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(54) Casting process, upeer mold assembly and method of securing core to upper mold

(57) The casting process includes the steps of: preparing an upper mold assembly (20) by securing a core to an upper mold; pouring a necessary minimum amount of a molten metal for obtaining a casting in the hollow of the lower mold; moving downwardly the upper mold assembly at a predetermined first speed to a predetermined height level just before the upper mold assembly comes into contact with a surface of the molten metal in the hollow of the lower mold; further moving downwardly the upper mold assembly, from the predetermined height level, at a predetermined second speed by changing the descending speed of the upper mold assembly from the first speed to the second speed; detecting a status information of the upper mold assembly in a state when the upper mold assembly is superimposed on the lower mold, or arrived at the lower mold; and stopping the descending movement of the upper mold assembly after detecting that the status information comes at a predetermined state. The upper mold assembly is prepared by securing the core to the upper mold with a mechanical means, an adhesive, frictional engagement of a projection (24a,24b) with a recess (22a,22b) or engagement of a projection (24C) with stamped molding sand of the upper mold.

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Description

Technical background

[0001] The present invention relates to a method of producing a casting (i.e. a casting method), an upper mold assembly used in the method, and a method of securing a core to an upper mold. More particularly the present invention relates to a sand mold press-casting process wherein an upper mold is put on a lower mold to define a cavity into which a molten metal is poured to produce a casting.

[0002] According to a conventional sand mold casting process, a mold cavity for casting is defined by putting an upper mold on a lower mold, and a molten metal is poured in the cavity for production of a casting. The common casting process employs a gating system which necessarily needs flow channels of the pouring molten metal for controlling a flow of the pouring molten metal in order to obtain a high-quality casting free from inclusion of impurities and gasses, but the flow channels are irrelevant to shapes of a casting. In this sense, a yield of casting is degraded, and labor and time are required for separating additional metal pieces, e.g. risers and runners, from a casting after crushing sand molds, resulting in a decrease in productivity of casting and an increase in production costs.

[0003] In order to raise a yield of casting, a sand mold press-casting process is proposed in JP-A-2005-52871. The proposed process uses (1) a lower mold, which is prepared by a proper molding method so as to provide a cavity just for defining a profile of a casting itself without a cavity for the aforesaid gating system and (2) an upper mold, which is prepared by a proper molding method to a form with a projection for defining a mold cavity for a casting in combination with the cavity of the lower mold. According to the proposed process, an amount of a molten metal necessary for producing the casting is poured in the cavity of the lower mold, and then the upper mold is put on the lower mold in the manner that the projection of the upper mold is fitted into the poured molten metal so as to define a mold cavity necessary for a profile of the casting.

[0004] The sand mold press-casting process has the advantage that a casting with an objective profile is produced with high yield of molten metals, but can not be simply applied to a casting method using cores due to flotation of the cores. According to a conventional gating system for settling a core at a proper position in a casting mold, a recess with a shape similar to a core print of a core is generally formed as a part for receiving the core print in a lower mold, the core is placed in the receiving part and clamped between the upper and lower molds, and subsequently a molten metal is poured into the mold, as disclosed JP-A-9-57396. By virtue of the core print, the floatation of the core is inhibited regardless buoyancy caused by the poured molten metal. However, the sand mold press-casting process involves a step of putting an upper mold on a lower mold after pouring a molten metal in the lower mold. If a core is simply placed in the lower mold before pouring, the core unfavorably floats due to buoyancy of the poured molten metal, resulting in defective a profile of a casting. In sand mold press-casting process, thus, it is indispensable to prevent the core from floatation in the mold, since there will arise the floatation problem of the core when pouring the molten metal into the mold in the case where the core is simply placed in the lower mold like as the conventional casting process.

Brief summary of the invention

[0005] Taking the above problem into consideration, an object of the present invention resides in providing a new casting technique in the sand mold press-casting process with use of a core, which casting technique ensures a casting operation with a high yield while preventing occurrence of defective profiles of a cast product.

[0006] In light of the above object, according to a first aspect of the invention, there is provided a casting process with use of a lower mold having a hollow corresponding to a partial profile of a casting, and an upper mold which supports a core and defines a mold cavity in cooperation with the lower mold, wherein the casting process comprises the steps of:

preparing an upper mold assembly by securing a core to an upper mold;
pouring a necessary minimum amount of a molten metal for obtaining a casting in the hollow of the lower mold;
moving downwardly the upper mold assembly at a predetermined first speed to a predetermined height level just before the upper mold assembly comes into contact with a surface of the molten metal in the hollow of the lower mold;
further moving downwardly the upper mold assembly, from the predetermined height level, at a predetermined second speed by changing the descending speed of the upper mold assembly from the first speed to the second speed;
detecting a status information of the upper mold assembly in a state when the upper mold assembly is superimposed on the lower mold, or arrived at the lower mold; and
stopping the descending movement of the upper mold assembly after detecting that the status information comes at a predetermined state.

[0007] In the casting process of the invention, preferably the status information of the upper mold assembly is of a pressure applied from the upper mold assembly to the molten metal in the hollow and/or the lower mold, or of a total descending movement distance of the assembled upper mold.

[0008] According to a second aspect of the invention, there is provided an upper mold assembly which comprises an upper mold and a core secured to the upper mold, and which defines a mold cavity in cooperation with the lower mold.

[0009] In the upper mold assembly, the core is preferably secured to the upper mold by a mechanical means.

[0010] In the upper mold assembly, the core is preferably secured to the upper mold by an adhesive.

[0011] In the upper mold assembly, the core is preferably secured to the upper mold by a frictional fitting relationship between a projection formed on the core and a recess formed in the upper mold.

[0012] In the upper mold assembly, the core is preferably secured to the upper mold by an engagement relationship between an engaging projection formed on the core and a stamped molding sand of the upper mold.

[0013] In any of the above upper mold assemblies, a plurality of cores may be secured to the upper mold, and a plurality of hollows corresponding to the plurality of cores may be formed in the lower mold, whereby making possible to produce simultaneously a plurality of castings by a single pair of the upper and lower molds.

[0014] According to a third aspect of the invention, there is provided a method of securing a core to an upper mold with use of a frictional force,
wherein a casting mold consisting of the upper mold and a mating lower mold is used, which upper and lower molds are prepared by foundry molding, respectively, and which are superimposed on each other so as to define a mold cavity having a product profile for obtaining a casting,
wherein the core has a partial profile of the casting, and wherein the method comprises steps of:

> preparing the upper mold having a recess for securing the core therein and the core having a projection to be fitted into the recess; and press-fitting the projection of the core into the recess of the upper mold by relatively moving a core supporter for supporting the core to the upper mold such that with use of an information value of securing the core to the upper mold, the press-fitting operation is effected until the information value meets a predetermined information value of securing the core to the upper mold.

[0015] In the core securing method of the invention, preferably the core may have one or more projections, and the upper mold also may have one or more recesses for receiving the one or more projections, wherein the projections and the recesses are so formed that at least a deep region of each of the recesses has an inner diameter smaller than an outer diameter of a complementary contact part of each of the projections.

[0016] In the core securing method of the invention, provided that with use of a core model without a projection, the core supporter supporting the core model is moved relatively to the upper mold so as to bring the core model into contact with the upper mold, whereby preferably the information value of securing the core to the upper mold is a travel distance of the core supporter from an initial position when a pressure applied to the core model from the upper mold meets a predetermined information value.

[0017] According to the casting process and the upper mold assembly of the invention, since a press controlling method is employed, which method comprises: preparing the upper mold assembly by securing the core to the upper mold; pouring a necessary minimum amount of a molten metal for obtaining a casting in the hollow of the lower mold; moving downwardly the upper mold assembly to the lower mold; detecting a status information of the upper mold assembly in a state when the upper mold assembly is superimposed on the lower mold, or arrived at the lower mold; and stopping the descending movement of the upper mold assembly after detecting that the status information comes at a predetermined state, whereby the press process is completed, it is possible to shorten a time length from the pouring step to the completion of the press process to be minimum. By shortening the time length for the press process, a press process can be completed before a temperature of a molten metal poured in the mold cavity drops to occur a non-uniform temperature distribution in the molten metal, whereby it is possible to make a uniform metal structure of a casting.

