# United States Patent [19]

**Nakamura et al.**

[11] **3,880,055**

[45] **Apr. 29, 1975**


[54] **INJECTION PUMP FOR USE IN HOT CHAMBER TYPE DIE CAST MACHINES**


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[73] Assignee: **Toshiba Kikai Kabushiki Kaisha,** Tokyo, Japan



[22] Filed: **Dec. 3, 1973**

[21] Appl. No.: **421,284**

[30] **Foreign Application Priority Data**

May 24, 1973 Japan ................................ 48-57202

[52] **U.S. Cl.** .................................... **92/170;** 417/489

[51] **Int. Cl.** ............................................ **F04b 39/12**

[58] **Field of Search** ...... 92/169, 170; 417/489, 490, 417/437



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[57] **ABSTRACT**

In an injection pump for use in a hot chamber type die cast machine wherein the cylinder and the stationary ring surrounding the cylinder of the pump are made of materials having different coefficient of thermal expansion, there are provided a plurality of contact surfaces which permit relative movement of the cylinder and the stationary ring. The extensions of the contact surfaces intersect each other at or near a neutral point of thermal expansion of the cylinder.

**5 Claims, 10 Drawing Figures**

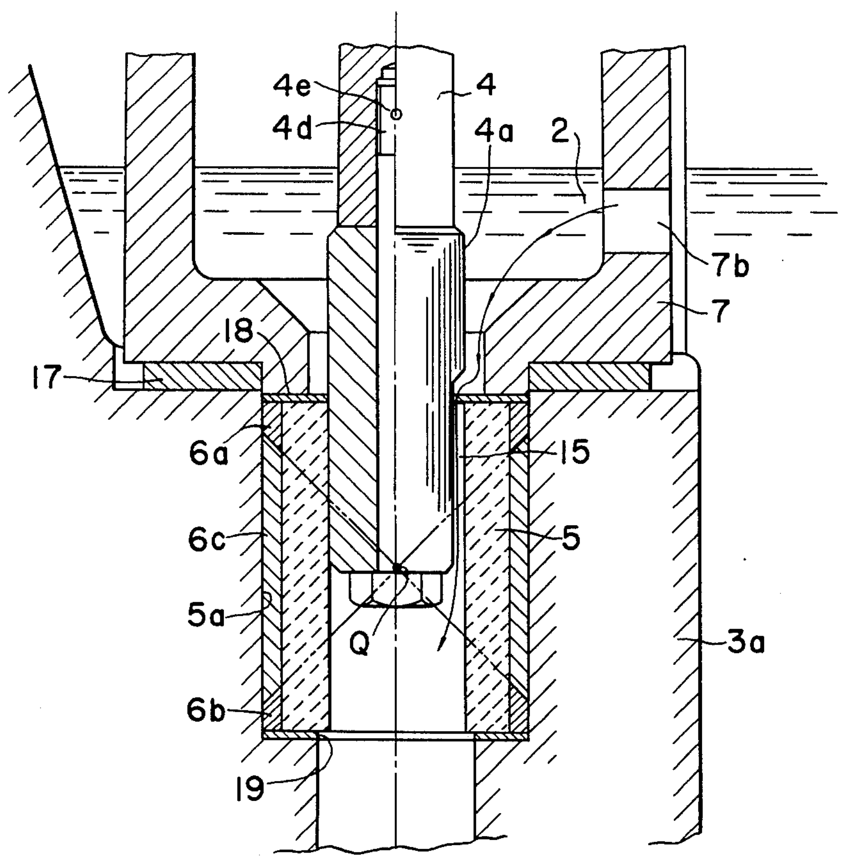
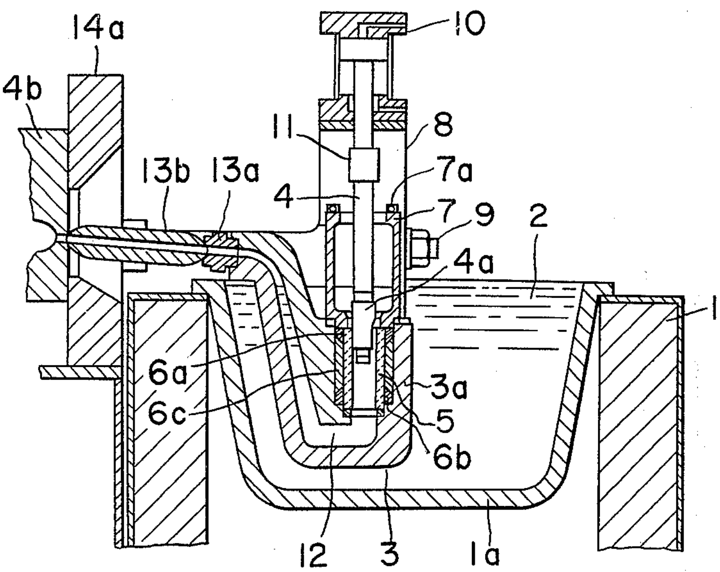



