United States Patent

Miura et al.

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[54] APPARATUS FOR DIE CASTING FERROUS METALS

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[52] **U.S. Cl.** **164/312,** 164/314, 164/4, 164/136, 164/113, 266/43

[51] **Int. Cl.** **B22d 17/04**

[58] **Field of Search** 164/312, 314, 113, 303

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Assistant Examiner—V. K. Rising
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[57] **ABSTRACT**

In a die casting machine for injection moulding metals of high melting points into a metal mold by means of an injection cylinder connected to the metal mold at one end and a plunger inserted into the injection cylinder from the opposite end, the injection cylinder comprises an outer cylindrical sleeve of high heat conductivity and is provided with a molten metal pouring opening near said opposite end and an inner cylindrical lining removably fitted in the outer sleeve, the inner lining including a plurality of sections of short axial length which are clamped together into the cylindrical lining, one of the sections positioned at the opposite end being provided with a molten metal pouring opening aligned with that of the outer sleeve.

1 Claim, 8 Drawing Figures

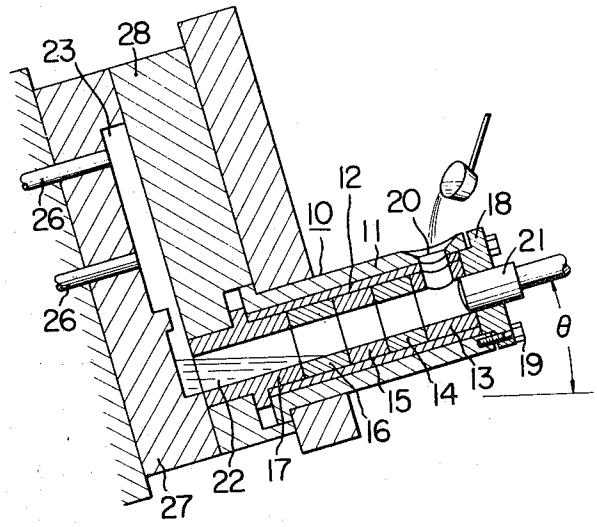


FIG. 2

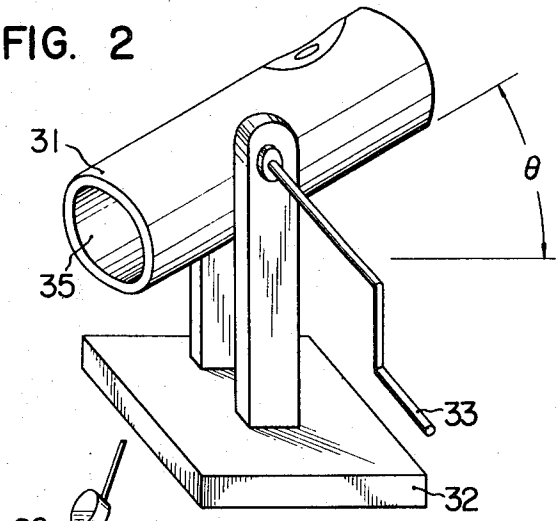


FIG. 1

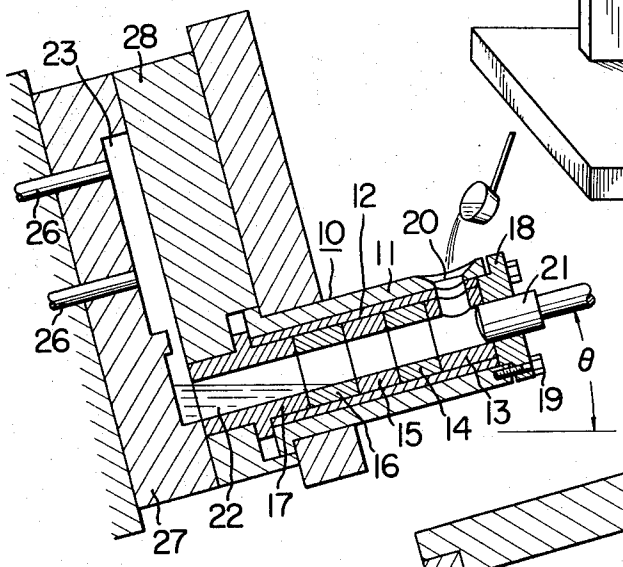


FIG. 3

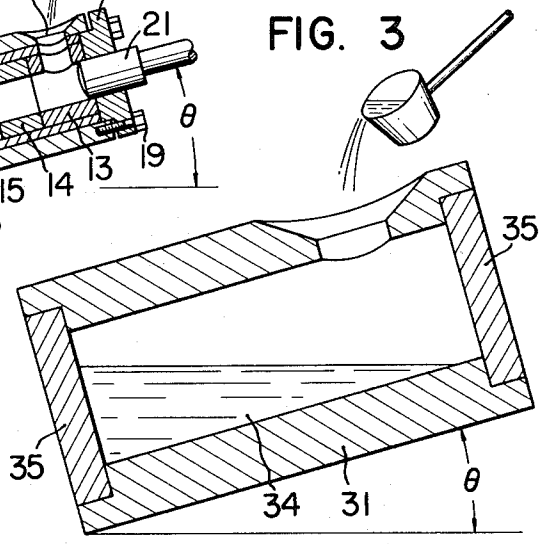
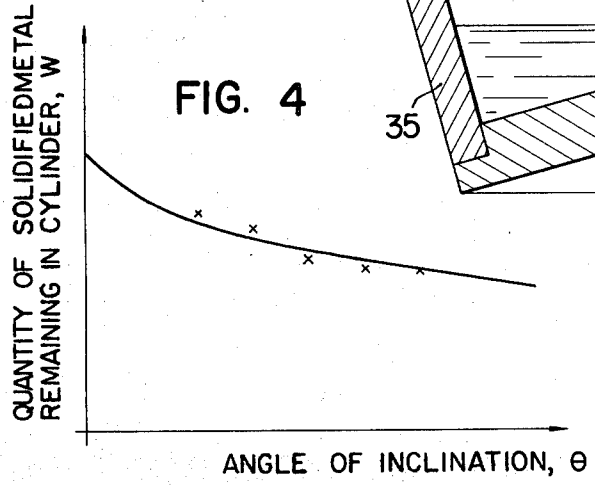