[0018] Further, in the case where a pressing force or a descending distance of the upper mold assembly is detected as the status information when pressing, it is possible to prevent the upper mold assembly from overpressing the lower mold whereby realizing a stable production of a casting with a high accuracy.

[0019] According to the core securing method of the invention, the following advantages are expectable.

1. In the method of securing the core to the upper mold with use of a frictional force, it is possible to save costs for parts by omission of securing parts or means as compared with a method of securing the core to the upper mold with a mechanically securing member or an adhesive. Further, since a work of fitting engagement of the core and the upper mold is simple, it is possible to enhance the productivity of the core securing.
2. In order to frictionally engage the core with the upper mold, it is needed only to press the core being supported by the core supporter against the upper mold by relative movement of the core to the upper mold. In this connection, when the core supporter is located under the upper mold and the core is loaded on the top of the core supporter whereby the core is brought into contact with the upper mold by lifting the core supporter, since it is unnecessary to hold the core with utilization of a holder or a vacuum suction means, a core securing device can be designed to have a simple structure.
3. It is possible to set a proper securing position for the core by measuring a contact load value between the upper mold and the core whereby realizing a sta-

ble size of a product.

Brief description of the several views of the drawings

[0020]

Fig. 1 is a schematic vertical sectional view showing a relationship between an upper mold assembly and a lower mold as one embodiment of the invention;
Fig. 2 is a schematic vertical sectional view of the upper mold assembly as one embodiment of the invention, which shows a mechanical connection relationship between the core and the upper mold;
Fig. 3 is a schematic vertical sectional view of an upper mold assembly as one embodiment of the invention, which shows an adhesive connection relationship between a core and an upper mold;
Fig. 4 is a schematic vertical sectional view of an upper mold assembly as one embodiment of the invention, which shows a frictional connection relationship between a core and an upper mold;
Fig. 5 is a schematic vertical sectional view of an upper mold assembly as one embodiment of the invention, which shows a connection relationship with use of molding sand between a core and an upper mold;
Fig. 6 is a schematic vertical sectional view illustrating a pouring operation with use of an upper mold assembly and a lower mold as one embodiment of the invention;
Fig. 7 is a schematic vertical sectional view illustrating a descending movement state of the upper mold assembly at a first speed after the pouring operation shown in Fig. 6;
Fig. 8 is a schematic vertical sectional view illustrating a further descending movement state of the upper mold assembly at a second speed in succession to the state shown in Fig. 7;
Fig. 9 is a schematic vertical sectional view illustrating a state when the descending movement of the upper mold assembly is stopped after the upper mold assembly is superimposed on and pressed to the lower mold in succession to the state shown in Fig. 8;
Fig. 10 is a schematic vertical sectional view, as one embodiment of the invention, which illustrates a state when a core loaded on a core supporter of a core securing device is located at a position facing to an upper mold above the core;
Fig. 11 is a schematic view illustrating a state when the core is brought into close contact with the upper mold after the core supporter has been lifted;
Fig. 12 is a schematic sectional view illustrating a fitting engagement relationship between a core and an upper mold as one embodiment of the invention;
Fig. 13 is a schematic view illustrating a core and an upper mold as another embodiment of the invention;
Fig. 14 is a schematic view illustrating an operation with use of a core model for pre-confirming a travel distance of a core for securing the core to an upper mold;
Fig. 15 is a schematic view illustrating the core model located at a lower position of the upper mold;
Fig. 16 is a schematic view illustrating the core model brought into close contact with the upper mold; and
Fig. 17 is a graph showing a relationship between a stroke (abscissa) of a piston rod and a pressure (ordinate) applied to the piston rod from the upper mold with respect to Figs. 14 to 16.

Detailed description of the invention

[0021] Referring to the attached drawings, embodiments of the present invention will be described herein below.

Example 1

[0022] Fig. 1 is a schematic vertical sectional view illustrating a casting machine comprising a lower mold 10 and an upper mold assembly 20 as one embodiment of the invention.

[0023] The lower mold 10 has a hollow 12 corresponding to a partial profile of a casting. The hollow 12 defines a mold cavity in combination with an upper mold 22 superimposed on the lower mold 10. The upper mold assembly 20 has a core 24 secured to a bottom of the upper mold 22. The core 24 serves as a projection 26 for shaping the profile of the casting in combination with the hollow 12.

[0024] In order to couple the upper mold 22 and the core 24 for fabrication of the upper mold assembly 20, securing of the core 24 to the upper mold 22 is performed by mechanical connection, connection with an adhesive, connection with a frictional force or stamping molding sand.

[0025] In Figs. 1 and 2, a bolt 28a and a nut 28b are used as a mechanical connection means. The bolt 28a is previously implanted in the core 24. The upper mold 22 is designed in the manner that the bolt 28a passes through the upper mold 22 along a vertical direction and the core 24 is held in contact with a bottom of the upper mold 22. A top of the bolt 28a is screwed into the nut 28b to prevent the core 24 to fall from the upper mold 22. The bolt 28a may be alternatively inserted through the preformed upper mold 22 so as to secure the core 24 at a position facing to the bottom of the upper mold 22. Wires or wedges may be used as a mechanical connection means instead of the bolt and the nut.

[0026] Fig. 3 illustrates a core 24A attached to an upper mold 22 with an adhesive. A plurality of projections 24a, formed on a surface of the core 24A, are fitted into respective recesses 22a formed in a bottom of the upper mold 22, and bonded to inner surfaces of the recesses 22a with an adhesive B. The adhesive B may be organic or inorganic without any restriction on its kind. A quick drying strong adhesive based on a vinyl acetate resin was used as the adhesive B in this embodiment. If the core 24A is weighty, a bonding strength can be increased by properly enlarging a bonded plane or properly designing a shape of the bonded plane.

[0027] Fig. 4 illustrates a core 24B attached to an upper mold 22 with a frictional force. Projections 24b formed on a surface of the core 24B are fitted into respective recesses 22b formed in a bottom of the upper mold 22. The projections 24b and the recesses 22b are designed with substantially the same shapes and dimensions. When the projections 24b are fitted into the recesses 22b, inner surfaces of the recesses 22b are scraped, and a frictional force is generated by the scraped molding sand grains entrained in gaps between the inner surfaces and the projections 24b whereby firmly holding the projections 24b in the recesses 22b, so that the core 24B is secured to the upper mold 22.

[0028] Fig. 5 illustrates a core 24C attached to an upper mold 22 with use of molding sand. The core 24C, which has projections 24c each having a diameter enlarged toward the distal end thereof, is integrally incorporated with the upper mold 22 when foundry molding, so that the core 24C is firmly secured in the upper mold 22 by the projections 24c embedded in stamped molding sand.

[0029] The securing means for attaching the cores 24, 24A, 24B and 24C to the upper mold 22, as shown in Figs. 2 to 5, are not limited to a single use of any one of them but also may be used in combination therewith for a single mold. Figs. 2 to 5 show one core 24, 24A, 24B or 24C attached to the respective upper mold 22, but a plurality of cores may be attached to one upper mold 22.

[0030] The upper mold assembly 22 shown in Fig. 1 is loaded on a lift 32 and vertically moved toward a lower mold 10 along guide rods 30. Although the lift 32 may be a proper means, e.g. an electric, hydraulics or pneumatic type, an electric servo cylinder is preferably used for controlling a height level and a descending speed of the upper mold assembly 20 with high accuracy. The electric servo cylinder includes screws, a driving motor and a rotary encoder as a position transducer. An electric servo cylinder for controlling a descending speed of the upper mold assembly 20 and a linear scale for detecting a position of the upper mold assembly 20 and controlling a height level of the upper mold assembly 20 in response to the detected value may be used in stead of the electric servo cylinder capable of controlling a height level and a descending speed of the upper mold assembly 20.

