June 24, 1958 F. HODLER 2,839,800

METHOD OF AND APPARATUS FOR DAMPING SHOCKS IN DIE-CASTING MACHINES

Filed Aug. 26, 1955 4 Sheets-Sheet 1

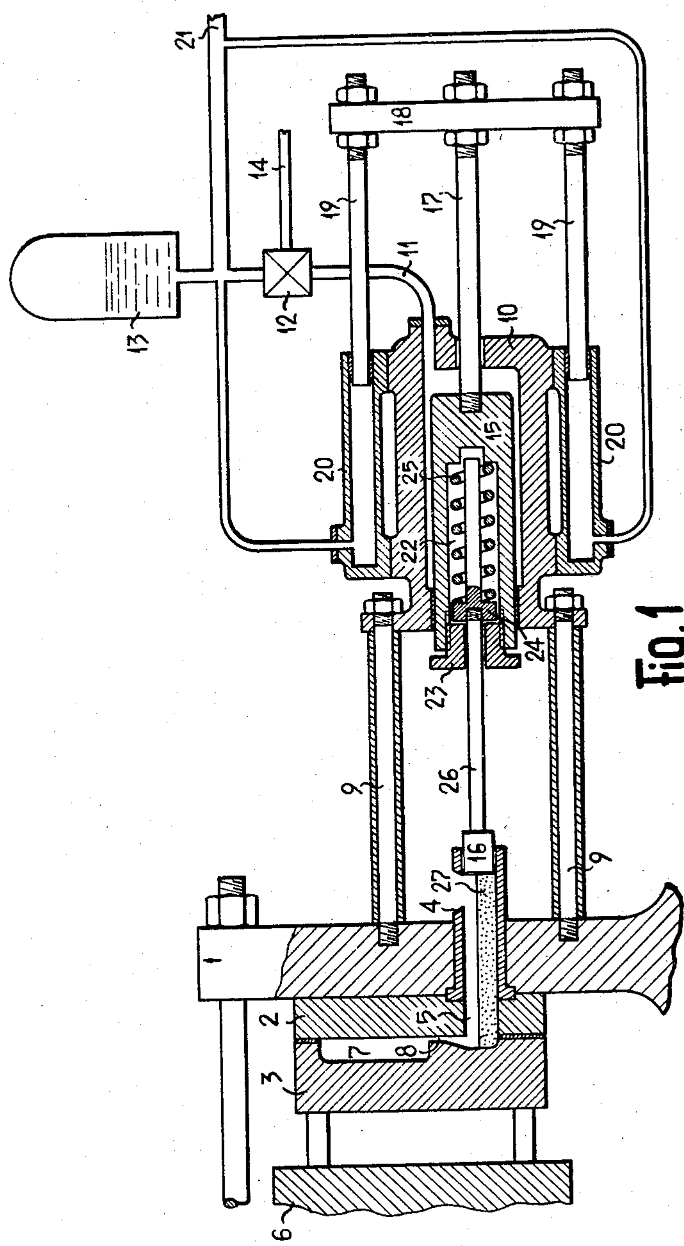

Fig. 1