FIG. 1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14b
13b
13a
10
11
8
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2
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6a
3a
6c
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6b
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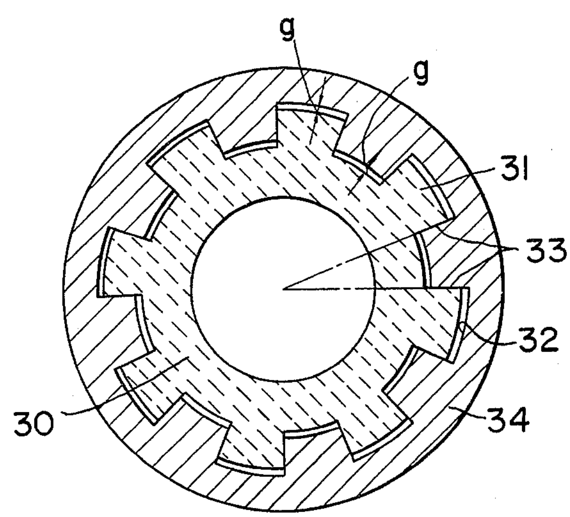
1a

FIG. 7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g
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32
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FIG. 2

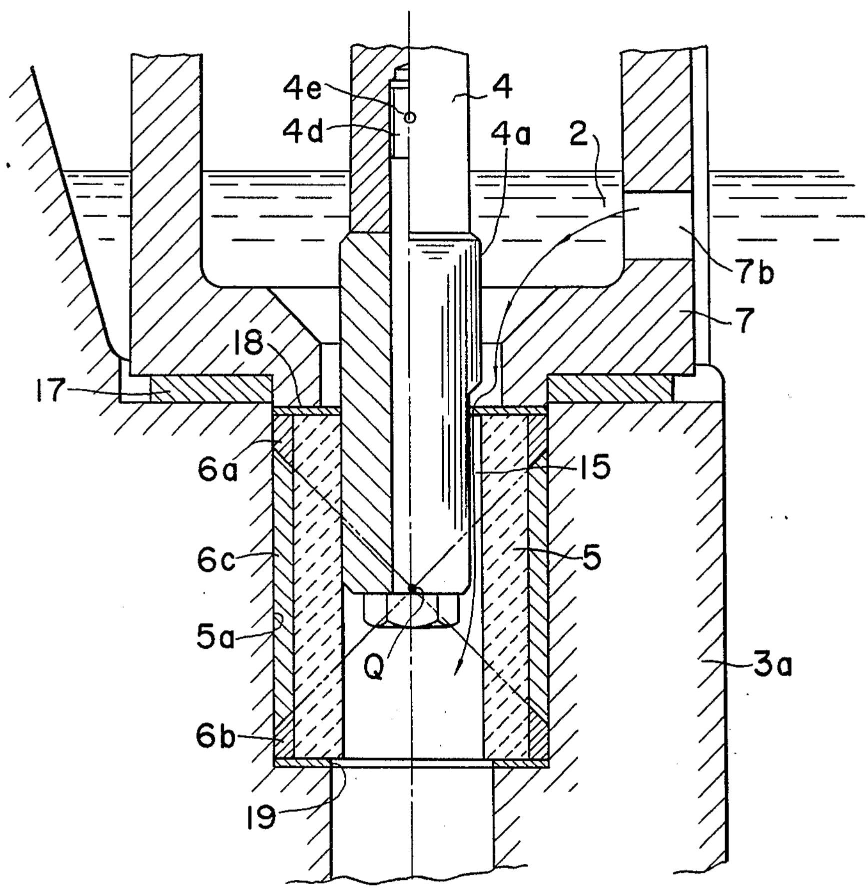


FIG. 3A

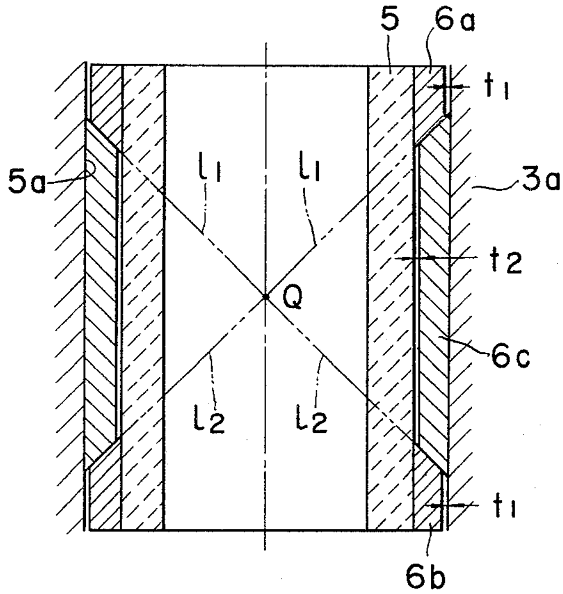



FIG. 3B

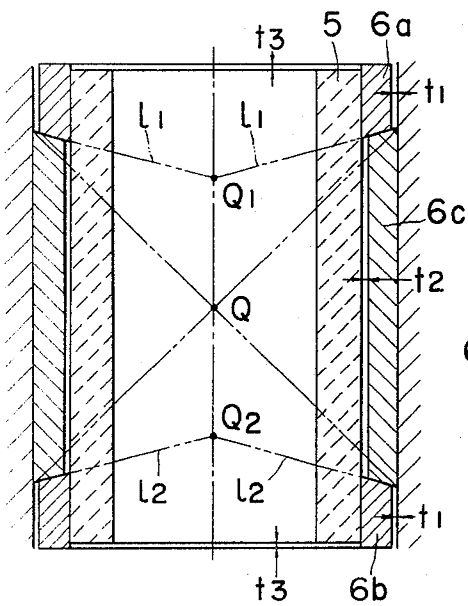



FIG. 3C

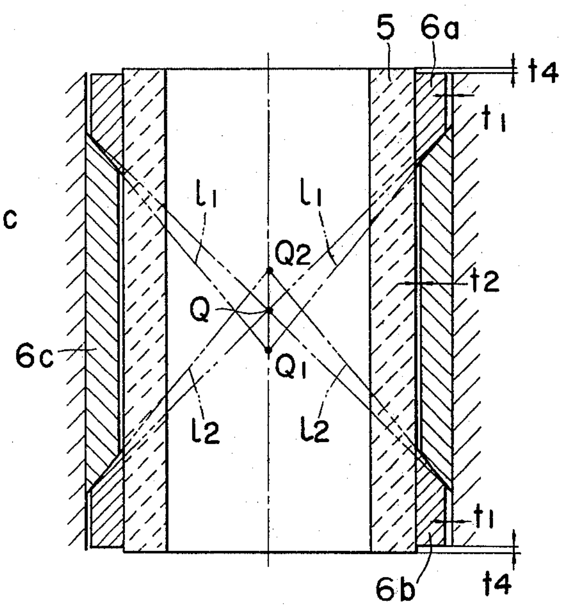


FIG. 4A

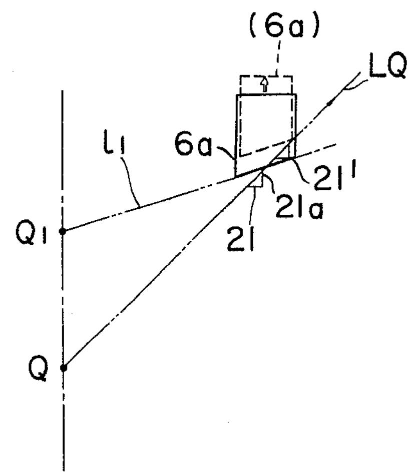



FIG. 4B

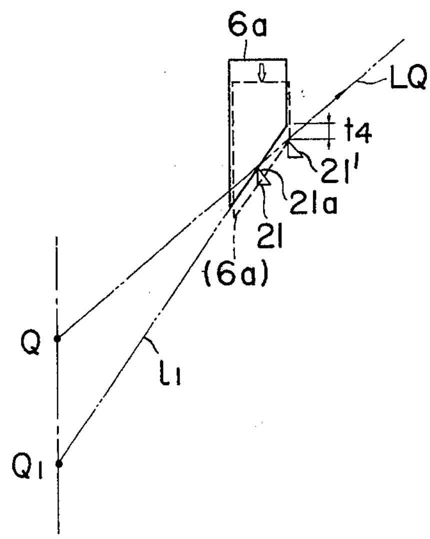


FIG. 5

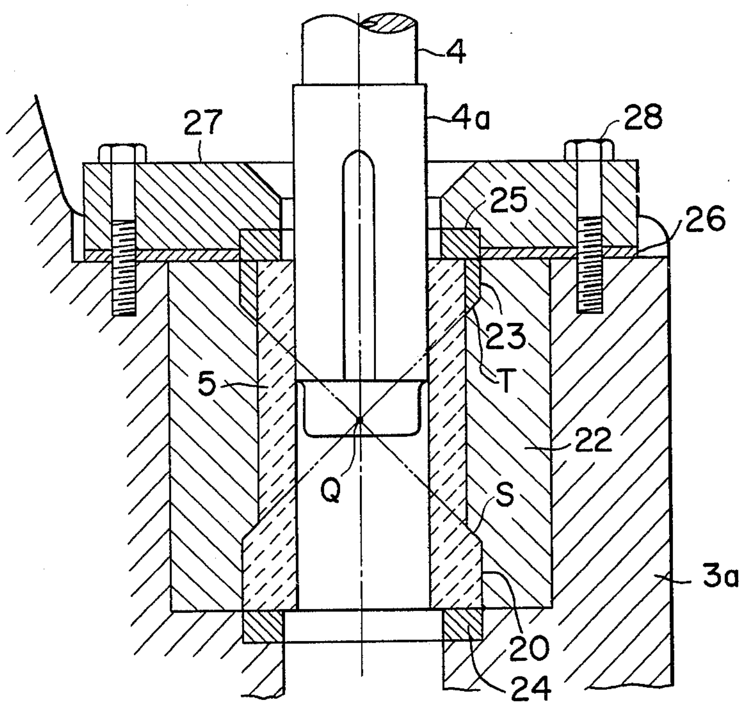
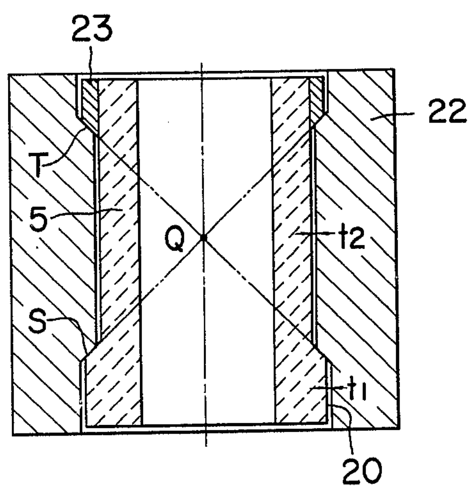



FIG. 6



# INJECTION PUMP FOR USE IN HOT CHAMBER TYPE DIE CAST MACHINES

## BACKGROUND OF THE INVENTION

This invention relates to an injection pump for injecting molten metal into a metal mould of a hot chamber type die cast machine.

In the hot chamber type die cast machine a metal melting furnace is installed near the die cast machine and the molten metal from the furnace is injected under a pressure into the metal mould of the die cast machine by means of an injection pump with its lower position immersed in the molten metal.

