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- **HONDA, Tsutomu**
Nihonmatsu-shi
Fukushima 964-8585 (JP)
- **WATANABE, Yoshimitsu**
Nihonmatsu-shi
Fukushima 964-8585 (JP)
- **WATANABE, Kenichi**
Nihonmatsu-shi
Fukushima 964-8585 (JP)

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(71) Applicant: **Techno-Metal Co., Ltd.**
Fukushima 964-8585 (JP)

(74) Representative: **Zimmermann & Partner**
Patentanwälte mbB
Postfach 330 920
80069 München (DE)

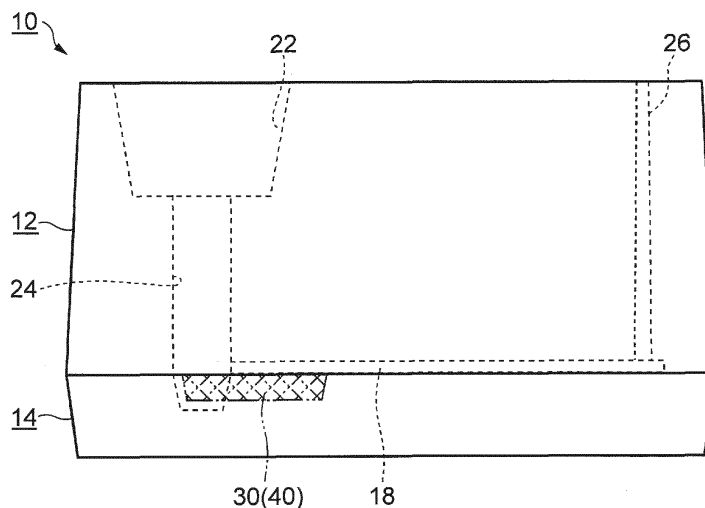
(72) Inventors:
• **MIURA, Tetsuo**
Nihonmatsu-shi
Fukushima 964-8585 (JP)

(54) **SAND CASTING METHOD**

(57) One object of the present invention is to produce a relatively thin-walled casting by a gravity casting process using a metal which has relatively poor fluidity. A sand mold includes a recess (30) formed in a main mold (12 and 14), opening to a cavity of the main mold (12 and 14) and a partial sand mold (40) configured to be detach-

ably attachable to the recess (30). Then, partial sand mold (40) is set to a temperature of 200°C or above, and casting is carried out by installing the partial sand mold (40) with a temperature of 200°C or above in the recess (30) of the main mold.

FIG.6



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Description**Technical Field**

[0001] The present invention relates to a sand casting method.

Background Art

[0002] In response to global demand in relation to recent environmental problems, it has become imperative for the automobile and aircraft industries, for example, to further reduce fuel consumption. An indication thereof can be found in Patent Literature 1. Patent Literature 1 proposes an austenitic heat resistant cast steel instead of ferritic heat resistant cast steels commonly adopted as materials for automotive exhaust system components such as an exhaust manifold and turbocharger. The austenitic heat resistant cast steel has excellent hot strength and provides good fluidity during casting. The austenitic heat resistant cast steel can meet requirements for high heat resistance while reducing casting defects.

[0003] A sand casting process is a metalworking method for making a product by pouring molten metal into a sand mold created by binding sand as aggregate using a binder. The sands used as aggregate can be classified into natural sand and artificial sand, and these sands as well as reclamation sand thereof are used appropriately according to the intended use. Known binders include organic (furan resin, phenol resin, urethane resin, gas curable binder, etc.), inorganic (e.g., water glass), and hybrid binders.

[0004] Patent Literatures 2 to 5 disclose hybrid binders and hybrid casting processes which use the hybrid binders. The hybrid binders secure strength (strength at room temperature) of a created sand mold (including a core) using an organic binder and secure strength (hot strength) of the sand mold during casting using ceramic.

[0005] The hybrid binder, which is called an **XP** alcoholic solution, is a solution composed principally of an alcoholic solution containing one or more alcohol-soluble metallic alkoxides and an alcohol-soluble alkali compound of an alkali metal or alkaline earth metal, both in a less advanced stage of hydrolysis, where the alcohol-soluble metallic alkoxides are selected from among alkoxides of the metals in the 4A group or 4B group (excluding carbon) and the metals in the 3A group or 3B group of the periodic table and partial hydrolysates of the alkoxides. For details of the **XP** alcoholic solution, refer to Patent Literatures 2 to 5.

[0006] The hybrid binder secures strength (strength at room temperature) of a created sand mold (including a core) using an organic binder component of the hybrid binder and secures strength (hot strength) of the sand mold during casting using a ceramic component of the hybrid binder. The hybrid casting process using the hybrid binder allows high-temperature molten metal to be

poured into the sand mold, making it possible to cast metal with poor fluidity or cast a thin-walled product of which fluidity is required strictly.

[0007]

Patent Literature 1: Japanese Patent Laid-Open No. 7-90502

Patent Literature 2: Japanese Patent No. 3139918

Patent Literature 3: Japanese Patent Laid-Open No. 2010-42985

Patent Literature 4: Japanese Patent Laid-Open No. 2012-35269

Patent Literature 5: Japanese Patent Laid-Open No. 2002-143983

Summary of Invention**Technical Problem**

[0008] In aiming to reduce the thickness of a casting, there is a high risk that molten metal will not spread to an entire product portion of the sand mold, i.e., a casting defect will occur. Since the hybrid casting process described above can maintain sand mold strength even under high temperature conditions of, for example, 1000°C or above, if hot casting process is adopted, which involves carrying out casting by heating the molten metal to a higher temperature and/or using a sand mold heated to a high temperature, the risk described above can be reduced greatly.

[0009] However, increases in a casting temperature at which the molten metal is poured into the sand mold will become a contributing factor to cost increases because thermal energy is required in order to heat the metal to a higher temperature. Also, heating the sand mold to a high temperature in a preliminary stage (adoption of a hot casting process), requires capital investment for that, thermal energy, and time and effort, which also becomes a contributing factor to cost increases. For example, it is practically difficult to apply a hot casting process to mass-produced products such as exhaust system components or a cylinder block of an automobile engine.

[0010] An object of the present invention is to provide a sand casting method which can limit the risk that molten metal will not spread to an entire area of a product portion of a sand mold while minimizing cost increases.

[0011] Another object of the present invention is to provide a sand casting method which can reduce casting defects of a metal which has relatively poor fluidity and casting defects of a thin-walled product of which fluidity is required strictly.

[0012] Still another object of the present invention is to provide a sand casting method which can produce a relatively thin-walled casting by a gravity casting process using a metal which has relatively poor fluidity.

Solution to Problem

[0013] According to one aspect of the present invention, the technical problems described above can be solved by providing a sand casting method comprising the steps of:

preparing a sand mold which includes a recess formed in a main mold, opening to a cavity of the main mold and a partial sand mold configured to be detachably attachable to the recess;
 setting the partial sand mold to a temperature of 200°C or above, which is higher than a temperature of the main mold;
 installing the partial sand mold which has a temperature of 200°C or above in the recess of the main mold; and
 carrying out casting by pouring molten metal into the main mold incorporated with the partial sand mold having a temperature of 200°C or above.