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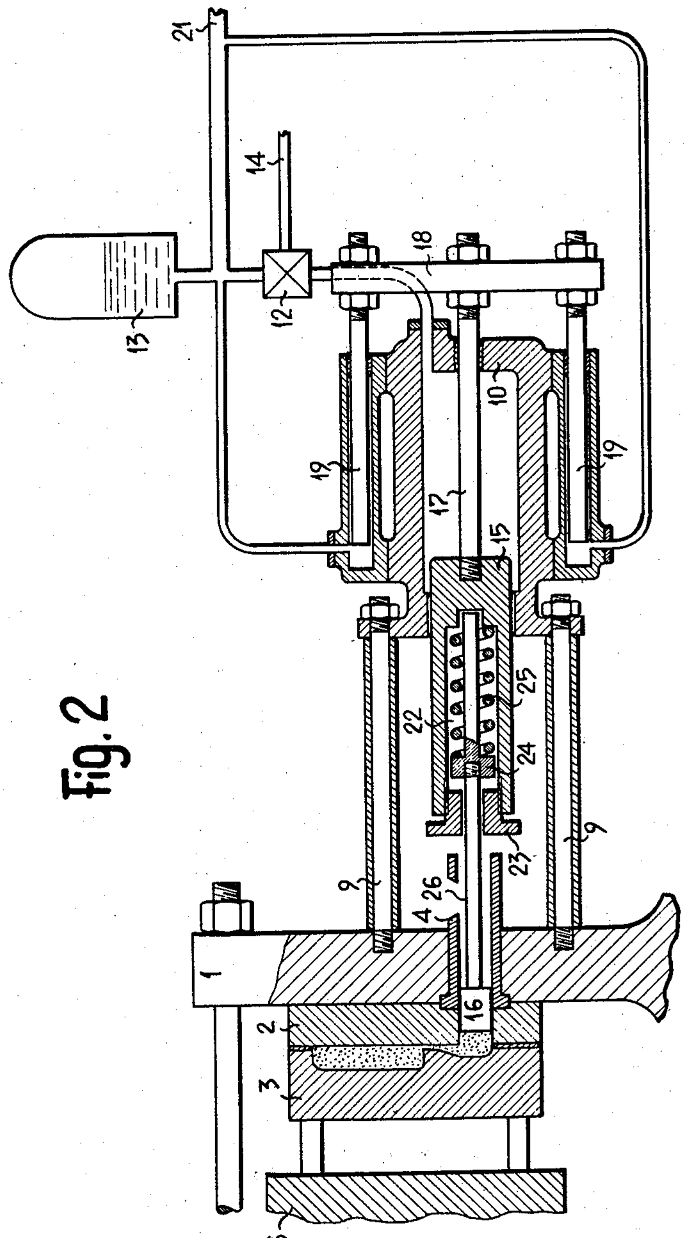
Fig. 2



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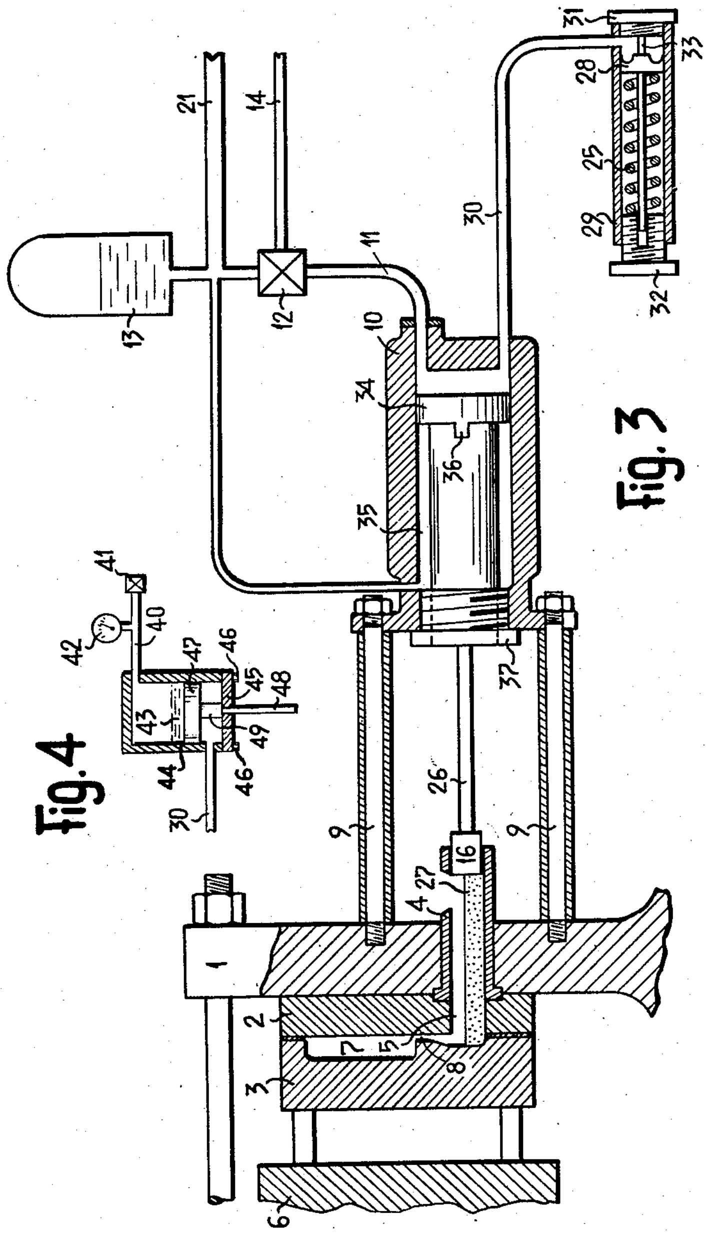