Where molten aluminum, magnesium or alloys thereof are injected, the piston and cylinder are severely eroded by the molten metal if they are made of an ordinary heat resistant iron base alloy. In addition, the piston and cylinder must resist against wear caused by friction therebetween under high temperatures. For these reasons, it has been the practice to insert a sleeve or lining made of heat resistant and wear resistant material such as hard ceramic in the body of the injection pump which is usually made of cast iron and to accommodate the piston in the sleeve. As a result, the body of the pump has a larger coefficient of thermal expansion than that of the sleeve and this difference in the coefficient of thermal expansion causes a gap between the body of the pump and the sleeve, whereby the sleeve is caused to displace in the lateral direction. Consequently, the axes of the piston and the sleeve become eccentric, thus causing fracture and severe wear of the piston and the sleeve. For this reason, the hot chamber type die cast machine has not been used widely for aluminum, magnesium and alloys thereof.

## SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved injection pump for use in a hot chamber type die cast machine capable of maintaining the cylinder and the stationary ring or sleeve surrounding the cylinder in exact concentric relation even when they expand thermally.

Another object of this invention is to provide an improved injection pump of the type referred to above capable of preventing molten metal from reaching the contact surfaces between the cylinder and the stationary ring.

Still another object of this invention is to provide an improved injection pump capable of simplifying the construction and reducing the cost of manufacturing the pump.

According to this invention these and further objects can be accomplished by providing an injection pump for use in a hot chamber type die cast machine wherein the cylinder of the pump and the stationary ring surrounding the cylinder are made of materials having different coefficient of thermal expansion, characterized in that there are provided a plurality of contact surfaces which permit relative movement of the cylinder and the stationary ring, and that the extensions of the contact surfaces intersect each other at or near a neutral point of thermal expansion of the cylinder.

According to one embodiment of this invention, the upper and lower guide rings are positioned above and below the stationary ring to surround the cylinder and the inclined contact surfaces are formed between the stationary ring and the guide rings.



According to a modified embodiment, one of the guide rings is substituted by a radial flange provided for the cylinder on the outer surface at one end thereof. The flange is formed with an inclined surface that cooperates with a corresponding inclined surface of the stationary ring thus forming said contact surface.

According to still further modification of this invention, the cylinder is provided with a plurality of radial projections and the stationary ring is provided with a plurality of dove-tail shaped grooves for accommodating the radial projections and the extensions of the contact surfaces between the projections and the groove intersect each other at or near the axis of the cylinder which includes the neutral point.

In any embodiment, since the extensions of the contact surfaces that permit relative movement of the cylinder and the stationary ring intersect each other at or near a neutral point of thermal expansion of the cylinder, when the cylinder and stationary ring undergo thermal expansion, the cylinder and the stationary ring are maintained always in an exact concentric relation notwithstanding the fact that they are made of materials with different coefficients of thermal expansion whereby the defects described above can be obviated. Moreover as the end surface of the guide ring or the stationary ring can be maintained in flush with the end surface of the cylinder it is possible to prevent the molten metal from reaching the contact surfaces.

This construction also simplifies construction of the pump and reduces its cost of manufacturing.

## BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages of the invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a sectional view of the injection pump embodying the invention;

FIG. **2** is an enlarged partial sectional view of the cylinder, piston and associated parts of the pump shown in FIG. **1**;

FIGS **3***a*–3c show sectional views of various designs wherein the guide rings and the stationary ring engage with each other at different inclination angles;

FIGS **4**A and **4**B shows diagrams useful to explain the operations of the designs shown in FIGS. **3***b* and **3***c;*

FIG. **5** is a sectional view of a modified cylinder;

FIG. **6** is a sectional view of the cylinder and the stationary ring shown in FIG. **5** to show thermal deformations thereof and

FIG. **7** is a cross-sectional view of another modification of the cylinder and the stationary ring.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. **1** of the accompanying drawings, a metal melting furnace **1***a* containing molten metal **2** is mounted on a pedestal **1** and an injection pump **3** embodying the invention is immersed in the molten metal **2.** Pump **3** is supported by a frame **8** extending above the furnace and secured to a stationary member **14***a* of a die cast machine by means of bolts **9.**

A cylinder **5** is disposed in the body **3***a* of the pump which is immersed in the molten metal for receiving a piston or plunger **4***a* secured to the lower end of a piston rod **4** which is connected via a coupling **11** to a piston-cylinder assembly **10** secured to the upper portion of the frame **8**.