FIG. 4



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FIG. 5

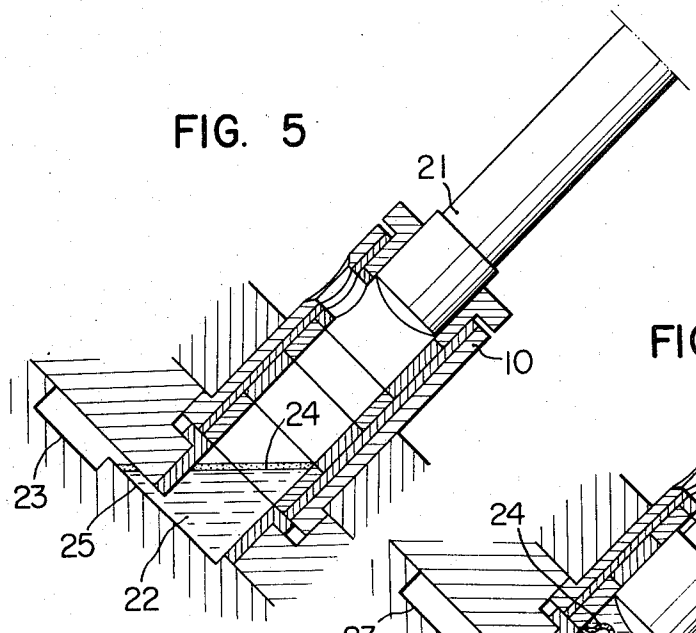


FIG. 6

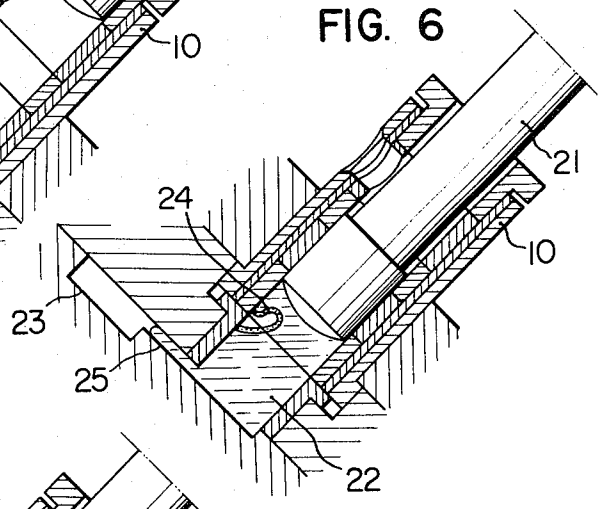


FIG. 7

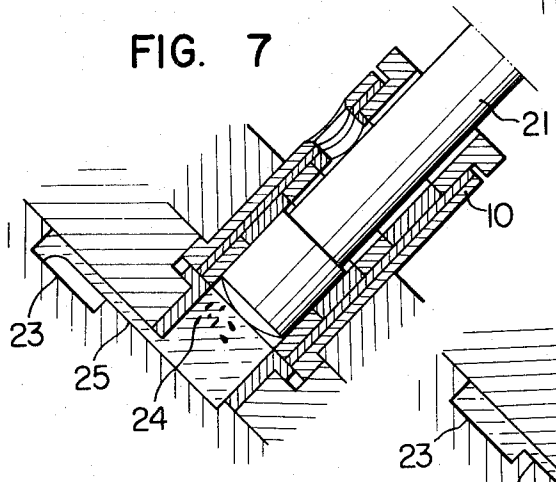
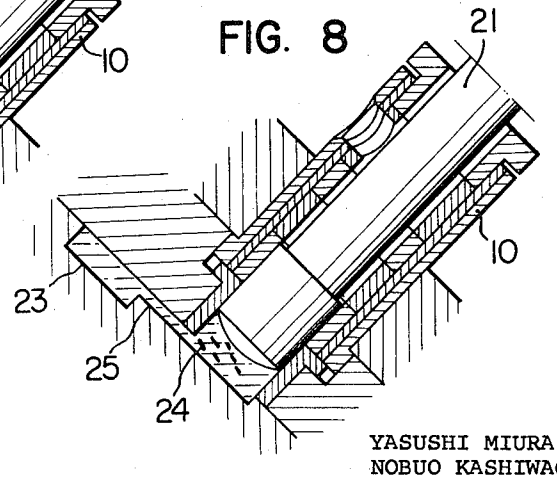


FIG. 8



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APPARATUS FOR DIE CASTING FERROUS METALS

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for die casting ferrous metals such as cast iron and steel.

When a high pressure die casting or injection moulding machine designed for die casting metals of low melting points such as aluminum, zinc or their alloys is used for ferrous metals having higher melting points, there arise a number of problems. More particularly, the conventional high pressure die casting machine for low melting point metals usually comprises a horizontal injection cylinder and a plunger or a piston movable therein. The cylinder is provided with an opening for receiving molten metal at one end thereof remote from a metal mould, and the plunger is operated to inject the molten metal into the metal mould under high pressure. Where the molten metal poured into the cylinder has a high melting point, the inner surface of the cylinder immediately beneath the opening becomes damaged due to heat shock of the molten metal poured into the cylinder. As above described, since the cylinder is horizontal, the distance in the cylinder over which the molten metal is driven by the plunger is relatively long, and the contact area between the molten metal and the plunger is wide. As a consequence, there is a tendency of forming a solidfied layer thus requiring higher injection pressure. This also causes deformation of the plunger cylinder, and die members.