Fig. 3

Fig. 4

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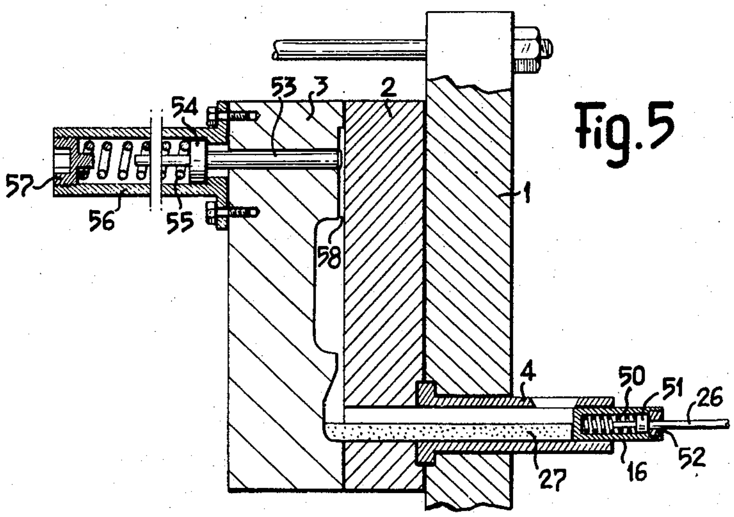

Fig. 5

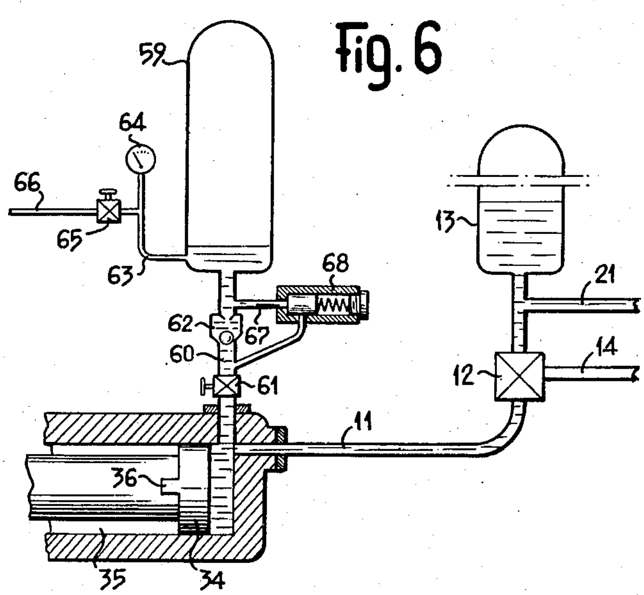

Fig. 6

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METHOD OF AND APPARATUS FOR DAMPING SHOCKS IN DIE-CASTING MACHINES

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Application August 26, 1955, Serial No. 530,769

Claims priority, application Switzerland September 27, 1954

12 Claims. (Cl. 22—68)

The present invention relates to a method of damping kinetic shock components which are set up in hot and cold chamber pressure-die-casting machine, below the final static pressure, at the beginning of, during, or at the end of the complete filling of the die, said damping being as complete as possible and being timed in such a manner as to give maximum results. This invention also relates to machines used for this purpose.

It is a well known fact that in the operation of hot and cold chamber pressure die-casting machines, in which one of the die-halves is movable, high injection- and die-closing forces are used and that these forces are supplied in general and preferably by hydraulic pressure. It may be observed that in order to produce high-grade castings, especially as far as surface quality is concerned, it is essential that the time needed for filling the die should be reduced as far as possible and that therefore the highest possible injection speeds are used. However, when these conditions are met the following disadvantages cannot be avoided.

A close analysis of the conditions prevailing during the injection operation will show that at the beginning of, during and especially at the end of the complete filling of the die-cavity extremely high brake-energies will be set up, caused by the sudden breaking effect produced on all the masses which are in motion and which are suddenly stopped as a result of the filling of the die. These brake energies and the sudden increase of pressure they cause in the hydraulic system, which exceeds the static theoretical end-pressure, have at first a detrimental effect on various parts of the machine and of the hydraulic system, but this effect is especially severe on and especially detrimental to the die, to which it is transmitted by the casting mass. It results in the impossibility of avoiding displacement of the movable part of the die.