[0031] Referring to Figs. 6 to 9, a sand mold press-casting process as one embodiment of the invention for producing a casting will be clearly understood from the following explanation.

[0032] At first, a molten metal in a necessity minimum amount for shaping a casting is poured in a hollow 12 of a lower mold 10, as shown in Fig. 6. An amount of the molten metal to be poured in the hollow 12 is properly determined in response to a demand. The molten metal to be poured is preferably kept at a temperature higher by 100°C or more than its liquidus temperature.

[0033] According to the invention, an upper mold assembly 20 is immediately put on the lower mold 10 before the molten metal is solidified in the lower mold 10. In order to press the molten metal in the hollow 12 for transferring a product profile to the molten metal, the upper mold assembly 20 is descended at a predetermined first speed quickly down to a predetermined height level just before coming into contact with a surface of the molten metal. The descending speed is 375 mm/second for instance, but the value is not restrictive. The descending speed is properly determined within a range whereat movement of the upper mold assembly 20 does not induce vibration of a casting machine as a whole. The proper range of the first descending speed is 300 to 1000 mm/second. The height level just before the upper mold assembly 20 comes into contact with the surface of the molten metal in the hollow 12 is 1 to 100 mm as a minimum distance from the surface of the molten metal to the upper mold 22 or the core 24.

[0034] After the upper mold assembly 20 moves to arrive at the predetermined height level just before coming into contact with the molten metal in the hollow 12, a descending speed of the upper mold assembly 20 including the upper mold 22 and the core 24 is changed to a predetermined second speed such that the upper mold assembly 20 slowly moves downwardly, as shown in Fig. 8.

[0035] If the second speed is too high, the molten metal is made turbulent so that gases are often included in a casting. If the second speed is too low on the contrary, solidification of the molten metal is completed before the upper mold assembly 20 arrives at a final position. Therefore, the second descending speed is properly determined in a range from 1 to 100 mm/second.

[0036] Anyway, the core 24 is firmly secured to the upper mold 22 in a pouring step without any fear about floatation of the core 24 in the molten metal.

[0037] The upper mold assembly 20 is moved to downwards at the predetermined second speed in this way and put on the lower mold 10, as shown in Fig. 9, and a status information of affections provided to the lower mold 10 by the upper mold assembly 20 is detected. The status information may be a pressure applied to the lower mold 10 from the upper mold assembly 20 or a total descending distance of the upper mold assembly 20. In this embodiment using an electric servo cylinder as a lift 32, the pressure can be detected by a load cell attached to a distal end of a piston rod.

[0038] When it is detected that the status information meets a predetermined information value, the descending movement of the upper mold assembly 20 is caused to stop. In this embodiment, the descending movement of the upper mold assembly 20 is caused to stop when a detected pressure reaches 1 kPa, and kept as such for a time length during which the molten metal is completely solidified, whereby a casting process is finished.

[0039] As is described above, in the invention, the upper mold assembly 20 with the core 24 secured to the upper mold 22 is moved downwardly to the lower mold 10 whereby effecting the casting operation, so that the core 24 is prevented from floating. Further, a movement time length of the core 24 in the molten metal can be adjusted to be minimum, so that it is possible to prevent deformation of the core 24 due to a heat or pressure of the molten metal and occurrence of casting defects such as misrun due to a temperature change of the molten metal. Consequently, according to the invention, when effecting casting operation by a sand mold press-casting process with use of a core, it is possible to carry out a casting operation without occurrence of shape defects of products.

[0040] In this process, many of upper mold assemblies may be previously stocked and sequentially used for each casting step. The status information of the upper mold assembly may be given in a descending period other than the situation that the upper mold assembly is put on the lower mold. The upper mold assembly may be prepared during or after a molten metal pouring step.

Example 2

[0041] Herein below there will be described an embodiment of connection of a core and an upper mold with use of frictional force.

[0042] Fig. 10 illustrates a core 40, which is loaded on a core supporter 58 of a core securing device 50 and located at a position facing to an upper mold 60 above the core 40. The core 40 has a rod-shaped projection 42 at a center of its top surface. The rod-shaped projection 42 is fitted into a recess 62 formed at a center of a bottom of the upper mold 60, so as to secure the core 40 to the upper mold 60 by frictional fitting engagement of the rod-shaped projection 42 with the recess 62.

[0043] The core securing device 50 mainly comprises a frame 90 supported with a base (not shown), sliding guide rods 52 attached to the frame 90, a pneumatically, hydraulically or electrically driving cylinder 54 having an upper part coupled to a frame 100 spanned over top ends of the guide rods 52 and a core supporter 58 secured to a top of a piston rod 56 of the driving cylinder 54.

[0044] An axis of the driving cylinder 54 (i.e. an axis of the piston rod 56) is aligned with an axis of the rod-shaped projection 42 of the core 40. These axes are also aligned with an axis of an upper mold 60. When the driving cylinder 54 in a state of Fig. 10 is operated for ascending the core 40, the rod-shaped projection 42 of the core 40 is fitted into the recess 62 of the upper mold 60.

[0045] Fig. 11 shows a state that the core 40 is lifted to a position in close contact with the upper mold 60 by fitting the rod-shaped projection 42 into the recess 62.

[0046] A dimensional relationship between the rod-shaped projection 42 and the recess 62 will become apparent from the following explanation referring to Fig. 12.

[0047] The rod-shaped projection 42 and the recess 62 are both formed to have a frustum conical shape, respectively. Alternatively, the rod-shaped projection may be formed to be a round rod having a constant diameter.

[0048] The rod-shaped projection 42 has a length smaller than a depth of the recess 62, so that some allowance remains at a part between a top of the rod-shaped projection 42 and a bottom (i.e. a deepest part) of the recess 62 when the rod-shaped projection 42 is completely fitted into the recess 62. A relationship of $B<a<b<A$ is preferably maintained between the rod-shaped projection 42 and the recess 62, wherein "a" is an outer diameter of a top of the rod-shaped projection 42, "b" is an outer diameter of a root of the rod-shaped projection 42, "A" is an inner diameter of an inlet of the recess 62 and "B" is an inner diameter of the recess 62 at a position near a deepest part at which the top of the rod-shaped projection 42 arrives.

[0049] The specified dimensional relationship assures smooth fitting motion of the rod-shaped projection 42 into the recess 62. As advance of the rod-shaped projection 42 through the recess 62, the top of the rod-shaped projection 42 is pressed onto an inner wall of the recess 62 so that the distal end of the rod-shaped projection 42 bites the inner wall of the recess 62. When the upper mold 60 is scraped, resultant scraped chips are entrained in an allowance between a top of the rod-shaped projection 42 and a bottom (i.e. a deepest part) of the recess 62. On the other hand, when the rod-shaped projection 42 is scraped, resultant scraped chips are entrained in a gap corresponding to a difference between the outer diameter "b" of the root of the rod-shaped projection 42 and the inner diameter "A" of the inlet of the recess 62. As a result, the core 40 is firmly secured to the upper mold 60 with the frictional engagement that the rod-shaped projection 42 bites the inner wall of the recess 62 and coupled with the inner wall of the recess 62.

[0050] The core 40 has one rod-shaped projection 42 as above-mentioned, but a plurality of rod-shaped projections may be formed in a core 40A as another example shown in Fig.13. In the example of Fig. 13, the core 40A has two rod-shaped projections 42a and 42b, while an upper mold 60A has two recesses 62a and 62b each corresponding to the rod-shaped projections 42a and 42b. A dimensional relationship between the rod-shaped projections 42a and 42b and the recesses 62a and 62b is specified in the same way as the dimensional relationship between the rod-shaped projection 42 and the recess 62.