Further, where a horizontal injection cylinder is used, and the molten metal partially fills the cylinder, slag floating on the upper surface of the molten metal contained in the cylinder may be entrained in the injected metal thus forming moulded products of non-uniform structure.

Another problem arises when ferrous metals are moulded by a die casting machine designed for metals of low melting point. Such metals of low melting points as aluminum, zinc or their alloys are usually injected under pressures ranging from 500 kg/cm² to 600 kg/cm². Such high pressures are advantageous for non-ferrous metals of low melting points because of their high plastic fluidity at elevated temperatures, thus decreasing blowholes and increasing the density and mechanical strength of moulded products.

However, in the case of ferrous metals, especially cast iron, plastic fluidity is very small so that the deformation coefficient before breakage is only 1/2000 of that of aluminum. On the other hand, ferrous metals are readily chilled to provide dense structures. Thus ferrous metals have physical characteristics quite different from those of non-ferrous metals. For this reason, high injection pressures adequate for non-ferrous metal can not be used for injection moulding ferrous metals. Rather such high pressures hasten damage of metal moulds, and thus require bulky and rigid construction of the injection moulding machines.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide an improved die casting machine wherein damaged portions of the injection cylinder can be readily replaced.

Another object of this invention is to provide a novel die casting machine by which blowholes or non-uniform structure of moulded products can be eliminated.

A further object of this invention is to provide a method of die casting ferrous metals under low pressures.

According to one aspect of this invention, an injection cylinder of a die casting machine is lined with a plurality of sections or sleeves of short axial length which are fitted in an outer sleeve of high heat conductivity. With this construction it is possible to replace damaged sections alone without replacing the entire cylinder.

According to another aspect of this invention, in order to prevent entrainment of slag and air bubbles, the injection cylinder is positioned at an angle to the horizontal.

According to still another aspect of this invention ferrous metals are die cast under low pressures, of the order of from 25 to 100 kg/cm².

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings

FIG. 1 shows a diagrammatic sectional view of a die casting machine constructed according to this invention;

FIG. 2 is a perspective view of an experimental device for measuring the heat insulating effect of molten metal;

FIG. 3 is a longitudinal sectional view of a cylindrical container shown in FIG. 2;

FIG. 4 is a plot of a heat insulating characteristic of the experimental device shown in FIGS. 3 and 4; and

FIG. 5 to 8 show successive steps of die casting utilizing an inclined injection cylinder.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 of the accompanying drawing, an injection cylinder **10** of a die casting machine comprises an outer cylinder **11**, a sleeve **12** of a metal of high thermal conductivity, such as copper, a lining consisting of a plurality of sleeves or sections **13**, **14**, **15**, **16** and **17** removably fitted in the copper sleeve **12**, said sleeves having split a short axial length and being clamped together by means of a clamping ring **18** and bolts **19**. As shown, the injection cylinder **10** is disposed at an angle θ with respect to the horizontal. A pouring opening **20** is formed near the outer end of the injection cylinder to pour molten ferrous metal **22** into a space defined by split sleeves **13** through **17**. A plunger **21** is inserted in the cylinder to inject under pressure the molten metal **22** into a mould cavity **23** connected to the inner end of the injection cylinder, said cavity being defined by a movable die member **27** and a stationary die member **28**.