[0014] According to a second aspect of the present invention, the technical problems described above can be solved by providing a sand casting method comprising the steps of:

preparing a sand mold which includes a main mold, a core installed in a product portion of the main mold, and a partial sand mold configured to be detachably attachable to a recess which is formed in the core, opening to a surface of the core;
 setting the partial sand mold to a temperature of 200°C or above, which is higher than a temperature of the core;
 installing the partial sand mold which has a temperature of 200°C or above in the recess of the core; and
 carrying out casting by pouring molten metal into the main mold with the core incorporated with the partial sand mold having a temperature of 200°C or above.

[0015] Further objects and operation and effects of the present invention will become clearer from the following detailed description of the present invention.

Brief Description of Drawings

[0016]

[Figure 1] Figure 1 is a graph showing strength of a test piece molded from resin coated sand (RCS) as measured by heating the test piece.

[Figure 2] Figure 2 is a graph showing strength degradation of a test piece molded from resin coated sand (RCS) as measured by heating the test piece.

[Figure 3] Figure 3 is a diagram for describing a cavity of a sand mold used to cast a thin-walled test piece of 2mm in wall thickness.

[Figure 4] Figure 4 is a side view of the sand mold

used to cast the thin-walled test piece of 2mm in wall thickness.

[Figure 5] Figure 5 is a plan view of the sand mold illustrated in Figure 4.

[Figure 6] Figure 6 is a side view of a sand mold which is used to cast a thin-walled test piece of 2mm in wall thickness and in which a first partial sand mold is incorporated into a runner and an upstream portion of a product portion.

[Figure 7] Figure 7 is a plan view of the sand mold illustrated in Figure 6.

[Figure 8] Figure 8 is a side view of a sand mold which is used to cast a thin-walled test piece of 2mm in wall thickness and in which a second partial sand mold is incorporated into a lateral portion of the product portion.

[Figure 9] Figure 9 is a plan view of the sand mold illustrated in Figure 8.

[Figure 10] Figure 10 is a side view of a sand mold which is used to cast a thin-walled test piece of 2mm in wall thickness and in which a third partial sand mold is incorporated into a downstream portion of the product portion.

[Figure 11] Figure 11 is a plan view of the sand mold illustrated in Figure 10.

[Figure 12] Figure 12 is a perspective view of the first partial sand mold.

[Figure 13] Figure 13 is a perspective view of the second partial sand mold.

[Figure 14] Figure 14 is a perspective view of the third partial sand mold.

[Figure 15] Figure 15 is a diagram showing test pieces of cast iron (FC) cast in a sand mold at room temperature and in a sand mold at 300°C.

[Figure 16] Figure 16 is a diagram showing test pieces of cast iron (FC) cast with the heated first partial sand mold installed in the runner and the upstream portion of the product portion.

[Figure 17] Figure 17 is a diagram showing test pieces of heat resistant steel (SCH) cast with the heated first partial sand mold installed in the runner and the upstream portion of the product portion.

[Figure 18] Figure 18 is a diagram showing test pieces of heat resistant steel (SCH) cast with the heated second partial sand mold installed in the lateral portion of the product portion which is prone to cause casting defects.

[Figure 19] Figure 19 is a diagram showing test pieces of heat resistant steel (SCH) cast with the heated third partial sand mold installed in the downstream portion of the product portion.

[Figure 20] Figure 20 is a diagram for qualitatively describing how the temperature of molten metal in a sand mold falls when the molten metal at a higher temperature is poured into the sand mold.

[Figure 21] Figure 21 is a diagram for qualitatively describing how the temperature of molten metal in a sand mold falls when casting is carried out using

a heated sand mold.

[Figure 22] Figure 22 is a diagram for qualitatively describing how the temperature of molten metal in a sand mold falls when casting is carried out with the heated first partial sand mold installed in the runner and the upstream portion of the product portion.

[Figure 23] Figure 23 is a diagram for qualitatively describing how the temperature of molten metal in a sand mold falls when casting is carried out with the heated second partial sand mold installed in the lateral portion of the product portion which is prone to cause casting defects.

[Figure 24] Figure 24 is a diagram for qualitatively describing how the temperature of molten metal in a sand mold falls when casting is carried out with the heated third partial sand mold installed in the downstream portion of the product portion.

[Figure 25] Figure 25 is a diagram for qualitatively describing how the temperature of molten metal in a sand mold falls when casting is carried out with a heated partial sand mold installed in a runner portion.

[Figure 26] Figure 26 is a diagram for qualitatively describing how the temperature of molten metal in a sand mold falls when casting is carried out with a heated partial sand mold installed in the upstream portion of the product portion.

[Figure 27] Figure 27 is a schematic diagram of a sand mold for carrying out casting using a heated main mold and/or heated core.

[Figure 28] Figure 28 is a schematic diagram of a sand mold in which a heated partial sand mold is installed in the runner portion of the main mold.

[Figure 29] Figure 29 is a schematic diagram of a sand mold in which heated partial sand molds are installed in the runner portion and product portion of the main mold, respectively.

[Figure 30] Figure 30 is a schematic diagram of a sand mold in which heated partial sand molds are installed in the runner portion of the main mold and in the core, respectively.

[Figure 31] Figure 31 is a schematic diagram of a sand mold in which heated partial sand molds are installed in the upstream portion of the product portion of the main mold and in the core, respectively.

[Figure 32] Figure 32 is a schematic diagram of a sand mold in which heated partial sand molds are installed in the runner portion and the product portion of the main mold and core, respectively.

Description of Embodiment

[0017] A basic concept of the present invention will be described below before describing an embodiment of the present invention in detail. First, to solve the problem of reducing the wall thickness of castings, the present inventors conducted the following tests.

[0018]

(A) Heating strength test (Figures 1 and 2) of a sand mold using an organic binder:

- (i) Cerabeads #650 was used as aggregate.
- (ii) A resin was used as an organic binder (1.8 mass%).
- (iii) Hexamine was used as a curing agent. Calcium stearate was used as a lubricant.

[0019] RCS (resin coated sand) was produced by mixing the aforementioned materials. Then, test pieces were molded using RCS, and strength and strength degradation were measured by heating the test pieces.

[0020] Figure 1 shows deflection strength (Kg/cm²), i.e., resistance of the test pieces to bending at room temperature, 200°C, and 300°C. Figure 2 shows strength degradation rate (%) of the test pieces with heating at 200°C, 300°C, 400°C, and 500°C. The strength degradation rate (%) was calculated based on room temperature.

[0021] The results of the above test revealed the following. That is, although approximately 40% strength degradation was observed at 200°C to 300°C, it was confirmed that the organic binder had appropriate strength (a deflection strength of approximately 40kg/cm² at 200°C and a deflection strength of approximately 24kg/cm² at 300°C). When measurement errors are allowed for, the organic binder is applicable to the present invention practically at approximately 200°C to approximately 350°C, and preferably at approximately 200°C to approximately 300°C.