[0051] When the rod-shaped projection 42 enters into the recess 62 so as to bring the core 40 in close contact with the upper mold 60, operation of the driving cylinder 54 shall be stopped. For the purpose, it is necessary to preset a stroke of a piston rod 56, i.e. a distance from an initial position of the core 40 on the core supporter 58, shown in Fig. 10, to a position of the core 40 completely coupled to the upper mold 60, shown in Fig. 11, at a controller of the driving cylinder 54. The presetting will be understood from the following explanation referring to Figs. 14 to 17.

[0052] Fig. 14 illustrates a core model 70, which has the same profile and dimensions as those of the core 40 except for omission of the rod-shaped projection, loaded on the core supporter 58 of the core securing device 50. The core securing device 50 in Fig. 14 is illustrated in a core loading position offset from an axis of the upper mold 60, at a fixed position, held by the upper mold holder 80.

[0053] The core securing device 50 moves from the position of Fig. 14 to a position of Fig. 15 where an axis of the core model 70 coincides with an axis of the upper mold 60 held at the predetermined position. In the state that the core model 70 is aligned co-axially with the upper mold 60, the driving cylinder 54 is started to extend the piston rod 56 and to bring the core model 70 on the core supporter 58 in close contact with the upper mold 60. As the core model 70 comes into contact with the upper mold 60, a pressure applied to the piston rod 56 from the upper mold 60 rises. Further extension of the piston rod 56 abruptly raises the pressure. An upward motion of the core model 70 after coming into contact with the upper mold 60 leads to an increase in a contact pressure applied to the upper mold 60. If the contact pressure excessively increases, the upper mold 60 and/or the core model 70 would be damaged. In this consequence, operation of the driving cylinder 54 shall be stopped at a time when the contact pressure reaches a proper value for sticking the core model 70 to the upper mold 60 with a proper engaging relation.

[0054] Fig. 17 is a graph representing a relationship between a stroke (abscissas) of the piston rod 56 and a pressure (ordinate) applied to the piston rod 56 from the upper mold 60 when bringing the core model 70 into close contact with the upper mold 60. A proper contact pressure is estimated to a value near a point X (i.e. a value range of 0.008 to 0.009 MPa).

[0055] From the graph of Fig. 17, it is possible to confirm a stroke of the piston rod 56 need to bring the core model 70 into close contact with the upper mold 60. The stroke of the piston rod 56 thus confirmed is preset as a movement distance of the core 40 at a controller of the deriving cylinder 54, when the core 40 is loaded and secured to the upper mold 60 in an actual preliminary work for casting, so that securing of the core 40 to the upper mold 60 is constantly performed at a proper position for mass production of casting molds capable of producing a high-quality casting.

List of components

[0056]

10	a lower mold
12	a hollow
20	an upper mold assembly
22	an upper mold
22a	recesses
24	a core
26	a projection
28a	a bolt
28b	a nut
30	a guide rod
32	a lift
40	a core
42	a rod-shaped projection
50	a core securing device
52	a guide rod
54	a driving cylinder
56	a piston rod
58	a core supporter
60	an upper mold
62	a recess
70	a core model
80	an upper mold holder
90	a frame
100	a frame
B	an adhesive

Claims

1. A casting process with use of a lower mold (10) having a hollow (12) corresponding to a partial profile of a casting, and an upper mold (22) which supports a core (24) and defines a mold cavity in cooperation with the lower mold (10), wherein the casting process comprises the steps of:

    preparing an upper mold assembly (20) by securing a core to an upper mold (22);
    pouring a necessary minimum amount of a molten metal for obtaining a casting in the hollow of the lower mold (10);
    moving downwardly the upper mold assembly (20) at a predetermined first speed to a predetermined height level just before the upper mold assembly (20) comes into contact with a surface of the molten metal in the hollow of the lower mold (10);
    further moving downwardly the upper mold assembly (20), from the predetermined height level, at a predetermined second speed by changing the descending speed of the upper mold assembly (20) from the first speed to the second speed;
    detecting a status information of the upper mold assembly (20) in a state when the upper mold assembly (20) is superimposed on the lower mold (10), or arrived at the lower mold (10); and
    stopping the descending movement of the upper mold assembly (20) after detecting that the status information comes at a predetermined state.

2. The casting process according to claim 1, wherein the status information of the upper mold assembly is of a pressure applied from the upper mold assembly (20) to the molten metal in the hollow (12) and/or

the lower mold (10), or of a total descending movement distance of the upper mold assembly (20).

3. An upper mold assembly (20) which comprises an upper mold (22) and a core (24) secured to the upper mold (22), and which defines a mold cavity in cooperation with the lower mold (10).

4. The upper mold assembly according to claim 3, wherein the core (24) is secured to the upper mold (22) by a mechanical means.

5. The upper mold assembly according to claim 3, wherein the core (24A) is secured to the upper mold (22) "by an adhesive.

6. The upper mold assembly according to claim 3, wherein the core (24B) is secured to the upper mold (22) by frictional fitting relationship between a projection (24b) formed on the core (24B) and a recess (22b) formed in the upper mold (22) .

7. The upper mold assembly according to claim 3, wherein the core (24C) is secured to the upper mold (22) by an engagement relationship between an engaging projection (24c) formed on the core (24C) and a stamped molding sand of the upper mold (22).

8. The upper mold assembly according to any one of claims 3 to 7, wherein a plurality of cores are secured to the upper mold (22).

9. A method of securing a core (24B) to an upper mold (22) with use of a frictional force,
wherein a casting mold consisting of the upper mold (22) and a mating lower mold (10) is used, which upper and lower molds (22, 10) are prepared by foundry molding, respectively, and which are superimposed on each other so as to define a mold cavity having a product profile for obtaining a casting,
wherein the core (24B) has a partial profile of the casting, and
wherein the method comprises steps of:

preparing the upper mold (22) having a recess (22b) for securing the core (24B) therein and the core (24B) having a projection (24b) to be fitted into the recess (22b); and
press-fitting the projection (24b) of the core into the recess (22b) of the upper mold (22) by relatively moving a core supporter (58) for supporting the core (24B) to the upper mold (22) such that with use of an information value of securing the core (24B) to the upper mold (22), the press-fitting operation is effected until the information value meets a predetermined information value of securing the core (24B) to the upper mold (22).

10. The method according to claim 9, wherein the core (24B) has one or more projections (24b), and the upper mold (22) has one or more recesses (22b) for receiving the one or more projections (24b), wherein the projections (24b) and the recesses (22b) are so formed that at least a deep region of each of the recesses (22b) has an inner diameter smaller than an outer diameter of a complementary contact part of each of the projections (24b).

11. The method according to claim 10, wherein with use of a core model (70) without a projection, the core supporter (58) supporting the core model (70) is moved relatively to the upper mold (60) so as to bring the core model (70) into contact with the upper mold (60), whereby the information value of securing the core (24B) to the upper mold (60) is a travel distance of the core supporter (58) from an initial position when a pressure applied to the core model (70) from the upper mold (60) meets a predetermined information value.