In the injection cylinder, the inner surface thereof immediately beneath the pouring opening **20**, in this embodiment the inner surface of the sleeve **13** is damaged most severely by the heat shock of the poured molten metal. The novel construction, however, permits easy renewal of such heavily damaged sleeve without the necessity of replacing the entire injection cylinder. Moreover, as the copper sleeve **12** enhances dissipation of heat both in the radial and axial directions, the temperature differentials between adjacent sleeves **13** through **17** are reduced thus alleviating damages caused by heat shock imparted to sleeves remote from the pouring opening **20**. This means that, except for the sleeve **13** including the pouring opening **20**, frequent renewal of other sleeves can be avoided. It was found that sleeves made of a molybdenum alloy and subjected to a special treatment could be used more than 1,000 times. Further, materials having excellent heat shock proof characteristics but which heretofore could not be used because of their brittleness, can be utilized, since according to this invention, sleeves **13** to **17** have short axial lengths and are covered by sleeve **12**, propagation of cracks is effectively prevented. In the conventional die casting machine the inner end of the plunger **21** is made flat. However, as the peripheral portion of the inner end of the plunger is subjected to extraordinary high thermal stress due to contact thereof with the molten metal and hence is deformed or creates a heat check. Accordingly, the gap between the inner wall of the injection cylinder and the plunger tends to increase with the result that a portion of the molten metal enters into the gap to interfere with the smooth movement of the plunger. However, by forming the inner end of the plunger to have a spherical configuration as shown in FIG. 1, the angle of the peripheral portion of the inner end becomes an obtuse angle thus minimizing abnormal thermal stress.

Another feature of this feature of this invention lies in the inclined disposition of the injection cylinder **10**. With the horizontal injection cylinder, the distance over which the molten metal is moved axially of the cylinder is large so that the molten metal forms a solidified layer in a short time which causes damage to the inner wall of the injection cylinder and the inner end of the plunger, thus decreasing their operating life. Moreover, where the molten metal partially fills the injection cylinder, slag and air above the surface of the molten metal are entrained in the moulded article to form blowholes,

cracks and non-uniform structure. However, with the inclined injection cylinder, the distance of movement of the molten metal in the injection cylinder is decreasing thus decreased, the above described difficulty. Moreover, the risk of entraining slag and gas can also be decreased, thus producing a product of uniform quality. Theoretically, as the ratio of the volume to the contact surface of the molten metal increases, thermal insulation of the molten metal is increased thus improving moldability thereof.

FIGS. **2** and **3** illustrate an experimental device for measuring the heat insulating effect of molten metal. The device shown in FIGS. **2** and **3** comprises a cylindrical container **31** for molten metal. The cylindrical container **31** corresponds to the injection cylinder **10** shown in FIG. **1** and is tiltably supported on a base **32**, the angle of inclination θ with respect to the horizontal being adjustable by means of a handle **33** attached to the container. As the angle of inclination θ is varied, the contact area between the molten metal **34** and the container **31** is varied. More particularly, as the angle of inclination θ is increased, the contact area is decreased. Thus, after selecting a predetermined angle θ , molten metal **34** of a predetermined quantity and at a predetermined temperature was poured into the container and after a predetumined time interval, one of the end covers **35** is removed to measure the quantity W of solidified metal remaining in the cylinder. The result showed that as the quantity of the molten metal increases, the degree of temperature drop of the molten metal decreases. Thus, the heat insulation effect is increased with an increase in the angle of inclination θ , a curve shown in FIG. **4** shows a heat insulating characteristic of the molten metal of the experimental device shown in FIGS. **2** and **3**. From this curve it will be clear that an inclined injection cylinder is more advantageous than a horizontal one.

The result of experiment shows that the angle of is preferably in a range of from 5° to 45°. Above 45°, prior to the actuation of the plunger **21**, a quantity of the molten metal **22** enters into the mould cavity thus disenabling the production of moulded articles of excellent quality. In order to prevent this difficulty, it is necessary to use an injection mechanism of more complicated construction. Moreover as the contact area between the molten metal in the injection cylinder and the plunger and cylinder **10** increases, cooling of the molten metal is enhanced and the operating life of the injection mechanism is decreased. In addition an excessively large angle of inclination requires higher injection pressure.

As shown in FIG. **1**, with an inclined injection cylinder, before commencing the moulding operation, the inner end of the plunger **21** is separated from a pool of molten metal **22** in the cylinder **10**, so that cooling of the molten metal can be reduced. Moreover, as the contact area between the molten metal and the injection cylinder is reduced, heat dissipation of the molten metal can also be reduced.