[0022] (B) The hybrid binder (XP alcoholic solution) described above has the property of being able to maintain sand mold strength at temperatures of up to approximately 1000°C or above. As described above, the XP alcoholic solution is a solution composed principally of an alcoholic solution containing one or more alcohol-soluble metallic alkoxides and an alcohol-soluble alkali compound of an alkali metal or alkaline earth metal, both in a less advanced stage of hydrolysis, where the alcohol-soluble metallic alkoxides are selected from among alkoxides of the metals in the 4A group or 4B group (excluding carbon) and the metals in the 3A group or 3B group of the periodic table and partial hydrolysates of the alkoxides. XP alcoholic solutions and sand molds using the same are described in detail in Japanese Patent No. 3139918 (Patent Literature 2) and Patent Literatures 3 to 5 cited above, and thus Patent Literatures 2 to 5 are incorporated herein by reference in their entirety by citing these related Patent Literatures.

[0023] Next, regarding metal materials with excellent heat resistance, it is known that HiSiMo ductile (spherical graphite) cast iron and austenitic spherical graphite cast iron (Ni-resist D5S) have excellent fluidity. On the other hand, it is known that cast iron (FC: Ferrum Casting) and heat resistant steel (SCH) have relatively poor fluidity and that the heat resistant steel (SCH) has poorer fluidity than cast iron (FC).

[0024] There is the barrier of the "2-mm wall thickness" in the casting industry and it is said that mass production technology of castings 2 mm or less in wall thickness is a dream technology. For example, it is said that the use of HiSiMo ductile cast iron enables mass production of an automotive exhaust manifold of 2.5 mm in wall thickness, but it is still considered that the barrier of the "2-mm wall thickness" is difficult to overcome.

[0025] Figures 3 to 5 show a sand mold used to cast a tabular test piece (2 mm in thickness) rectangular in planar view. Figure 3 shows a cavity in the sand mold used to cast the test piece. Figure 4 is a side view of the sand mold. Figure 5 is a plan view of the sand mold. The illustrated sand mold 10 for the test piece was made of RCS. As described above, RCS stands for resin coated sand, which contains Cerabeads as aggregate, and a resin as a binder.

[0026] The sand mold 10 for the test piece is made up of an upper mold 12 and a lower mold 14 (Figure 4). Referring especially to Figure 3, the cavity 16 in the sand mold 10 is made up of a product portion 18 and a runner 20. Molten metal poured into a down sprue 22 flows into the runner 20 through a gate stick portion 24. An overflow channel 26 is connected to a downstream end portion of the product portion 18, opening in a top surface of the upper mold 12. The product portion 18 measures 300.0 mm in length, 95.0 mm in width, and 2.0 mm in thickness.

[0027] According to one embodiment, the lower mold 14 of the sand mold 10 for test pieces has a first recess 30, which faces an upstream end portion of the product portion 18 and the runner 20, as indicated by imaginary lines in Figures 6 and 7. The first recess 30 is open upward.

[0028] Also, according to a second embodiment, the lower mold 14 of the sand mold 10 has a second recess 32 which extends from an upstream end to a downstream end on a lateral portion (lateral portion on the side further from the gate stick portion 24) of the product portion 18 as indicated by imaginary lines in Figures 8 and 9. The second recess 32 is open upward.

[0029] Also, according to a third embodiment, the lower mold 14 of the sand mold 10 has a third recess 34 which faces an entire area of the downstream end portion of the product portion 18 as indicated by indicated by imaginary lines in Figures 10 and 11. The third recess 34 is open upward.

[0030] Figures 12 to 14 show partial sand molds 40, 42, and 44 which are detachably attached, respectively, to the first to third recesses 30, 32, and 34 described above. The first partial sand mold 40 in Figure 12 has a tabular rectangular shape, which is complementary to the contour of the first recess 30 described above (Figures 6 and 7). When the first partial sand mold 40 is assembled onto the first recess 30, the first partial sand mold 40 forms a cavity wall surface in the upstream end portion of the product portion 18 and a cavity wall surface of the runner 20 by being integrated with the lower mold 14.

[0031] The second partial sand mold 42 in Figure 13 has the shape of a rectangular parallelepiped, which is complementary to the contour of the second recess 32 described above (Figures 8 and 9). When the second partial sand mold 42 is assembled onto the second recess 32, the second partial sand mold 42 forms a cavity wall surface in the lateral portion (lateral portion on the side further from the gate stick portion 24) of the product portion 18 by being integrated with the lower mold 14.

[0032] The third partial sand mold 44 in Figure 14 has a tabular rectangular shape, which is complementary to the contour of the third recess 34 described above (Figures 10 and 11). When the third partial sand mold 44 is assembled onto the third recess 34, the third partial sand mold 44 forms a cavity wall surface in the downstream end portion of the product portion 18 by being integrated with the lower mold 14.

[0033] Figure 15 shows an example in which test pieces Tp were cast from cast iron (FC) in the sand mold 10 made of RCS. Casting conditions of the first to third test pieces Tp(1) to Tp(3) shown in (I) to (III) of Figure 15 were as following.

[0034] Casting conditions in (I) of Figure 15 and results thereof:

- (1) The melting temperature of the cast iron (FC) was 1380°C.
- (2) The temperature of the sand mold 10 was room temperature.
- (3) The resulting first test piece Tp(1) had a shape in which a portion corresponding to the downstream portion of the product portion 18 of the sand mold 10 was lacking.

[0035] Casting conditions in (II) of Figure 15 and results thereof:

- (1) The melting temperature of the cast iron (FC) was 1465°C.
- (2) The temperature of the sand mold 10 was room temperature.
- (3) The second test piece Tp(2) cast in the sand mold 10 at room temperature had a shape in which a portion corresponding to the downstream portion of the product portion 18 of the sand mold 10 was lacking, but the lacking portion was smaller than the first test piece Tp(1) in (I) of Figure 15. It can be seen from these results that the higher the melting temperature, the further the fluidity can be improved.

[0036] Casting conditions in (III) of Figure 15 and results thereof:

- (1) The melting temperature of the cast iron (FC) was 1409°C, which was lower than in (II) described above.
- (2) The temperature of the sand mold 10 was 300°C.
- (3) The third test piece Tp(3) cast in the sand mold

10 heated to 300°C was a finished product. It was confirmed that molten metal spread to an entire area of the product portion **18** of the sand mold. Thus, it can be seen that the fluidity of molten metal can be improved using a heated sand mold **10**.

[0037] Figure **16** shows an example in which cast iron (**FC**) was cast in the sand mold **10** (Figures **6** and **7**) equipped with the first recess **30** and incorporated with the heated first partial sand mold **40** (Figure **12**). The partial sand mold **40** was made of **RCS**. The **RCS** was prepared from Cerabeads #650 and an organic binder (resin).