Between the outer surface of cylinder **5** and the inner surface of a cylinder bore **5*a*** are disposed two pairs of upper and lower guide rings **6*a*** and **6*b*** and an intermediate stationary ring **6*c***, as best shown in FIG. **2.** In order to prevent the molten metal from contacting upper and lower guide rings **6*a*** and **6*b***, and stationary ring **6*c*** resilient sealing members **18** and **19** are urged against the upper surface of the upper guide ring **6*a*** and the lower surface of the lower guide ring **6*b*** by means of a cylindrical clamping member **7** with its upper end secured to frame **8** by means of bolts **7*a***.

A pressurizing chamber **12** for the molten metal **2** is formed in the body **3*a*** of the pump to extend between the lower portion of the cylinder **5** and the left upper portion of the body. A hollow coupling memmber **13*a*** is secured to the left upper end of the pressurizing chamber **12** to connect it with one end of a nozzle **13*b*** having spherical surfaces on the opposite ends thereof, the opposite end of the nozzle **13*b*** being in engagement with a metal mould **14*b*** of the die cast machine. When the frame **8** is secured to stationary member **14*a*** by tightening bolts **9** the opposite ends of the nozzle **13*b*** are tightly clamped between the mould **14*b*** and the coupling member **13*a*** thus preventing leakage of the molten metal **2.**

As shown in FIG. **2,** piston **4*a*** is secured to the lower end of piston rod **4** by means of a bolt **4*d*** extending through the piston **4*a***. The upper end of bolt **4*d*** is connected to the lower end of piston rod **4** by means of a transverse pin **4*e*** to prevent relative rotation of piston **4*a*** and piston rod **4.** Equally spaced apart grooves **15** extending from the bottom of piston **4*a*** to an intermediate point thereof are formed in the outer peripheral surface of piston **4*a***. Accordingly, when the piston **4*a*** is moved upwardly by the piston-cylinder assembly **10,** the molten metal **2** is permitted to flow into the pressurizing chamber **12** through the grooves **15** as shown by an arrow. An opening **7*b*** is formed to extend through the side walls of the cylindrical clamping member **7** for permitting the molten metal to flow into the grooves **15** from outside.

Cylinder **5** is made of a material having high resistance to wear and heat shock and a relatively small coefficient of thermal expansion, ceramic for example, whereas guide rings **6*a*** and **6*b*** are made of a material having substantially the same coefficient of thermal expansion as cylinder **5**, for example tungsten and molybdenum. The stationary ring **6*c*** is made of a material having substantially the same coefficient of thermal expansion as the body **3*a*** of the pump, said coefficient of thermal expansion being larger than that of the cylinder **5** and guide rings **6*a*** and **6*b***.

Contacting surfaces between the upper and lower guide rings **6*a*** and **6*b*** and the stationary ring **6*c*** are inclined with respect to the horizontal. Extensions (shown by dot and dash lines) of these inclined contact surfaces intersect at point Q on the axes of the piston and cylinder, the point Q being the neutral or reference point of thermal expansion of the cylinder **5**; that is, the point at which lines passing through the initial and final points of any point of the cylinder **5** intersect when said any point displaces due to thermal expansion when the cylinder **5** is heated to bring off its points to the same temperature. So long as the apices of two cones defined by the extensions of the inclined contact surfaces are located near the reference point Q, the inclination angles of the upper and lower contact surfaces will not necessarily be equal.

A resilient sealing ring **17** is interposed between the upper surface of the body **3*a*** of the pump and the lower surface of the cylindrical clamping member **7** for preventing the molten metal from flowing into the gap between the body **3*a*** and upper and lower guide rings **6*a*** and **6*b*** and the stationary ring **6*c***.

FIGS. **3*a*, 3*b*** and **3*c*** are diagrams to explain the reason that the upper and lower end surfaces of the cylinder **5** and the upper and lower guide rings **6*a*** and **6*b*** become out of alignment due to the difference in the thermal expansion of the cylinder **5**, guide rings **6*a*** and **6*b*** and stationary ring **6*c***.