As described before, with a horizontal injection cylinder, contaminants or slag such as oxides of metal and non-metal or gas are entrained in the stream of the molten metal with the result that the mechanical strength and density of the moulded products are impaired. More particularly, during injection when the plunger is advanced at a high speed, the molten metal in front of the plunger is vigorously stirred to entrain said containants in the stream of the molten metal injected into the cavity of a mould.

FIGS. **5** through **8** illustrate the advantage of the inclined injection cylinder **10**. In the condition shown in FIG. **5**, a portion of the molten metal is already in a gate **25**, but the major portion of the molten metal **22** is contained in the injection cylinder and the slag **24** is floating thereon. Consequantly, as the plunger **21** is advanced at a high speed, while the slag is broken up into small pieces and admixed with the molten metal, it is retained in the injection cylinder until the cavity **23** of the mould is completed filled. In this manner, the quality of the moulded product can be improved.

Another feature of this invention lies in the method of die casting metals of high melting points, especially ferrous metals. Non-ferrous metals such as aluminum, zinc or their alloys are die cast under a relatively high pressure of the order of about 500 to 600 kg/cm² (7,000 to 8,500 lbs/in²). As such non-ferrous metals have high plastic fluidity at elevated temperatures, such high pressures are effective to improve the mechanical strength of the moulded products owing to the decrease in blowholes and increase in the density. However, as mentioned before, the plastic fluidity of ferrous metals, especially cast iron is very small and as they are chilled very easily, it is necessary to provide high strength by annealing. Due to these basic differences, it is not possible to inject ferrous metals under high pressures comparable with those for non-ferrous metals. We have found that the pressure for die casting ferrous metal, particularly cast iron can be reduced to about 25 to 100 kg/cm² (355 lbs/in² to 1,500 lbs/in²) which is only sufficient to fill the molten metal in the mould cavity and to prevent drawing, the range of injection pressure being determined according to the volume or surface area of the mould Thus, the quantity of molten metal to be moulded and the injection speed thereof increase with the volume of the mould and the time required for the molten metal to solidify increases. For this reason, the injection pressure can be decreased to about 1/10 to 1/20 of that required for die casting non-ferrous metals. It was found that products having complicated configurations such as gears, cast under an injection pressure of 45 kg/cm² had smooth surfaces and all corners were completely filled. Whereas in products cast under a pressure of less than 20 kg/cm² surface, rumples and incomplete filling at corner portions were noted.

Where an injection pressure of more than 200 kg/cm² was used, after several casting operations molten metal leaked through the gap between the stationary die **28** (see FIG. **1**) and the injection cylinder **10**, thus greatly deforming cast products.

Thus, in die casting ferrous metals in metal moulds, injection pressure ranging from 25 to 100 kg/cm² prevents damage at gaps between the movable die **27** and ejection pins **26** (see FIG. **1**), the joint between the stationary die **28** and the injection cylinder **10** and the joint between a core (not shown) and the base of a metal mould can be prevented so that the operating life of the metal mould is elongated and fins on the moulded products are reduced, thus enabling the manufacture of die cast articles at a low cost.

We claim:

1. In a die casting machine for metals of high melting points comprising a metal mold, an injection cylinder connected to said metal mold at one end, and a plunger inserted into said injection cylinder through the opposite end thereof to inject under pressure molten metal into said mold, the improvement wherein said injection cylinder is inclined with respect to the horizontal such that said opposite end is maintained at a higher level than said one end of said injection cylinder, and said injection cylinder comprises an outer cylindrical sleeve of high heat conductivity and is provided with a molten metal pouring opening through said sleeve near said opposite end and an inner cylindrical lining removably fitted in said outer sleeve, said inner lining including a plurality of cylindrical sections of short axial length which are clamped together within said cylindrical inner lining, one of said sections positioned at said opposite end being provided with a molten metal pouring opening aligned with said pouring opening of said outer sleeve.

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