By reason of the fact that the medium which transmits the pressure has a relatively low degree of compressibility, and also since the efficient operation of the machine makes a predetermined rigidity of the various parts of same and of the installation necessary, this sudden and considerable increase in pressure is inevitable and must necessarily result in the injection force exceeding the die-closing force. The consequence of this is that the movable part of the die is subjected to a movement opposed to the die-closing force and in its opening direction. This allows the metal, which is still fluid, to penetrate between the two die-halves and to form burrs or "flash" at the junction of the die-halves, or, when the ratio of the forces is still more unfavorable, the fluid metal may be projected from the die at the junction of the two die-halves.

The main disadvantages of the burrs or "flash" are that they must be removed, which involves additional work and expense and that they also render working to close tolerances impossible. Another disadvantage is that parts of these burrs often fuse to the surface of the die-halves at their junction which makes it impossible for the die to be closed effectively and must therefore be re-

moved. The projection of fluid metal from the die also leads to similar disadvantages and further constitutes an element of considerable danger to the operators. As a result a fairly high percentage of rejects results.

An obvious solution for counteracting this unfavourable ratio of forces and the consequences thereof would appear to be an increase of the closing force of the machine. However, this solution must be rejected, not only from an economical point of view, in which case it would be necessary to provide a closing force which is several times, for example 3 to 6 times as large as the injection force, but also from a technical point of view, by reason of the necessity of increasing the dimensions of some of the parts of the machine, thus influencing the cooling conditions of the casting material and consequently also deleteriously affecting the surface quality of the castings.

It has therefore been necessary to find a solution for damping these harmful brake-energies.

A primary condition, however, for the solution of this problem is the correct understanding of the conditions prevailing at the beginning of, during and at the end of the complete filling of the die-cavity.

Contrary to accepted theories it has been assumed that the ideal condition to be aimed at should be the damping of all kinetic energy set up in the machine, in such a manner as to prevent the increasing injection force, during the injection operation, and after same has been completed, from rising above the static theoretical value and to time this damping in such a mannner as to cause the pressure at the end of the injection phase, i. e. the quasi static final pressure and the forces resulting therefrom, to be reached only when the metal has reached at least a partial state of solidification.

In theory it has been thought that the increase of the injection force at the end of the injection phase, as a result of the kinetic shock, may be instrumental in causing a higher degree of compression of the casting material during the solidification phase. However, it is considered that although the amplitude of the maximum pressure, as far as the time factor is concerned, is sufficient to cause detrimental effects such as those referred to, the time during which this maximum pressure obtains is altogether too short to have any appreciable influence on the degree of compression of the metal.

It is not denied that in some cases, when castings have to be produced, in which, because of their shape and volume, shrink holes may occur, an increase of the injection force at the end of the injection phase can be used with good results. However, this increase of the injection force should be produced only after the kinetic shock has been absorbed.

In order to resolve the problem of absorbing the kinetic shock of the moving masses in die-casting machines, in which the fluid metal is injected under pressure, it is believed that the best possible casting results can be obtained when the injection time is kept as short as possible, in other words when the time required for the complete filling of the die-cavity is reduced as far as possible. It is therefore considered that at least as good, or even better results, as regards surface quality and the casting being a true copy of the die-cavity, are obtained with a short injection time, even when the lowest possible injection force is used, as is the case when a very much higher injection force and a longer injection time are used. Whilst this may appear contradictory it will be clear, when fully appreciated, that pressure is not the only factor which determines the time required for filling the die-cavity but that this also depends on the dimensions of the entrance gate into the die-cavity. When a low injection force is used, the gate must be so dimensioned as to allow the die-cavity to be filled in the shortest possible period of time. In order to meet these conditions the moving masses must be subjected to a high velocity and the kinetic shock resulting from the sudden braking of this velocity must be absorbed to the fullest extent.

The kinetic shock in pressure die-casting machines is composed of the brake energy of the masses in motion between the pump or accumulator and the injection piston, the mass of the injection piston itself and of all the parts associated therewith and finally the masses of casting material in motion in the injection sleeve, in the feed channels to the die-cavity, in the die-cavity itself and in possible overflow channels.

According to the present invention a machine for die-casting under pressure comprises damping means for absorbing shocks arising from the kinetic energy of masses which are decelerated in the operation of filling the die.

The invention also relates to a method of damping, preferably below the static end pressure, a part of or all kinetic shock components of the masses in motion in hot and cold chamber pressure die casting machines, said damping being effected at the beginning of, during, or at the end of the complete filling of the die-cavity.