According to the design shown in FIG. **3*a*,** the apex of the cone defined by the extension of the contact surface between upper guide ring **6*a*** and the stationary ring **6*c*** and that of the cone defined by the extension of the contact surface between lower guide ring **6*b*** and the stationary guide ring **6*c*** substantially coincide with each other and these apices are located at or close to the neutral point Q of the cylinder **5** so that due to thermal expansion a gap $t_2$ will be formed between the inner surface of the stationary ring **6*c*** and the outer surface of cylinder **5** and gaps $t_1$ will be formed between the outer surfaces of guide rings **6*a*** and **6*b*** and the inner surface of the cylinder bore **5*a***. The extensions of the contact surfaces between stationary ring **6*c*** and guide rings **6*a*** and **6*b*** intersect at or near the neutral point Q. Since cylinder **5** and guide rings **6*a*** and **6*b*** are made of materials having substantially the same coefficient of thermal expansion the upper and lower contact surfaces of the stationary ring **6*c*** tend to expand outwardly along lines $l_1$ and $l_2$ shown in FIG. 3A. As a result, the end surfaces of the cylinder **5** and guide rings **6*a*** and **6*b*** always lie in the same horizontal planes even when they undergo thermal expansion.

In the design shown in FIG. 3B, the inclination angles of the contact surfaces are made smaller than those of the design shown in FIG. 3A. Thus the apices $Q_1$ and $Q_2$ of respective cones are displaced upwardly and lowerwardly from the neutral point Q. Consequently, upon thermal expansion the end surfaces of guide rings **6*a*** and **6*b*** project by $t_3$ beyond the end surface of the cylinder **5.**

In the design shown in FIG. **3*c*,** the inclination angles of the contact surfaces are made larger than those of the design shown in FIG. 3A so that the apices $Q_1$ and $Q_2$ of the cones are displaced downwardly and upwardly from the neutral point Q, and the end surfaces of the guide rings **6*a*** and **6*b*** terminate at horizontal planes shorter than the end surface of the cylinder **5** by $t_4$. However, it should be understood that distance $t_4$ is not caused by thermal expansion as distance $t_3$ but caused by the movement of guide rings **6*a*** and **6*b*** to fill the gaps formed between the contact surfaces of the stationary ring **6*c*** and guide rings **6*a*** and **6*b*** as will be described later in more detail.

FIGS. 4A and 4B correspond to FIGS. 3B and 3C respectively and show the relative positions of the guide ring **6*a*** and the stationary ring **6*c*** when they undergo thermal expansion. Thus, FIG. 4A shows a case wherein the inclination of the contact surface is small and in which the stationary ring **6*c*** in contact with the guide ring **6*a*** is shown as a triangle **21.** It is assumed that the apex **21*a*** of the triangle **21** is in contact with the lower surface of the guide ring *6a* and a line interconnecting the apex **21***a* and the reference or neutral point Q is designated by $L_Q$. To simplify the description it is assumed now that the thermal expansion of the guide ring *6a* is zero. Then, when the stationary ring *6c* undergoes thermal expansion, the triangle **21** moves toward right upper along line $L_Q$ with the result that the contact surface of the guide ring *6a* is pushed upwardly as shown by dotted lines.

Where the inclination angle of the contact surface is large as shown by FIG. 4B, the triangle will be shown by **21'** and its apex will move toward right upper along line $L_Q$ thereby forming a gap $t_4$ between the lower surface of guide ring **6***a* and the apex of triangle **21'**.

The invention described above has the following advantages.

1. Upon thermal expansion, although gaps $t_1$ and $t_2$ are formed as shown in FIG. 3A, the guide rings *6a* and *6b* do not move relative to cylinder **5** so that the end surfaces of the guide rings *6a* and *6b* are maintained always in the same horizontal plane as the end surface of the cylinder **5** with the result that the molten metal does not enter through the resilient sealing member.

2. The invention simplifies the configuration of the component parts and allows for component parts other than the cylinder with materials having higher workability than ceramics. For example, guide ring *6a* and *6b* may be made of tungsten or molybdenum. As a result, it is possible to use simple machine tools and cheap materials, thus decreasing the cost of manufacturing of the injection pump.

3. When the configuration of the cylinder, which is most expensive to manufacture, becomes complex, its cost of manufacturing increases greatly. For this reason, although many attempts have been made in the past to solve the same problem as in this invention they were proved to be unsatisfactory because of their lower utility and economy. Furthermore, the cylinder is usually made by a hot press process, so that when the cylinder is made to have a configuration other than cylindrical, it is difficult to make homogenous the hot pressed material, thus causing deformation and fracture of the cylinder during use. According to this invention, deformation of the peripheral portion of the cylinder caused by thermal expansion is prevented by designing the cylinder to have a cylindrical configuration and by obviating the adverse effect caused by the thermal displacement of the peripheral portion of the cylinder by causing the extension of the contact surfaces between the guide rings and the stationary ring to interest each other at or near the neutral point of the cylinder.