FIG.1

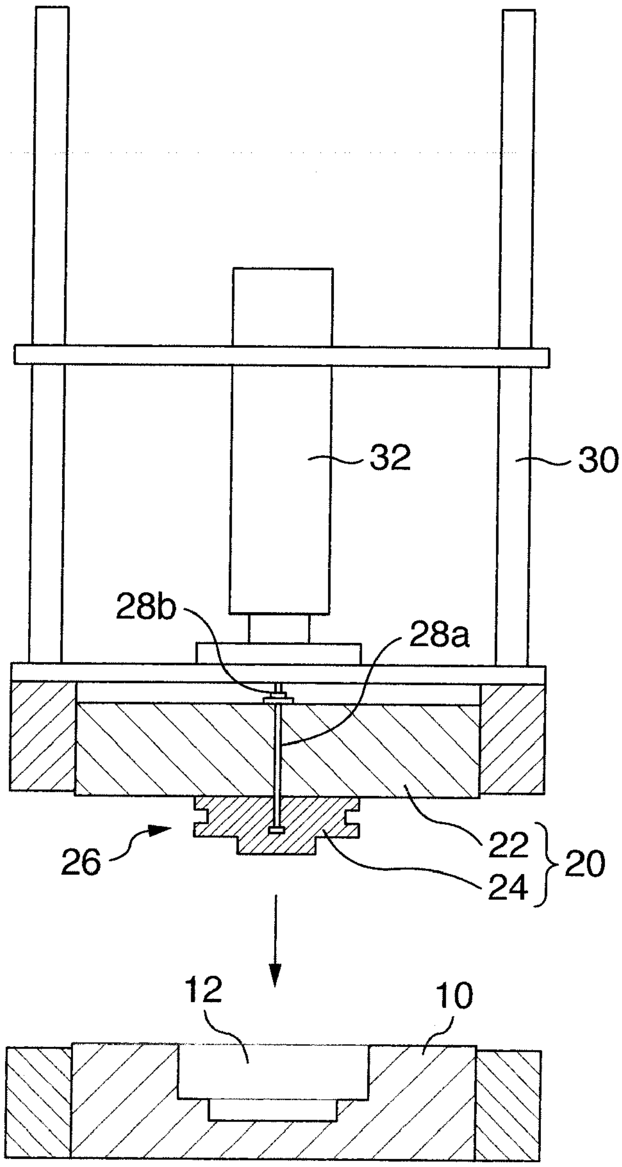


FIG.2

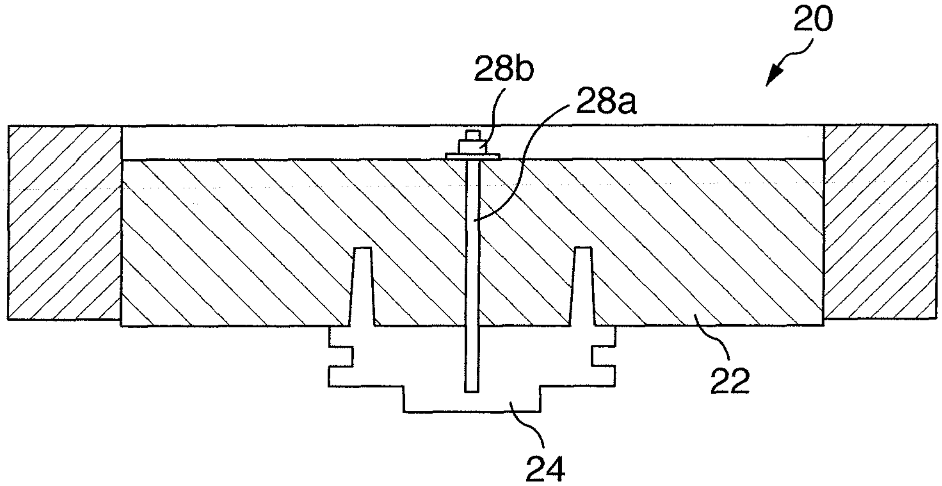


FIG.3

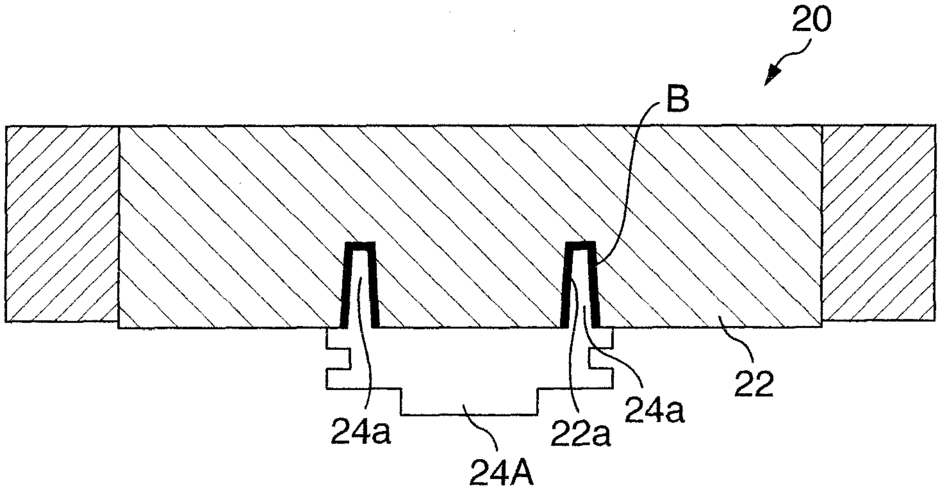


FIG.4

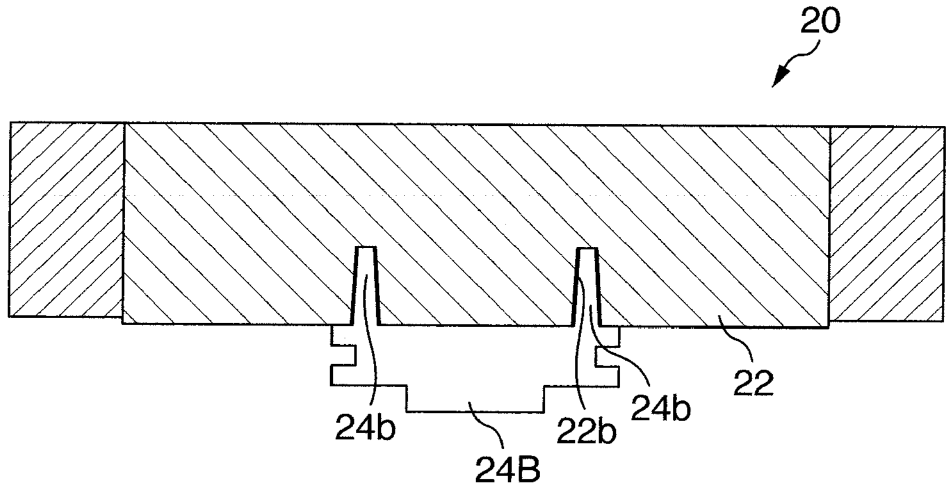


FIG.5

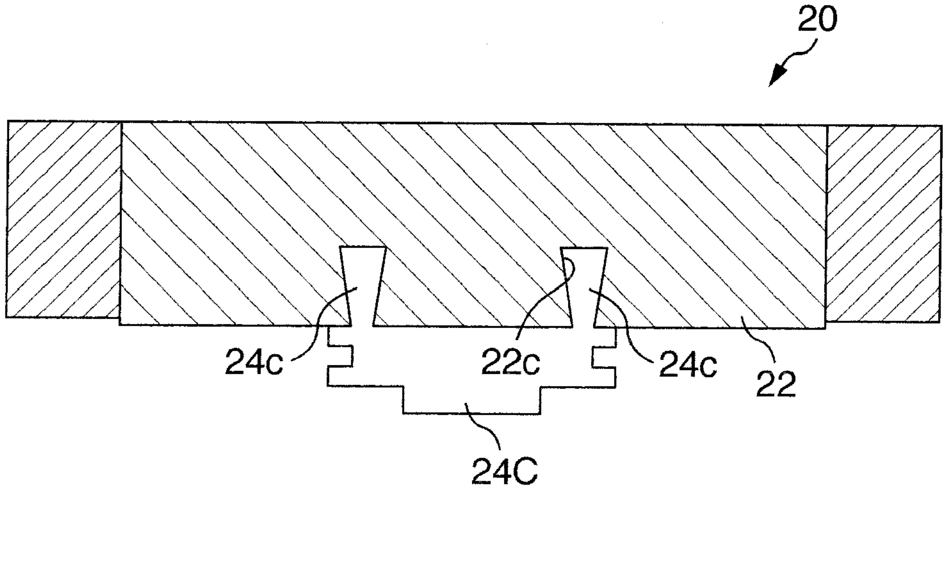


FIG.6

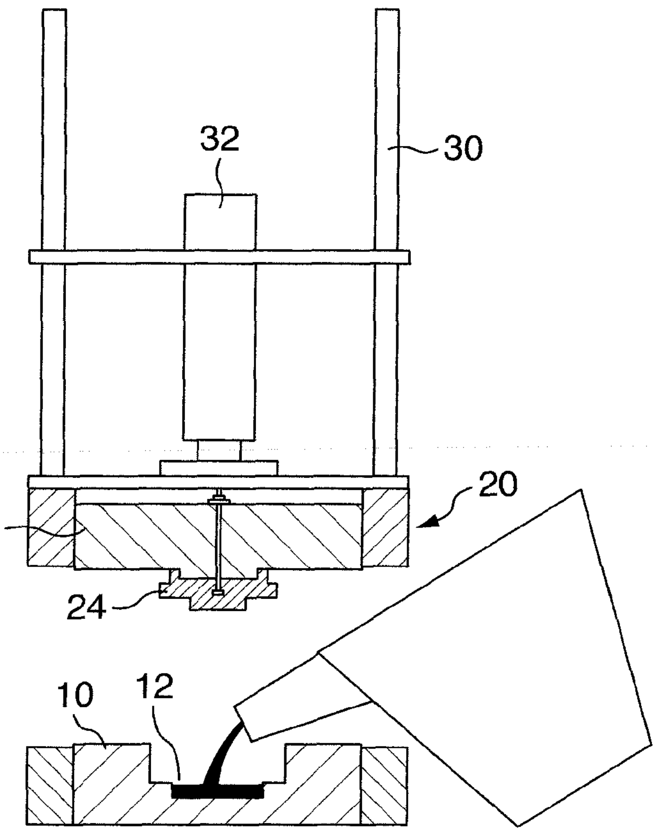


FIG.7

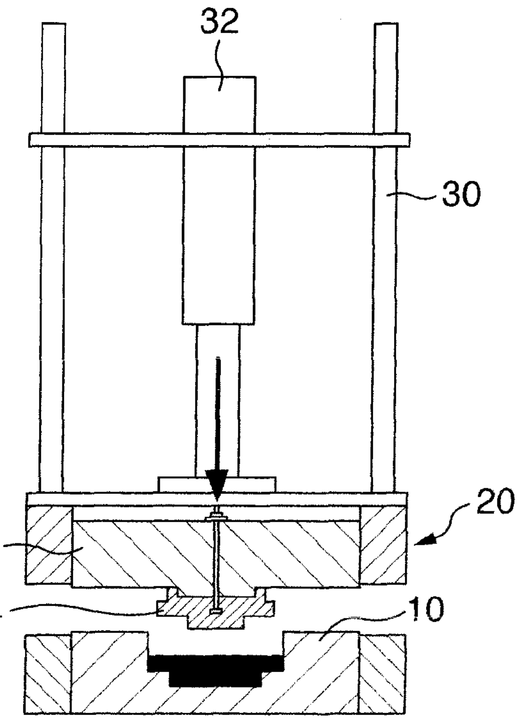