[0038] Casting conditions in (IV) of Figure 16 and results thereof:

- (1) The melting temperature of the cast iron (**FC**) was 1380°C.
- (2) The temperature of the sand mold **10** was room temperature.
- (3) The heated first partial sand mold **40** was incorporated into the first recess **30** of the sand mold **10** (lower mold **14**) (Figures **6** and **7**). The temperature of the first partial sand mold **40** (Figure **12**) was 300°C.
- (4) The cast fourth test piece **Tp(4)** had a shape in which a portion corresponding to the downstream portion of the product portion **18** of the sand mold **10** was lacking as can be seen from (IV) of Figure **16**. Note that the casting conditions are the same as the first test piece **Tp(1)** in (I) of Figure **15** except that the heated first partial sand mold **40** was incorporated, but the lacking portion was smaller than of the first test piece **Tp(1)** in (I) of Figure **15**. It was found from these results that the fluidity in the product portion **18** can be improved if the heated first partial sand mold **40** is installed on an upstream portion of the product portion **18** and the runner **20**.

[0039] Casting conditions in (V) of Figure 16 and results thereof:

- (1) The melting temperature of the cast iron (**FC**) was 1398°C.
- (2) The temperature of the sand mold **10** was room temperature.
- (3) The heated first partial sand mold **40** (Figure **12**) was incorporated into the first recess **30** of the sand mold **10** (lower mold **14**) (Figures **6** and **7**). The temperature of the first partial sand mold **40** was 300°C.
- (4) The fifth test piece **Tp(5)** which was cast had almost a complete shape although there was a slight lack at the downstream end of the product portion **18** of the sand mold **10**.

[0040] When the casting conditions of (IV) and casting conditions of (V) in Figure **16** are compared, the difference is only in the temperature of the molten metal

poured into the sand mold **10**, and the temperature is approximately 20°C higher under the casting conditions of (V) than that under the casting conditions of (IV). Again it can be seen that the fluidity in the product portion **18** can be improved as the temperature of the molten metal gets higher.

[0041] Figure **17** shows an example in which test pieces **Tp** were cast from heat resistant steel (**SCH22**) using the first partial sand mold **40** (Figure **12**) described above. The first partial sand mold **40** was made using the hybrid binder (**XP** alcoholic solution). The aggregate used was Cerabeads #650.

[0042] Casting conditions in (VI) of Figure 17 and results thereof:

- (1) The melting temperature of the heat resistant steel (**SCH22**) was 1514°C.
- (2) The temperature of the sand mold **10** was room temperature.
- (3) The first partial sand mold **40** was incorporated into the first recess **30** of the sand mold **10** immediately after being heated in a furnace at 1100°C for 60 minutes.
- (4) The sixth test piece **Tp(6)** which was cast was a finished product without any lacking portion.

[0043] Figure **18** shows an example in which seventh and eighth test pieces **Tp(7)** and **Tp(8)** were cast from heat resistant steel (**SCH22**) using the second partial sand mold **42** (Figure **13**) described above. The second partial sand mold **42** was made using the hybrid binder (**XP** alcoholic solution). The aggregate used was Cerabeads #650.

[0044] Casting conditions in (VII) of Figure 18 and results thereof:

- (1) The melting temperature of the heat resistant steel (**SCH22**) was 1528°C.
- (2) The temperature of the sand mold **10** was room temperature.
- (3) The second partial sand mold **42** was incorporated into the second recess **32** of the sand mold **10** immediately after being heated in a furnace at 1100°C for 60 minutes.
- (4) The seventh test piece **Tp(7)** which was cast contained a lacking portion. The lacking portion was in the lateral portion on the side further from the gate stick portion **24** (Figure **3**).

[0045] Casting conditions in (VIII) of Figure 18 and results thereof:

- (1) The melting temperature of the heat resistant steel (**SCH22**) was 1536°C.
- (2) The temperature of the sand mold **10** was approximately 300°C.
- (3) The second partial sand mold **42** was incorporated into the second recess **32** of the sand mold **10**

immediately after being heated in a furnace at 1100°C for 60 minutes.

(4) The eighth test piece **Tp(8)** which was cast had a complete shape without any lacking portion.

[0046] When the casting conditions of **(VII)** and casting conditions of **(VIII)** in Figure 18 are compared, the casting conditions of **(VIII)** which provided the completed eighth test piece **Tp(8)** differ from the casting conditions of **(VII)** in that (a) the melting temperature was approximately 10°C higher and that (b) the heated sand mold **10** was used. Thus, it can be seen that the fluidity can be improved if the melting temperature of the heat resistant steel is increased and the sand mold **10** is heated.

[0047] Also, when the seventh test piece **Tp(7)** cast under casting conditions **(VII)** in Figure 18 is checked for any portion containing a casting defect by referring to Figures 8, 9, and 18, a casting defect is observed in a portion corresponding to the lateral portion of the product portion 18 on the side further from the gate stick portion 24. Thus, it can be seen that this region has poor fluidity. The eighth test piece **Tp(8)** was cast under the casting conditions **(VIII)** by installing a heat source (heated partial sand mold **42**) in the region with poor fluidity, and produced good casting results. From this fact, it was found that if not only the sand mold **10** is heated, but also a heat source (heated partial sand mold **42**) is installed in a region prone to cause casting defects or in a portion upstream of this region, this is effective in reducing the occurrence of casting defects in the region with poor fluidity.

[0048] Figure 19 shows an example in which ninth and tenth test pieces **Tp(9)** and **Tp(10)** were cast from heat resistant steel (**SCH22**) using the third partial sand mold **44** (installed in the downstream portion of the product portion 18: Figure 19) described above. The third partial sand mold **44** was made using the hybrid binder (**XP** alcoholic solution). The aggregate used was Cerabeads #650.

[0049] Casting conditions in **(IX)** of Figure 19 and results thereof:

(1) The melting temperature of the heat resistant steel (**SCH22**) was 1530°C.

(2) The temperature of the sand mold **10** was room temperature.

(3) The third partial sand mold **44** was used for casting by being installed in the sand mold **10** immediately after being heated in a furnace at 1100°C for 60 minutes.

(4) The ninth test piece **Tp(9)** which was cast contained a lacking portion.

[0050] Casting conditions in **(X)** of Figure 19 and results thereof:

(1) The melting temperature of the heat resistant steel (**SCH22**) was 1530°C (the same as under the

casting conditions in **(IX)** above).

(2) The temperature of the sand mold **10** was approximately 300°C.

(3) The third partial sand mold **44** was used for casting by being installed in the sand mold **10** immediately after being heated in a furnace at 1100°C for 60 minutes.

(4) The test piece **Tp(10)** which was cast contained a lacking portion.

[0051] Even though the third partial sand mold **44** heated to a high temperature was installed downstream of the product portion **18**, good effects were not obtained.

[0052] The following can be said in a qualitative sense from the test results described above. The solid line in Figures 20 to 26 indicates temperatures in various places inside the sand mold **10** when molten metal at a typical temperature is poured into the sand mold **10**. If these temperatures are taken as reference temperatures, the temperature of the molten metal falls while the molten metal is flowing inside the sand mold **10**.

[0053] Figure 20 shows falls (chain double-dashed line) in the once raised temperature of molten metal poured into the sand mold **10**. By raising the temperature of the molten metal, it is possible to maintain the temperature in various places of the sand mold **10** at levels higher than the reference temperatures. Figure 20 teaches that the possibility of occurrence of casting defects can be reduced by raising the temperature of the molten metal.