In order to enable the invention to be more readily understood, reference is made to the accompanying drawings which illustrate diagrammatically and by way of example six embodiments thereof, in which:

Fig. 1 is a partial view in section of the machine in the position of filling the injection sleeve.

Fig. 2 shows the same machine as in Fig. 1 in the position at the end of the injection of metal into the die.

Figs. 3 to 6 show modified forms of construction.

In the drawings, **1** indicates part of the framework of the machine carrying a die consisting of parts **2** and **3** and an injection sleeve **4**. The stationary part **2** of the die is secured to the framework **1** and is provided with a passage **5** which communicates with the injection sleeve **4**. The movable part **3** of the die is held against the part **2** by a tightening member **6**. The molten metal enters the die-cavity **7** through the gate **8**.

A cylinder **10** is secured to the framework **1** by means of bolts **9**. Said cylinder **10** is connected by a pipe **11** to a three-way cock **12** enabling it to be placed into communication either with a pipe **21** for the supply of liquid under pressure, or with an exhaust pipe **14**. The pipe **21** for the supply or liquid under pressure is also in communication with an energy accumulator **13**.

The piston **15**, sliding in the cylinder **10**, is connected to the injection piston **16**, which latter slides in the injection sleeve **4**. Said piston **15** is secured to a rod **17** passing through the bottom of the cylinder **10** and connected to a traverse member **18** carrying two piston rods **19** sliding in cylinders **20**, the axes of which are parallel to the axes of the cylinder **10**. The cylinders **20** are connected at one end thereof to a pipe **21** for the supply of fluid under pressure and they are adapted to effect the return movement of the piston **15** in the cylinder **10** after each working stroke.

The piston **15** is hollow and the front end of its bore **22** is closed by a nut **23** which serves as a stop for a part **24** carrying a spring **25**. The nut **23** has a central opening through which passes a rod **26** connected at one end to the piston **16** and at the other end to the part **24**.

The cycle of operations of the machine is as follows:

After a predetermined quantity of liquid metal has been supplied to the sleeve **4**, the valve **12** is opened to allow fluid under pressure to flow into the cylinder **10**. The hydraulic pressure in the latter only reaches a value which is necessary to overcome the constant force applied to the pistons **19** and resistances which oppose the forward movement of the injection piston.

When metal reaches the gate **8** of the die, the pressure in the hydraulic cylinder **10** rises suddenly but remains well below the quasi-static pressure in the accumulator **13**, by reason of losses due to friction between the said accumulator and the cylinder **10**. The velocity of the liquid in the pipe **11** is high and in general reaches a value of approximately 100 ft. per second. The pressure applied to the control piston **15** thus equals the static pressure in the accumulator **13** minus losses due to friction. In this manner it becomes possible to ascertain the force applied to the injection piston **16** while the metal is being pressed into the die, whilst, by means of the nut **23**, the spring **25** is compressed to such an extent as to balance said force exactly when the part **24** is in the postion shown in Fig. 1.

Once the die-cavity has been filled the pressure in the control cylinder **10** rises until it reaches the value of the static pressure in the accumulator, whilst at the same time the spring **25** is compressed until it balances this static pressure. This result is obtained slightly before the end of the part **24** comes into contact with the end of the piston **15**, as shown in Fig. 2. While the spring **25** is being compressed, it absorbs an amount of work produced by the difference between the static thrust and the injection thrust and the length to which it is compressed. This work is equivalent to the kinetic energy of the fluid in motion and would produce a hydraulic shock if not absorbed by the said spring. The spring also absorbs the kinetic energy resulting from the movement of the piston **15** and of the masses **17, 18** and **19**, which are secured thereto. The maximum amplitude of the pressure may even exceed the static pressure in the case of high injection speeds and according to the mass of the movable parts **15, 17, 18** and **19**, but this amplitude can never reach the same value, as would be the case when no shock-absorption means are provided. In order to produce the return stroke of the piston **16** the position of the valve **12** is reversed, thus allowing liquid in the cylinder **10** to flow into the pipe **14**. The liquid under pressure supplied by the pipe **21**, enters the cylinders **20** and repels the pistons **19**. As soon as the valve **12** is opened, expansion of the spring **25** returns it to the position shown in Fig. 1.