FIG.8

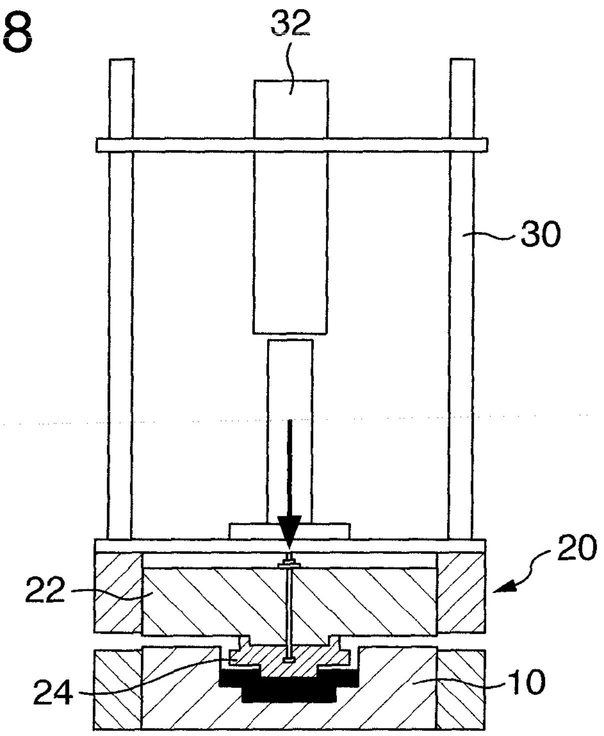


FIG.9

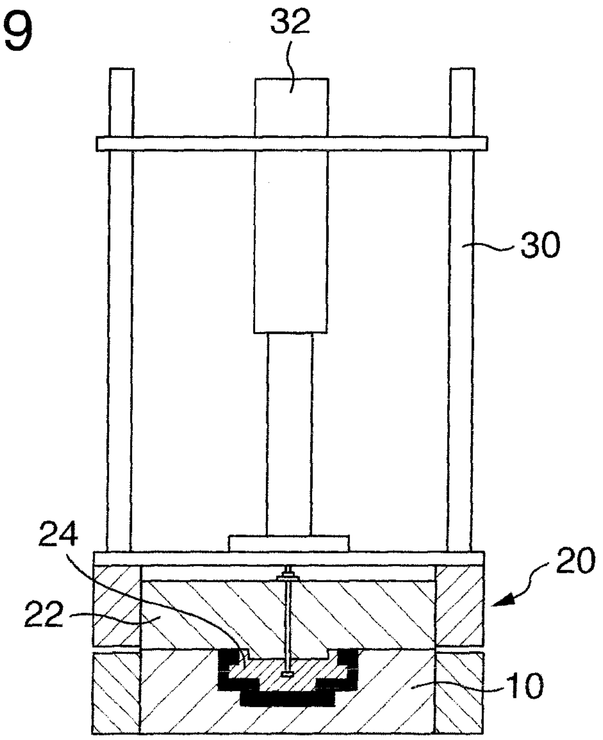


FIG.10

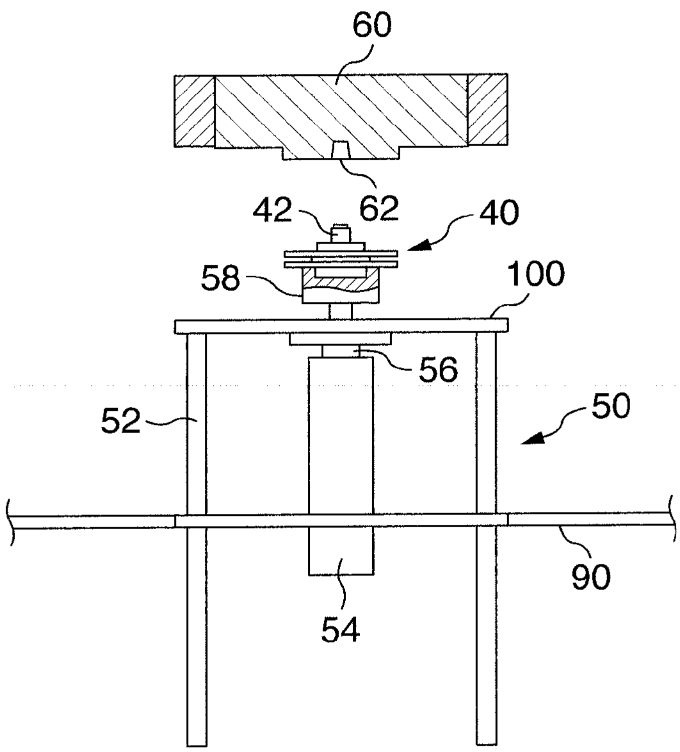


FIG.11

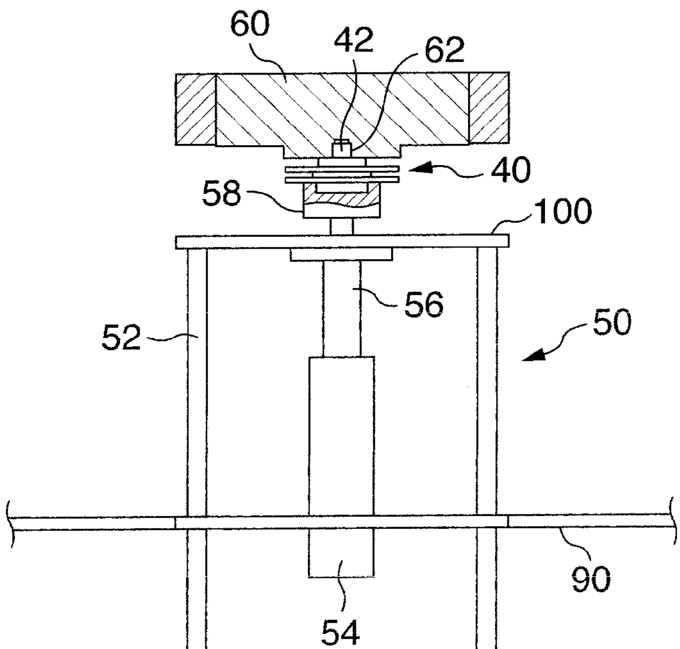


FIG.12

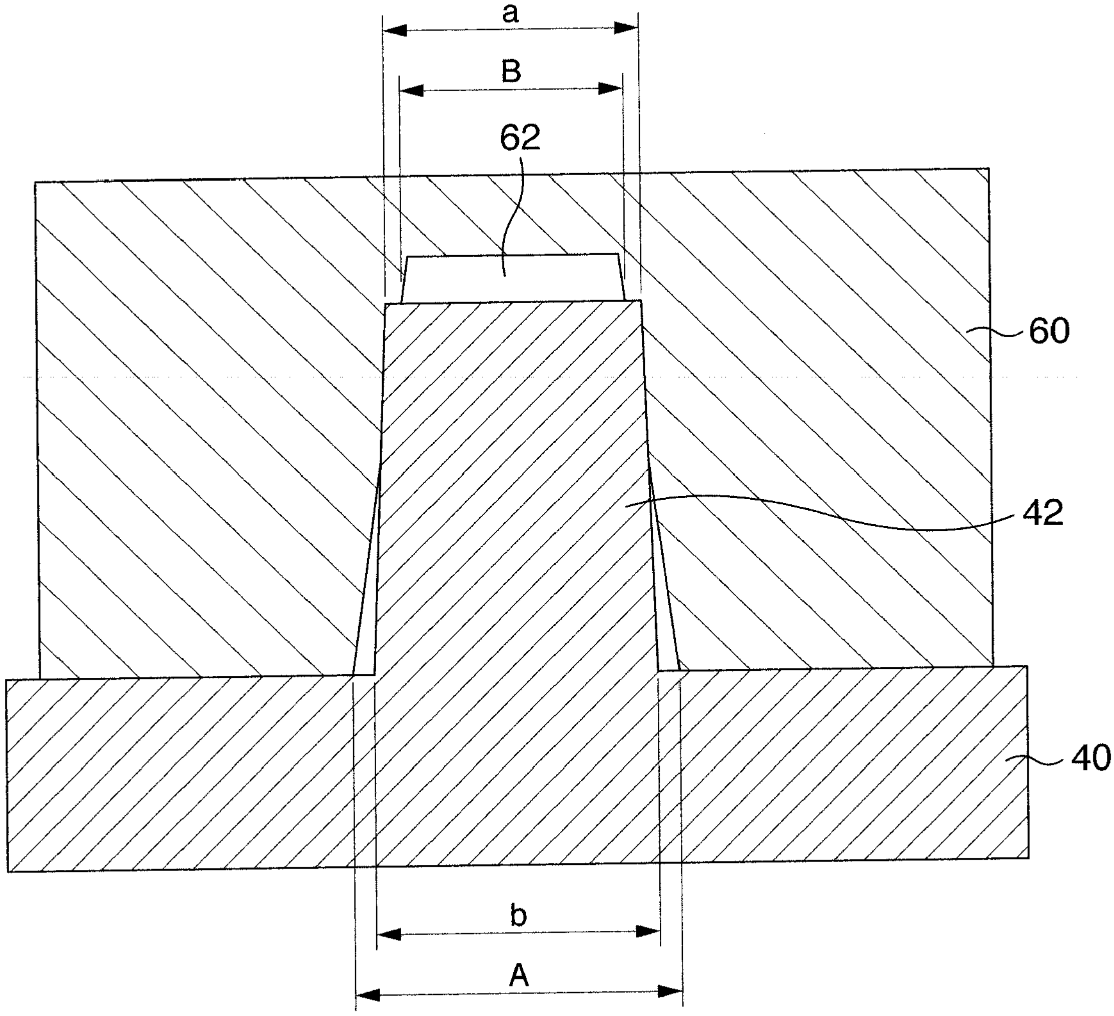


FIG.13

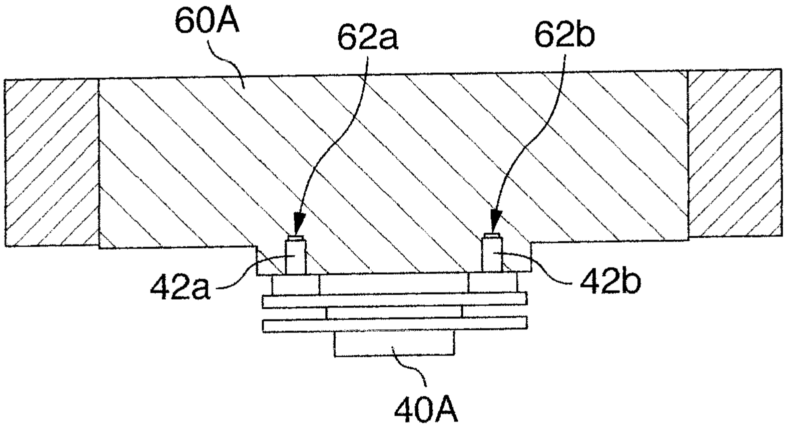


FIG.14

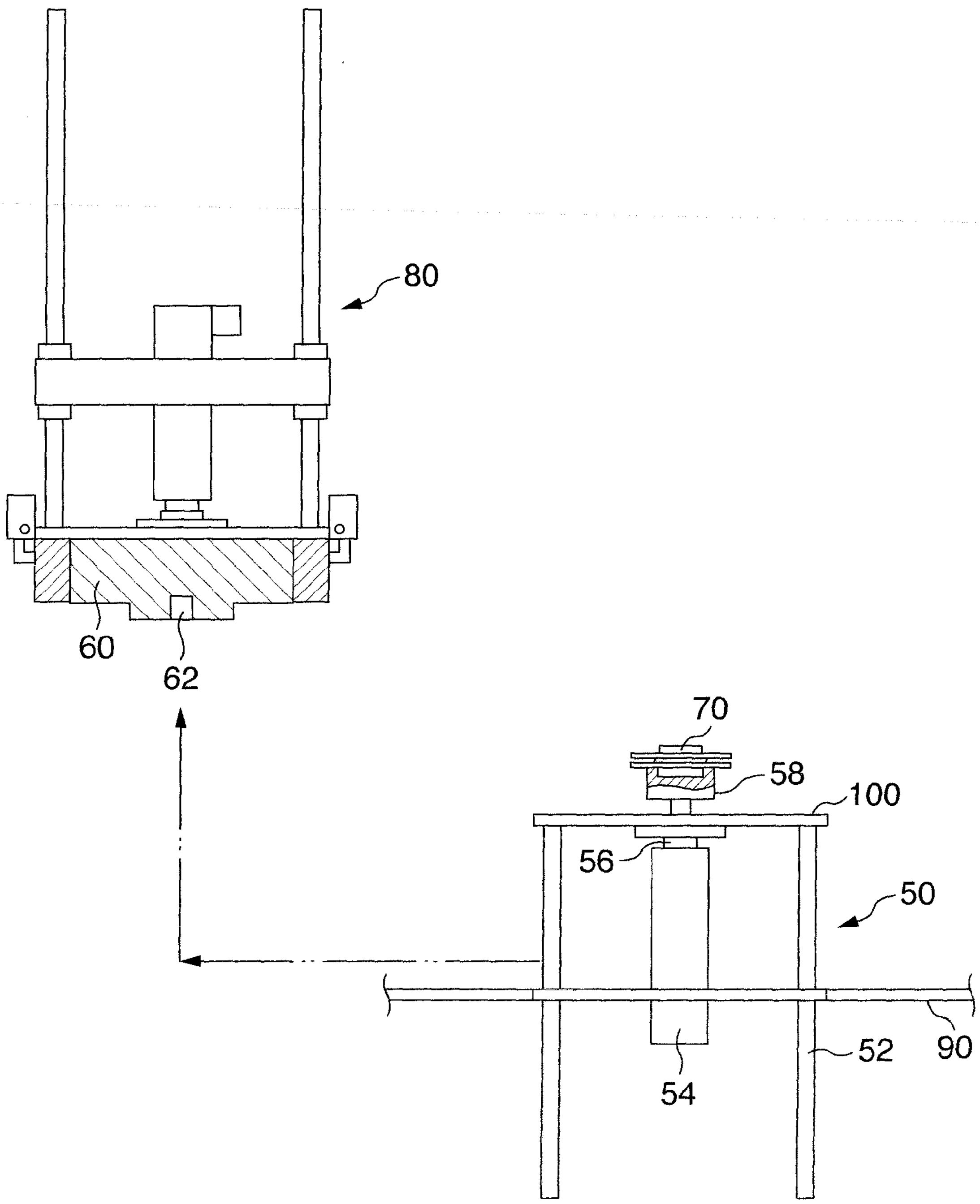