[0054] Figure 21 shows temperature falls in the molten metal flowing in the sand mold **10** heated for use in casting, where the temperature is indicated by a chain double-dashed line. The chain double-dashed line in Figure 21 corresponds to casting under the casting conditions of **(III)** in Figure 15. The use of the heated sand mold **10** for casting can reduce the slope of the temperature fall. That is, the temperature falls in the molten metal flowing in the sand mold **10** can be reduced in magnitude. Figure 21 teaches that the possibility of occurrence of casting defects can be reduced by using the heated sand mold **10** for casting.

[0055] Figure 22 shows temperature falls in the molten metal flowing in the sand mold **10** when casting is carried out by installing a heat source (first partial sand mold **40**) in a downstream portion of the runner **20** and upstream portion of the product portion **18**, where the temperature is indicated by a chain double-dashed line. The molten metal introduced into the sand mold **10** enters the runner **20** while falling in temperature. The temperature falls in the molten metal in the downstream portion of the runner **20** and upstream portion of the product portion **18** are retarded by the heat source (first partial sand mold **40**) placed in the downstream portion of the runner **18** and upstream portion of the product portion **18**. Thus, the temperature of the molten metal in the entire area of the product portion **18** including the downstream portion of the product portion **18** can be maintained at a relatively

high level. Figure 22 teaches that the possibility of occurrence of casting defects can be reduced by placing the heat source in the upstream portion of the product portion 18 and the runner 20 located upstream of the product portion 18.

[0056] Figure 23 shows temperature falls in the molten metal flowing in the sand mold 10 (especially in the lateral portion where a heat source is placed) when casting is carried out by installing the heat source (second partial sand mold 42 (Figure 13)) in the lateral portion of the product portion 18 prone to cause casting defects, where the temperature is indicated by a chain double-dashed line. The temperature falls in the molten metal introduced into the sand mold 10 and flowing in the lateral portion of the product portion 18 are retarded by the heat source (second partial sand mold 42) placed in the lateral portion. Thus, the flow of the molten metal can be improved by maintaining the temperature of the molten metal in the lateral portion of the product portion 18 prone to cause casting defects at a relatively high level. Figure 23 teaches that the possibility of occurrence of casting defects can be reduced by placing the heat source in that part of the product portion 18 which is prone to cause casting defects.

[0057] Figure 24 shows temperature falls in the molten metal flowing in the sand mold 10 (especially in the lateral portion where a heat source is placed) when casting is carried out by installing the heat source (third partial sand mold 44 (Figure 14)) in a recess in the downstream portion of the product portion 18, where the temperature is indicated by a chain double-dashed line. The temperature falls in the molten metal introduced into the sand mold 10 and flowing in the downstream portion of the product portion 18 are retarded by the heat source (third partial sand mold 44) placed in the recess in the downstream portion of the product portion 18. This corresponds to the casting conditions of (IX) and (X) in Figure 19. Casting defects were found in the resulting test pieces Tp(9) and Tp(10), meaning that the effect of the heat source (third partial sand mold 44) placed in the recess in the downstream portion of the product portion 18 in reducing casting defects was limited and localized.

[0058] Figure 25 shows temperature falls in the molten metal flowing in the sand mold 10 (especially in the lateral portion where a heat source is placed) when casting is carried out by installing the heat source in a recess in the downstream portion of the runner 20, where the temperature is indicated by a chain double-dashed line. The temperature falls in the molten metal introduced into the sand mold 10 and flowing in the downstream portion of the runner 20 are retarded by the heat source placed in the downstream portion of the runner 20. This makes it possible to maintain the temperatures of the molten metal in various parts of the product portion 18 at relatively high levels. Figure 25 teaches that the flow of molten metal in the entire area of the product portion 18 can be improved by placing the heat source (heated partial sand mold) in the downstream portion of the runner 20. Of course, a

heat source (heated partial sand mold) may be placed in the entire area of the runner 20 in a flow direction or a heat source (heated partial sand mold) may be placed in an upstream portion or intermediate portion of the runner 20 in the flow direction.

[0059] Figure 26 shows temperature falls in the molten metal flowing in the sand mold 10 when casting is carried out by installing a heat source (heated partial sand mold) in a recess in the upstream portion of the product portion 18, where the temperature is indicated by a chain double-dashed line. The temperature falls in the molten metal flowing into the product portion 18 are retarded by the heat source (heated partial sand mold) placed in the upstream portion of the product portion 18. Thus, the temperature of the molten metal in the entire area of the product portion 18 can be maintained at a relatively high level. Figure 26 teaches that the possibility of occurrence of casting defects can be reduced by placing the heat source (heated partial sand mold) in the upstream portion of the product portion 18.

[0060] Figure 27 shows a reference example. Referring to Figure 27, a sand mold 100 is made up of a main mold 102 and a core 104 while the main mold 102 in turn is made up of an upper mold 106 and a lower mold 108.

[0061] Aggregate for the main mold 102 and core 104 may be natural sand, artificial sand, or synthetic sand obtained by mixing the natural sand and artificial sand. Regarding the aggregate which can be adopted, at least one type of casting sand selected from the group consisting of silica sand, mullite, synthetic mullite, alumina, quartz, zircon, fused silica, silica flour, chamotte, and synthetic chamotte can be adopted. Also, the binder to be added to the aggregate may be either an organic binder or inorganic binder.

[0062] Figure 27 shows an example in which casting is carried out using a heated main mold 102. Typically the main mold 102 is made using an organic binder. In this case, casting is carried out in the main mold 102 heated to a temperature of approximately 200°C to approximately 300°C. The main mold 102 may be heated either in a heating furnace or by blowing hot air into the main mold 102.

[0063] In the sand mold made using the hybrid binder (XP alcoholic solution) described above, conventionally hot casting is carried out by heating the sand mold to temperatures 1000°C or above. In the application of the present invention, after the main mold 102 made using the hybrid binder is heated, casting may be carried out in the main mold 102 at a temperature of approximately 350°C to approximately 800°C.

[0064] Figure 27 shows an example in which casting is carried out using a heated core 104. The binder for the core 104 may be an organic binder, an inorganic binder, or the hybrid binder (XP alcoholic solution) described above. Since the hybrid binder can maintain strength at temperatures of up to 1000°C or above, casting may be carried out using the core 104, for example, at approximately 350°C to approximately 1100°C, preferably at ap-

proximately 350°C to approximately 1000°C, and more preferably at approximately 350°C to approximately 800°C. The temperatures of the core **104** are only exemplary. The temperatures which can prevent casting defects may be determined experimentally according to the metal and product geometry to be used.

[0065] When the core **104** is formed using an organic binder, casting may be carried out by heating the core **104**, for example, to approximately 200°C, approximately 250°C, approximately 300°C, or approximately 350°C. The temperatures of core **104** are only exemplary. The temperatures which can prevent casting defects may be determined experimentally according to the metal and product geometry to be used. The temperatures at which a predetermined strength can be maintained may be determined experimentally by taking into consideration the type of aggregate and binder used to form the core **104**. When the core **104** is formed using an inorganic binder, the temperatures at which the strength of the core **104** can be maintained by the inorganic binder when the core **104** is heated may be determined experimentally.

