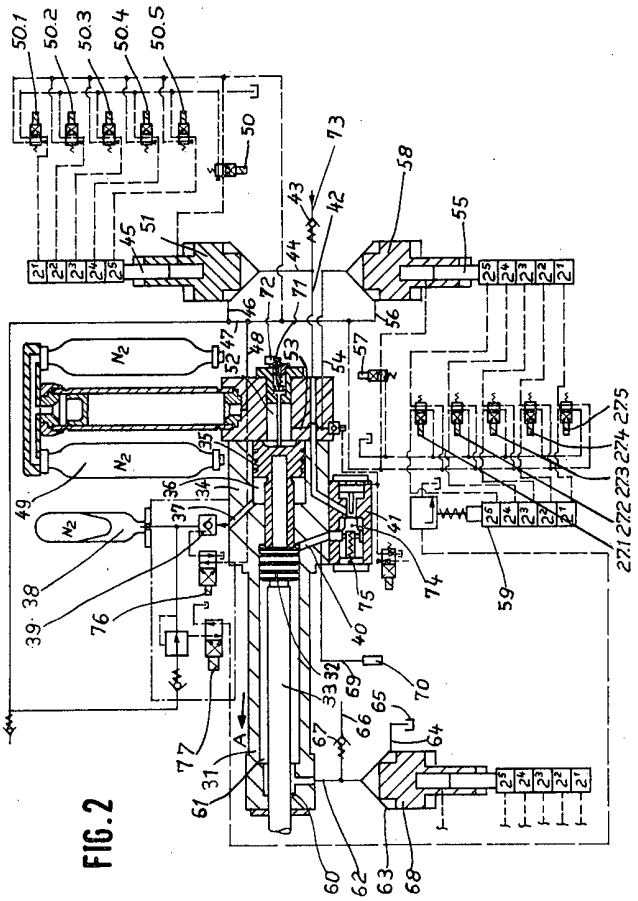

FIG. 2

FIG.3

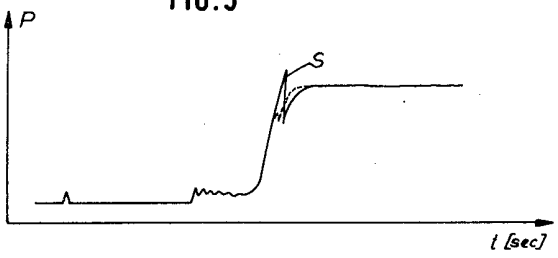

FIG.4