Fig. 3 shows another embodiment of the invention by way of example in which the shock-absorbing device is formed by a free piston **28** which is held in its normal position by a spring **25**, said spring having been pretensioned in the manner described above. The piston **28** slides in a cylinder **29** which is connected to the cylinder **10** by a pipe **30**. The ends of the cylinder **29** are closed by the plugs **31** and **32**, the plug **31** having a projection **33** forming a stop for defining the normal position of the piston **28**. The plug **32** is screwed into the cylinder **29** to a sufficient distance so as to enable the tension of the spring to be adjusted to the value required for keeping the free piston **28** in its normal position.

In this embodiment the hydraulic control piston is formed by a differential piston **34** connected directly to the injection piston **16** by a rod **26**. It will be seen that the piston **34** has two opposed faces of different diameters. In order to inject the metal, the fluid under pressure is supplied through the pipe **11**, as is the case in the embodiment described above, whilst the return stroke of the piston is effected through the action of the fluid under constant pressure passing from the pipe **21** into the chamber **35** and acting on the face of small diameter of the piston **34**.

The piston **34** has a projection **36** adapted to cooperate with a nut **37** which closes the cylinder **10**, in such a manner as to limit the possible movement of the piston **34**, in order to prevent the latter from blocking the opening through which the liquid enters the chamber **35**. It will be clear that in the case of this embodiment the masses which move at the same time as the piston **34**, are much smaller than in the embodiment of the invention hereinbefore described.

The action of this shock-absorbing device is identical with that of the embodiment of the invention described with reference to Figs. 1 and 2, but in this case only the kinetic energy of the hydraulic fluid is damped, a slight shock subsisting by reason of the kinetic energy of the control piston **34**. However, said piston may be relatively light and since its speed is low compared with that of the liquid in the pipe **11**, the resulting shock will be much smaller than in the case of a die-casting machine having a control piston, as shown in Figs. 1 and 2. However, the embodiment of the invention shown in Fig. 3 has the advantage that the shock-absorbing device can be readily added to existing machines. It will be understood that also in this embodiment of the invention, the control piston may be of the same type as that shown in Fig. 1.

Fig. 4 shows still another embodiment of a shock-absorbing device which can be used in connection with the machine shown in Fig. 3. The pipe **30** leads into a cylinder **44**, the lower end of which is closed by a cover **45**, secured by the screws **46**. In the cylinder **44** a free piston **47** can slide, said piston being secured to a rod **48** passing through a bore in the cover **45**, said bore being provided with a fluid-tight lining, not shown. The rod **48** has a part **49** of larger diameter, which is adapted to abut against the cover **45** so as to determine the normal position of the piston **47**. With the upper part of the cylinder **44** communicates a pipe **40**, the end of which is provided with a valve **41**. A gauge **42** indicates the pressure prevailing in the cylinder **44** and a predetermined quantity of liquid **43** is provided above the piston **47** in order to facilitate obtaining a sufficient degree of fluid-tightness between the latter and the cylinder **44**. Before the machine is set in operation compressed air is supplied to the upper part of the cylinder **44** until the required pressure is reached.

This pressure should approximately equal the static pressure in the accumulator **13**, minus the losses due to friction of the liquid in the pipe **11** and the valve **12**. When this pressure is reached the valve **41** is closed and the cycle of operations can be begun.

The action of this shock-absorbing device is similar to that of the one shown in the embodiment of Fig. 3. As soon as the die-cavity is filled, the kinetic energy of the fluid arriving in the cylinder **10** displaces the piston **47** against the pressure of the air-cushion contained in the cylinder **44**. The part of the rod **48** which projects from the latter makes it possible to verify that the piston **47** does not move during the injection stroke but only at the end thereof. It will be understood that the length of the pipe **30** and the mass of the free piston must be as small as possible in the embodiments of the invention shown in Figs. 3 and 4.

It will be understood that it is not absolutely necessary for the resilient element, formed either by the spring **25** or the air-cushion in the cylinder **44**, to be in a state of pretension at the beginning of the injection stroke of the piston **16**, but when the said resilient element is not under tension at the beginning of the injection stroke the injection speed, during the time required for bringing the element under tension, will be reduced and this reduction of the injection speed may, in some cases, influence the quality of the casting.