[0066] Figure **28** shows an example in which a heated partial sand mold **120** is installed in the upper mold **106** in an embodiment of the present invention. The runner **20** is illustrated as an installation location of the partial sand mold **120** by way of example, but the number and installation locations of partial sand molds **120** are arbitrary, and locations effective in making molten metal spread smoothly to the entire area of the product portion **18** may be determined experimentally.

[0067] Figure **29** shows an example in which a heated partial sand mold **120** is installed in a recess in that portion of the lower mold **108** which faces the runner **20**. The partial sand mold **120** installed in the lower mold **108** is exposed to the runner **20**, forming a cavity surface which defines the runner **20**. Besides, Figure **29** also shows an example in which a heated partial sand mold **120** is installed in a recess in the upstream portion of the product portion **18**. The partial sand mold **120** is exposed to the product portion **18**, forming a cavity surface which defines the product portion **18**.

[0068] Figure **30** shows an example in which heated partial sand molds **120** are installed in the upper mold **106** and lower mold **108**. A recess facing the runner **20** is illustrated as an installation location of the partial sand mold **120** by way of example, but the installation location is arbitrary, and the locations effective in making molten metal spread smoothly to the entire area of the product portion **18** may be determined experimentally. The partial sand molds **120** installed in the upper mold **106** and lower mold **108** are exposed to the runner **20**, forming cavity surfaces which defines the runner **20**.

[0069] Besides, Figure **30** also shows an example in which a partial sand mold **120** is installed in the core **104**. The partial sand mold **120** installed in the core **104** is in a state of being exposed to the product portion **18**. Either a single partial sand mold **120** or plural partial sand molds **120** may be installed in the core **104**.

[0070] Figure **31** shows an example in which heated partial sand molds **120** are installed in a recess in the upstream portion of the product portion **18** and a recess in the core **104**.

[0071] Figure **32** shows an example in which a heated partial sand mold **120** extending from the upstream portion to the downstream portion of the product portion **18** is installed in a recess in the lower mold **108**. Besides, Figure **32** also shows an example in which a heated partial sand mold **120** is installed in a recess in the core **104**.

[0072] The number and installation locations of partial sand molds **120** are not limited to those in the examples of Figures **28** to **32**. The locations effective in making molten metal spread smoothly to the entire area of the product portion **18** may be determined experimentally.

[0073] The aggregate and binder of the partial sand mold **120** may be selected arbitrarily. The partial sand mold **120** may be made using coated sand prepared by mixing aggregate and a binder or may be made before coating the aggregate with the binder. The binder may be an organic binder, inorganic binder, or hybrid binder (**XP** alcoholic solution) which is capable of maintaining sand mold strength even at ultra-high temperatures. When plural partial sand molds **120** are installed in the sand mold **100**, the partial sand molds **120** may be equal in both material and temperature, may be equal in material and differ in temperature, or may differ in both material and temperature.

[0074] Examples of combinations of a heated main mold **102**, heated core **104**, and heated partial sand mold **120** include the following.

(1) The main mold **102** is heated. When the main mold **102** is made using an organic binder, typically, the main mold **102** of approximately 200°C to approximately 350°C, and preferably of approximately 200°C to approximately 300°C is used for casting. When the main mold **102** is made using a hybrid binder, the main mold **102** of approximately 350°C to approximately 800°C is used for casting.

(2) When the core **104** is formed using an organic binder, the core **104** of approximately 200°C to approximately 350°C, and preferably of approximately 200°C to approximately 300°C is used for casting. When the core **104** is formed using a hybrid binder, the core **104** of approximately 350°C to approximately 800°C after heating the core **104** is used for casting.

(3) Casting is carried out using the heated main mold **102** and heated core **104**. The temperature of the main mold **102** can be selected from temperatures of approximately 200°C to approximately 350°C, and preferably approximately 200°C to approximately 300°C (in the case of an organic binder) or approximately 350°C to approximately 800°C (in the case of a hybrid binder). The temperature of the heated core **104** can be selected from temperatures of approximately 200°C to approximately 350°C and pref-

erably approximately 200°C to approximately 300°C (in the case of an organic binder). In the case of a hybrid binder, the temperature of the heated core **104** can be selected from temperatures of approximately 350°C to approximately 1100°C, preferably approximately 350°C to approximately 1000°C, and more preferably approximately 350°C to approximately 800°C.

(4) Casting is carried out by incorporating the heated partial sand mold **120** into the main mold **102**. The main mold **102** may be used by being left at room temperature or by being heated. In a typical example, the temperature of the heated main mold **102** is approximately 200°C to approximately 350°C and preferably approximately 200°C to approximately 300°C. The temperature of the partial sand mold **120** may be approximately 200°C to approximately 350°C and preferably approximately 200°C to approximately 300°C (in the case of an organic binder) or may be higher (e.g., approximately 350°C to approximately 1100°C, and preferably approximately 350°C to approximately 800°C) (in the case of a hybrid binder).

(5) In (4) above, the core **104** of approximately 200°C to approximately 350°C and preferably of 200°C to approximately 300°C, or of approximately 350°C to approximately 1100°C, preferably of approximately 350°C to approximately 1000°C, and more preferably of approximately 350°C to approximately 800°C is incorporated and used for casting.

(6) In (4) above, casting is carried out by incorporating the partial sand mold **120** of approximately 350°C to approximately 1100°C, preferably approximately 350°C to approximately 1000°C, and more preferably approximately 350°C to approximately 800°C into the core of approximately 200°C to approximately 350°C and preferably approximately 200°C to approximately 300°C.

(7) Casting is carried out by incorporating the heated partial sand mold **120** into the main mold **102**. The main mold **102** may be used by being left at room temperature or by being heated to approximately 200°C to approximately 350°C, and preferably approximately 200°C to approximately 300°C, or, for example, approximately 350°C to approximately 800°C. The temperature of the partial sand mold **120** may be approximately 200°C to approximately 350°C and preferably approximately 200°C to approximately 300°C (in the case of an organic binder) or may be higher (e.g., approximately 350°C to approximately 800°C) (in the case of a hybrid binder).

(8) In (7) above, the core **104** of approximately 200°C to approximately 350°C, and preferably of approximately 200°C to approximately 300°C or of approximately 350°C to approximately 1100°C (preferably, e.g., of approximately 350°C to approximately 800°C) is incorporated and used for casting.

(9) In (7) above, casting is carried out by incorporat-

ing the partial sand mold **120** of approximately 350°C to approximately 1100°C and preferably, for example, approximately 350°C to approximately 800°C into the core of approximately 200°C to approximately 350°C and preferably approximately 200°C to approximately 300°C.

[0075] Whereas the present invention has been described above, the material (aggregate and binder) and temperature of the main mold, the material and temperature of the core, the material and temperature of the partial sand mold incorporated into the main mold, and the material and temperature of the partial sand mold incorporated into the core as well as combinations thereof are arbitrary. The material and temperature of the main mold, the material and temperature of the partial sand mold, and the like may be selected such that the flow of metal in the product portion can be facilitated and that the occurrence of casting defects can be reduced.