In a modification shown in FIGS. **5** and **6**, the lower guide ring of the foregoing embodiment is made integral with the cylinder. More particularly, cylinder **5** made of ceramic material is formed with an integral radial shoulder **20** about its lower end. The shoulder **20** corresponds to guide ring 6b of the previous embodiment and is formed with an upwardly inclined surface S at its upper end. The upper guide ring **23** is similar to guide ring *6a* described above and is disposed symmetrically with respect to shoulder **20.** Extentions of the inclined surfaces S and T of the shoulder **20** and guide ring **21** intersect each other at or near the neutral point Q on the axis of the cylinder. A stationary ring **22,** made of ferrous material for example, has an inside configuration closely surrounding the outer surfaces of cylinder **5,** its shoulder **20** and guide ring **23.** Resilient sealing rings **24, 25** and **26** are provided to prevent the molten metal from reaching the contact surface and are held in position by means of a clamping ring **27** and bolts **28.**

When heated, the cylinder **5** and stationary ring **22** expand in the radial and axial directions about the neutral point Q. Due to the difference in the coefficient of thermal expansion gaps $t_1$ to $t_2$ are formed between the cylinder and the stationary ring. At the same time, although contact surfaces between inclined surfaces S and T and the cooperating surfaces of the stationary ring also expand, no gap will be formed at these contact surfaces because these cooperating surfaces expand in the same direction, whereby the center axis of the cylinder will not be displaced.

In another embodiment is shown in FIG. **7**, the contact or sliding surfaces between the cylinder and the stationary ring extend in the radial direction with respect to the center axis of the cylinder. In this embodiment, cylinder **30** made of ceramic material is provided with a plurality of integral radial projections **31** each received in a dove-tail shaped axial groove **32** of stationary ring **34,** made of ferrous metal for example. The contact or sliding surfaces **33** of projections **31** and dove-tail grooves **32** extend in the radial direction.

When heated, as the coefficients of thermal expansion of the cylinder and the stationary ring are not equal, that is the thermal expansion coefficient of the cylinder is smaller than that of the stationary ring, there is a tendency of forming gaps g between the outer surface of the cylinder and the inner surface of the stationary ring. However, as the contact surfaces between these members extend in the radial direction starting from the common axis of the cylinder and the stationary ring which includes the neutral point, these members are maintained always in the concentric relation, thus preventing displacement of the axis of the cylinder.

What we claim is:

**1.** In an injection pump for use in a hot chamber type die cast machine wherein the cylinder and the stationary ring surrounding the cylinder of said pump are made of materials having different coefficients of thermal expansion, the improvement which comprises a plurality of contact surfaces which permit relative movement of said cylinder and said stationary ring, the extensions of said contact surfaces intersecting each other at or near a neutral point of expansion of said cylinder.

**2.** The injection cylinder according to claim **1** wherein said stationary ring is formed with two inclined surfaces near its upper and lower ends, the extensions of said inclined surfaces intersecting at or near the neutral point of the thermal expansion of said cylinder, said cylinder being provided with a radial flange having an inclined surface mating with one of the inclined surfaces of said contact ring, said injection cylinder further comprising a guide ring interposed between said stationary ring and said cylinder, said guide ring being provided with an inclined surface mating with the other of said inclined surfaces of said stationary ring.

**3.** The injection pump according to claim **1** wherein said cylinder is provided with a plurality of radial projections and said stationary ring is provided with a plurality of dove-tail shaped grooves for accommodating said radial projections, the extensions of the contact surfaces between said projections and said grooves intersecting each other at or near the axis of said cylinder.

**4.** The injection pump according to claim **1** which further comprises upper and lower guide rings positioned above and below said stationary ring to surround said cylinder, and wherein said contact surfaces are formed between said stationary ring and said guide rings.



**5.** The injection pump according to claim **2** wherein said stationary ring is made of a material having a coefficient of thermal expansion larger than that of the materials comprising said cylinder and said guide rings.

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