It is also possible to absorb practically all the brake-energy components, whereby the machine operates very smoothly and rapid wear of some parts, caused by kinetic shocks, is eliminated. The life of the machine and particularly of the die of the injection sleeve **4** and of the injection piston **16**, will thus be considerably longer. Also the efficient operation of some parts of the machine, especially of the extractors, slides and cores, is facilitated. In existing machines which are not provided with shock-absorbing devices of the types described above, the extractors and especially the slides and cores often jam as a result of burrs of metal entering between these parts and their seats. When, however, a large part of the kinetic shocks is absorbed, interruptions of work through this jamming will disappear.

Fig. 5 shows an embodiment of part of a machine in which the kinetic shock is absorbed to the largest possible degree. This figure shows the die, consisting of the parts **2** and **3**, the injection sleeve **4** and the injection piston **16** of a die-casting machine, the other parts, which are not shown, being identical to those shown in Figs. 1 and 2. In this case the sliding injection piston **16** is mounted at the end of the rod **26**. This piston **16** is hollow and a helical spring **50** is provided in the chamber formed by the bore, this spring being supported at one end by the front face of the piston and at the other end by a shoulder **51** of the rod **26**. The rear part of the piston **16** is closed by a screwplug **52** against which the shoulder **51** abuts. When the die-cavity is filled, the spring **50** is compressed and absorbs the kinetic energy of the rod **26** and of the masses of the parts connected thereto.

Consequently the kinetic shock of all masses in motion in the machine is absorbed, except the kinetic shock due to the movement of the piston **16** itself and of the fluid metal **27**. In order to absorb this last kinetic shock component, the part **3** of the die has a bore in which a rod **53**, which acts as a piston, can slide. This rod **53** has an annular shoulder **54** against which rests a spring **55** which is housed in a cylinder **56** secured to the part **3** of the die. The tension of the spring **55** can be adjusted by screwing or unscrewing the screwplug **57**, which is screwed into the end of the cylinder **56**. When the die-cavity is filled the metal enters the channel **58** at the upper end of the die-cavity and displaces the rod **53** against the pressure of the spring **55** which is adapted to absorb the kinetic energy of the metal **27** and of the injection piston **16**. The pressure applied to the fluid metal by the rod **53**, when the spring **55** is fully compressed should be approximately equal to the static pressure applied to the metal by the injection device.

It will be understood that this modification of the embodiment of the invention may also be applied to other types of die-casting machines, for example to the one shown in Fig. 3. In this case the spring **50**, provided in the injection piston **16**, must be stronger, so as to be capable of absorbing not only the kinetic energy of the rod **26** but also that of the control piston **34**. It will also be understood that the springs may be replaced by other resilient elements and that in particular the spring **55** may be replaced by a cushion of compressed air, in which case the air-cushion and the rod **53** may be connected together by means of a hydraulic fluid.

Fig. 6 shows an embodiment of part of a machine of the type shown in Fig. 3, which has been modified in such a manner as to make possible the limitation of the pressure applied to the metal in the die to a value which is lower than the static pressure applied by the hydraulic installation, these conditions being maintained until at least partial solidification of the casting has been reached.

In this machine the chamber of the cylinder **35**, supplied with the fluid producing the movement of the control piston **34**, is brought into communication with a reservoir **59** which contains a cushion of compressed air. The communication between the reservoir **59** and the said chamber is effected by means of the pipe **60** of large diameter, said pipe being provided with a regulating valve **61** and a non-return valve **62**. The reservoir **59** is provided at its lower end with a pipe **63**, with a gauge **64**, said pipe **63** being connected through a valve **65** to the tube **66** through which compressed air can be passed. A by-pass **67**, provided with an automatic valve **68**, enables the hydraulic fluid to circulate in a direction opposite to that permitted by the non-return valve **62**.

Before the machine is operated the air-pressure in the reservoir **59** is adjusted by means of the valve **65** and controlled by the gauge **64** in order to ascertain whether this pressure is equal, or slightly inferior to the pressure in the cylinder **35** during the injection phase. When the die is filled, the hydraulic fluid circulating at high speed in the pipe **11** is not stopped suddenly but changes its course and enters the reservoir **59** through the pipe **60**. When, during the injection, the pressure inside the reservoir **59** is lower than the pressure in the cylinder **35**, a predetermined volume of liquid flows, during the injection, into the reservoir **59** so that the closing member of the non-return valve **62** has already been lifted from its seat. Therefore, when the control piston **34** is stopped suddently, at the moment of the complete filling of the die-cavity, the liquid, which is circulating at high speed, does not have to overcome the inertia of the closing member of the valve **62** and of the mass of hydraulic fluid in order to flow into the reservoir **59**. The dimensions of the latter must be such that a relatively long period of time must elapse before the pressure of the air-cushion reaches the static value of the liquid supplied by the pipe **21**. Before this state of balance is reached, the casting has entered a stage of at least partial solidification so that the closing force of the die may be lower than the force which is required for balancing the static pressure.