[0076] The temperatures of the main mold, core, and partial sand mold may be determined to the extent that a predetermined strength can be maintained, by actually examining the aggregate and binder adopted. Also, if a simple geometry is selected for the partial sand mold, the required strength (deflection strength) can be limited to a relatively small value.

Industrial Applicability

[0077] The present invention is widely applicable to metal casting. The application of the present invention allows the occurrence of casting defects to be reduced even if molten metal is at a relatively low temperature. This makes it possible to reduce the amount of thermal energy used to heat metal. Also, the present invention is effective in reducing casting defects of metal which has poor fluidity in molten state. Also, the present invention enables mass production of thin-walled products 2 mm or less in wall thickness.

Reference Signs List

[0078]

100	Sand mold
102	Main mold
104	Core
106	Upper mold
108	Lower mold
18	Product portion of sand mold
20	Runner of sand mold
22	Down sprue of sand mold
24	Gate stick portion of sand mold

Claims

1. A sand casting method comprising the steps of:

- preparing a sand mold **(10, 100)** which includes a recess **(30, 32, 34)** formed in a main mold **(102)**, opening to a cavity of the main mold **(102)** and a partial sand mold **(40, 42, 44, 120)** configured to be detachably attachable to the recess **(30, 32, 34)**;
 setting the partial sand mold **(40, 42, 44, 120)** to a temperature of 200°C or above, which is higher than a temperature of the main mold **(102)**;
 installing the partial sand mold **(40, 42, 44, 120)** which has a temperature of 200°C or above in the recess **(30, 32, 34)** of the main mold **(102)**; and
 carrying out casting by pouring molten metal into the main mold **(102)** incorporated with the partial sand mold **(40, 42, 44, 120)** having a temperature of 200°C or above.
2. The sand casting method according to claim 1, wherein the partial sand mold **(40, 42, 44, 120)** is installed in a runner portion **(20)** of the main mold **(102)**.
3. The sand casting method according to claim 1, wherein the partial sand mold **(40, 42, 44, 120)** is installed in an upstream portion of a product portion **(18)** of the main mold **(102)**.
4. The sand casting method according to any one of claims 1 to 3, wherein:
 the partial sand mold **(40, 42, 44, 120)** is made using an organic binder; and
 a temperature of the partial sand mold **(40, 42, 44, 120)** is 200°C to 350°C.
5. The sand casting method according to any one of claims 1 to 3, wherein a temperature of the partial sand mold **(40, 42, 44, 120)** is 350°C to 1100°C.
6. A sand casting method comprising the steps of:
 preparing a sand mold **(100)** which includes a main mold **(102)**, a core **(104)** installed in a product portion **(18)** of the main mold **(102)**, and a partial sand mold **(120)** configured to be detachably attachable to a recess **(30, 32, 34)** which is formed in the core **(104)**, opening to a surface of the core **(104)**;
 setting the partial sand mold **(120)** to a temperature of 200°C or above, which is higher than a temperature of the core **(104)**;
 installing the partial sand mold **(120)** which has a temperature of 200°C or above in the recess **(30, 32, 34)** of the core **(104)**; and
 carrying out casting by pouring molten metal into the main mold **(102)** with the core incorporated
- with the partial sand mold **(120)** having a temperature of 200°C or above.
7. The sand casting method according to claim 6, wherein:
 the partial sand mold **(120)** is made using an organic binder; and
 a temperature of the partial sand mold **(120)** is 200°C to 350°C.
8. The sand casting method according to claim 6, wherein a temperature of the partial sand mold **(120)** is 350°C to 1100°C.