FIG.15

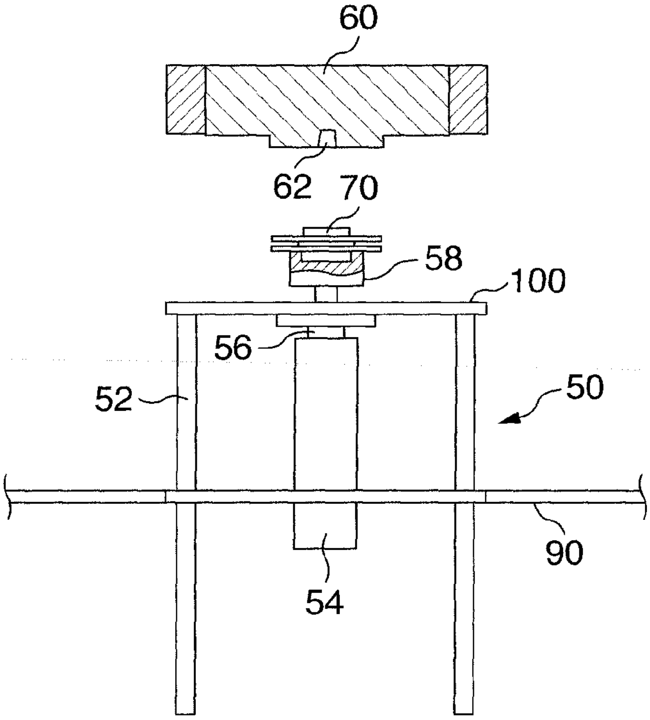


FIG.16

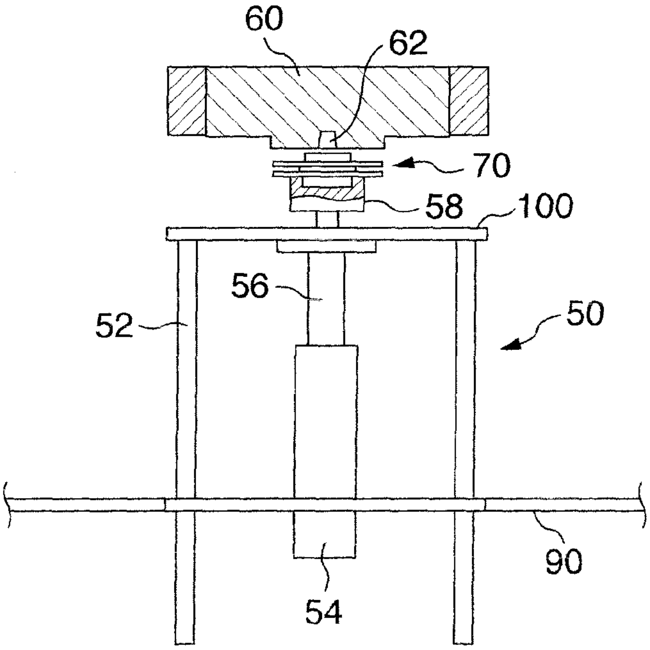
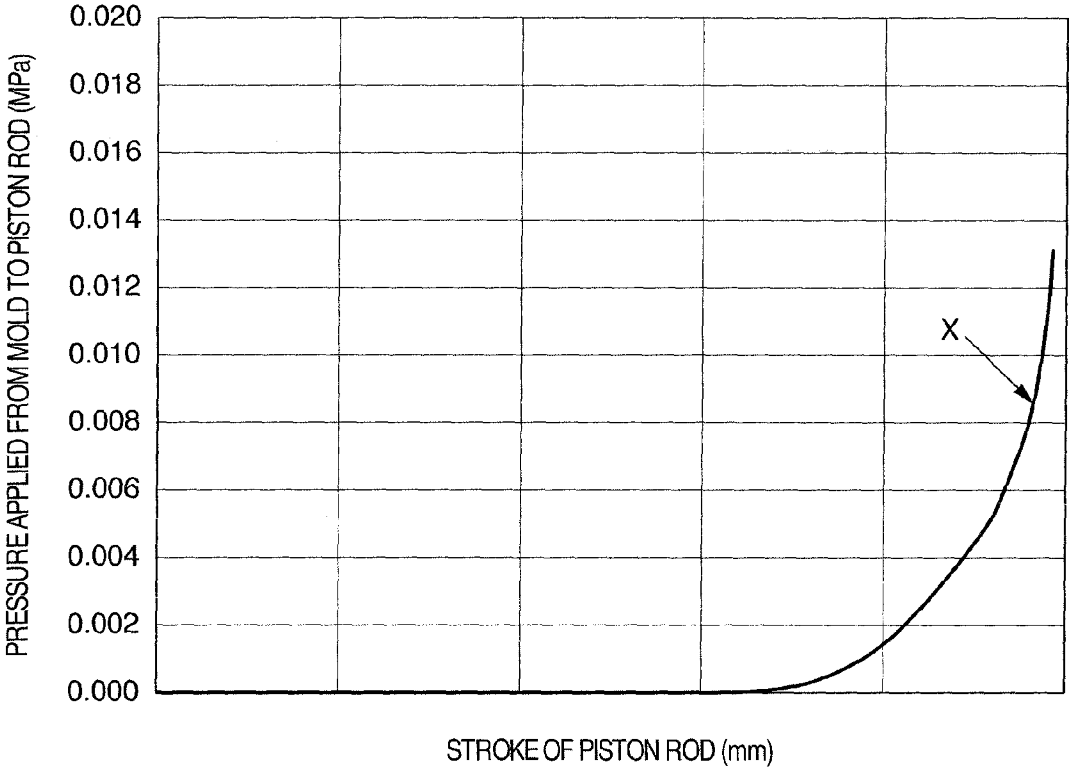


FIG.17


0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
PRESSURE APPLIED FROM MOLD TO PISTON ROD (MPa)
X
STROKE OF PISTON ROD (mm)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 12 0818

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X X	DE 198 21 770 C1 (SIEMENS AG [DE]) 15 April 1999 (1999-04-15) * column 6, lines 32-53; figure 3 *	3,5 4	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	13 March 2008	Scheid, Michael

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13-03-2008

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