The valve **61** makes it possible to influence the action of the shock-absorbing device relatively to the force and to time. In fact, by reducing the flow of liquid through the pipe **60**, by means of the valve **61**, a sudden increase of the pressure in the cylinder **35**, at the moment the die-cavity is completely filled, can be produced, although this increased pressure can be kept at a value, which is below that of the static pressure. As a result of this reduction of the flow through the pipe **60** the time required for filling the reservoir **59** will be longer, so that more time will elapse before the pressure reaches its static value. In this manner it is possible to modify the duration of the shock-absorption, by simply operating the valve **61** in order to enable this duration to be adapted to the variations of the time required for the solidification of the castings, this time depending on the shape and volume of the castings. When the cycle of operations of the machine is terminated, i. e. the moment the position of the valve **12** is changed, the higher pressure in the reservoir **59** causes the valve **68** to be opened and at the same time it causes the non-return valve **62** to be closed. Consequently the liquid contained in the reservoir **59** can flow through the pipes **67**, **11** and **14**. The valve **68** is adjusted in such a manner as to be closed automatically as soon as the pressure in the reservoir **59** sinks to a predetermined value. As soon as the valve **68** is closed a new cycle of injection operations can be commenced.

It will be understood that the invention is not limited to the embodiments described and shown in the accompanying drawings but that modifications may be made without departing from the scope of the invention as set out in the appendant claims. For example, it is not limited to the horizontal type pressure die-casting machine shown, but with suitable modifications it can be applied to other types, for example vertical hot- and cold chamber die-casting machines. Machines equipped with shock-absorbing devices according to the invention show improved results when they are provided with means for the removal or exhausting of air and gases from the die-cavity.

What I claim is:

1. A die-casting machine comprising a die, an injection sleeve connected to said die, means for delivering molten metal to said sleeve, an injection piston mounted to reciprocate in said sleeve, a hydraulic system, a cylinder connected to said hydraulic system, a control piston mounted to reciprocate in said cylinder, said control

piston being connected to said injection piston, means for delivering hydraulic flud under pressure from said hydraulic system into said cylinder, and a damping device for absorbing the kinetic energy of the hydraulic fluid simultaneously with the filling of the die with molten metal.

2. A die-casting machine as defined in claim 1 in which the damping device comprises an elastic element which is held under a normal tension substantially equal to the force applied to the injection piston during the filling of the die with molten metal.

3. A die-casting machine as defined in claim 2 in which said damping device includes a reservoir containing a compressed gas.

4. A die-casting machine as defined in claim 3 wherein said damping device further includes a conduit connecting said cylinder with said reservoir and a valve in said conduit.

5. A die-casting machine as defined in claim 4 in which said valve automatically permits fluid to flow from said cylinder into said reservoir but prevents fluid from leaving said reservoir, and further including a second conduit forming a bypass to said valve and a second valve controlling said second conduit, said second valve being spring controlled.

6. A die-casting machine as defined in claim 3 wherein one end of said reservoir is connected to said hydraulic system, and wherein said damping device further includes a free piston mounted to reciprocate in said reservoir between said compressed gas and the end of said reservoir which is connected to said hydraulic system.

7. A die-casting machine as defined in claim 2 in which said elastic element comprises a spring and a free piston mounted in a chamber hydraulically connected to said cylinder.

8. A die-casting machine as defined in claim 2 in which said damping device forms a part of the connection between said control piston and said injection piston.

9. A die-casting machine as defined in claim 8 in which said control piston has a cylindrical cavity therein and said elastic element is positioned in said cavity.

10. A die-casting machine as defined in claim 9 comprising an adjustable stop member connected to said control piston and adapted to adjust the tension on said elastic element.

11. A die-casting machine as defined in claim 9 in which the injection piston is provided with a cylindrical cavity and a second elastic element is positioned within said cavity in said injection piston.

12. A die-casting machine as defined in claim 11 comprising a cylindrical cavity connected to the cavity of said die and an elastic element positioned in said last named cylindrical cavity.

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