FIG.1

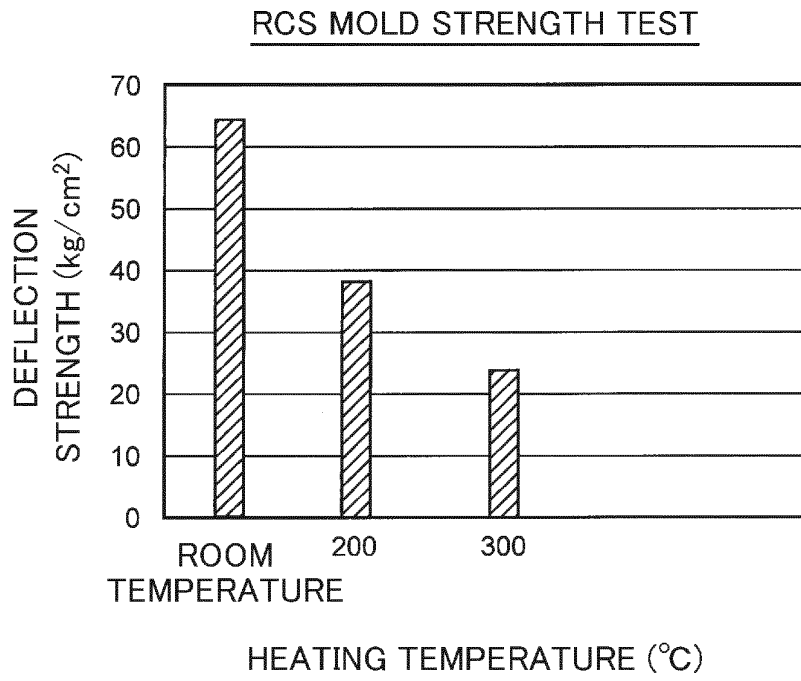


FIG.2

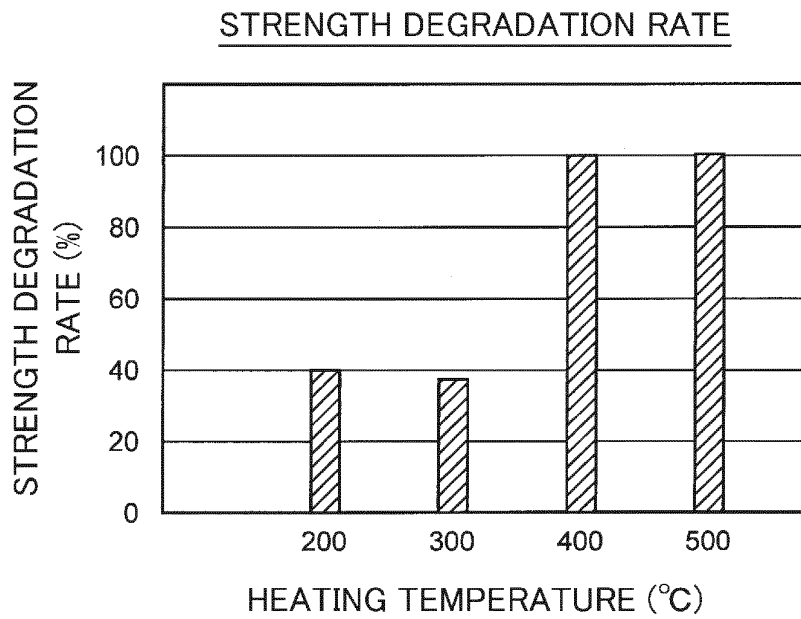


FIG.3

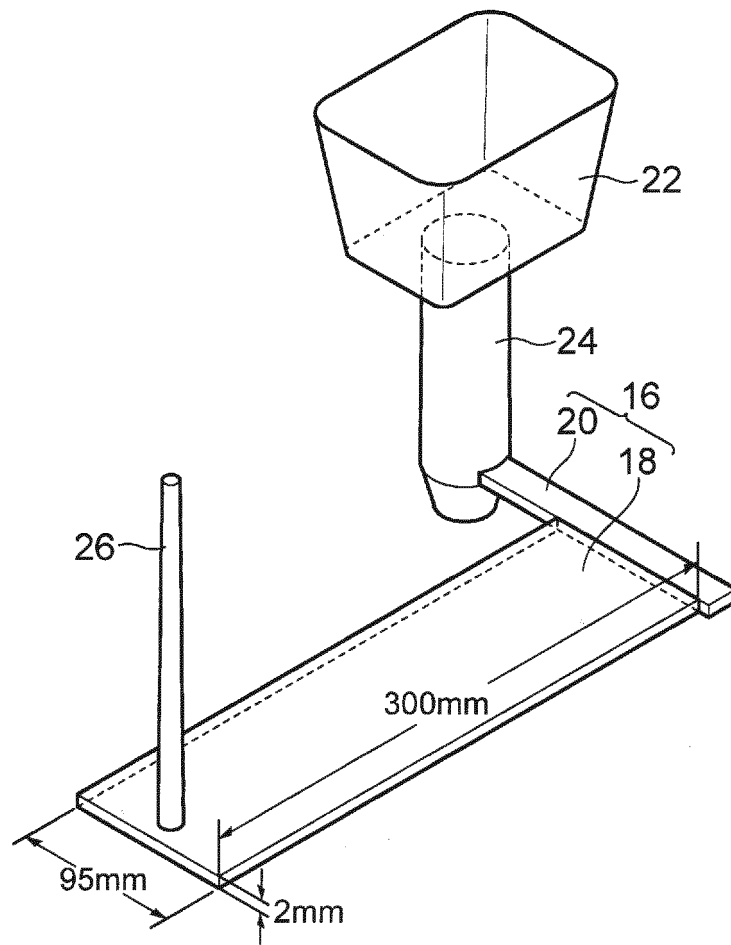


FIG.4

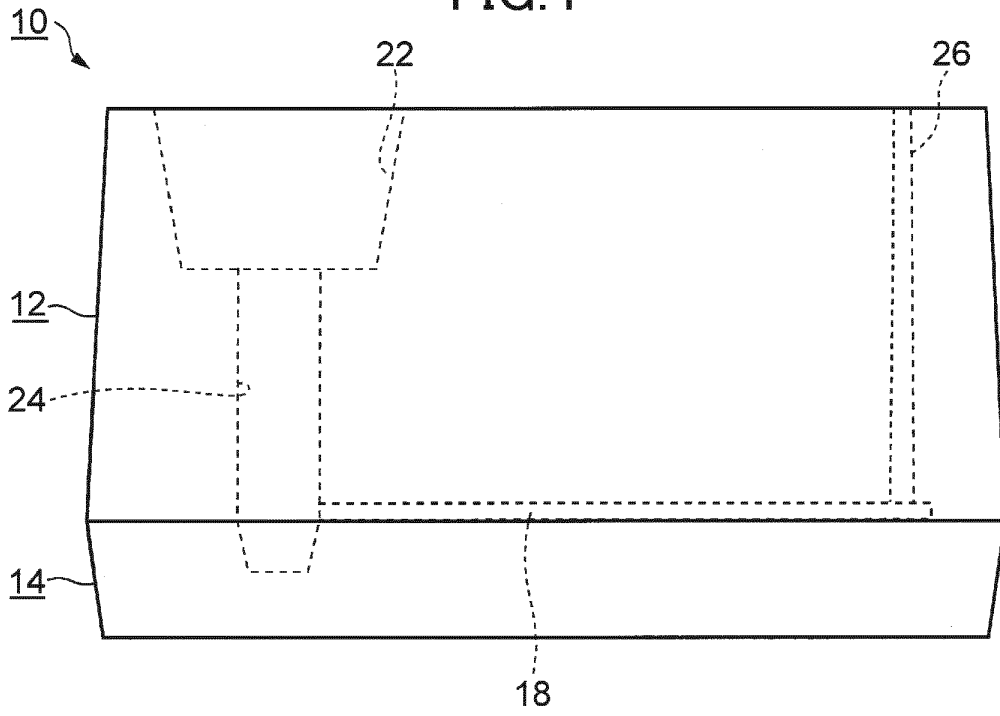


FIG.5

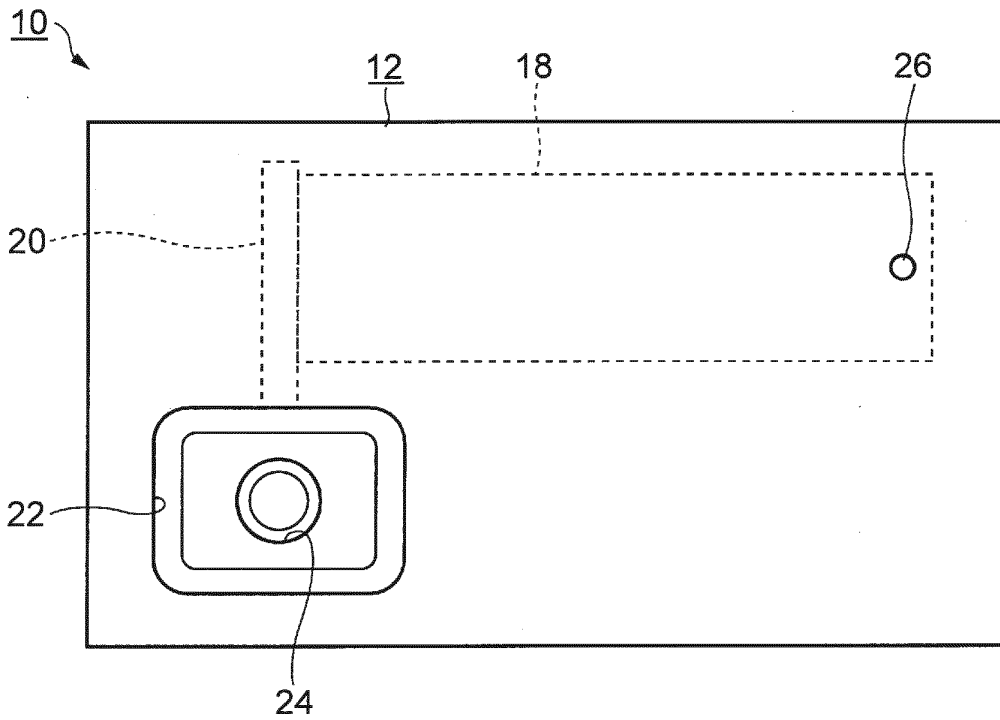


FIG.6

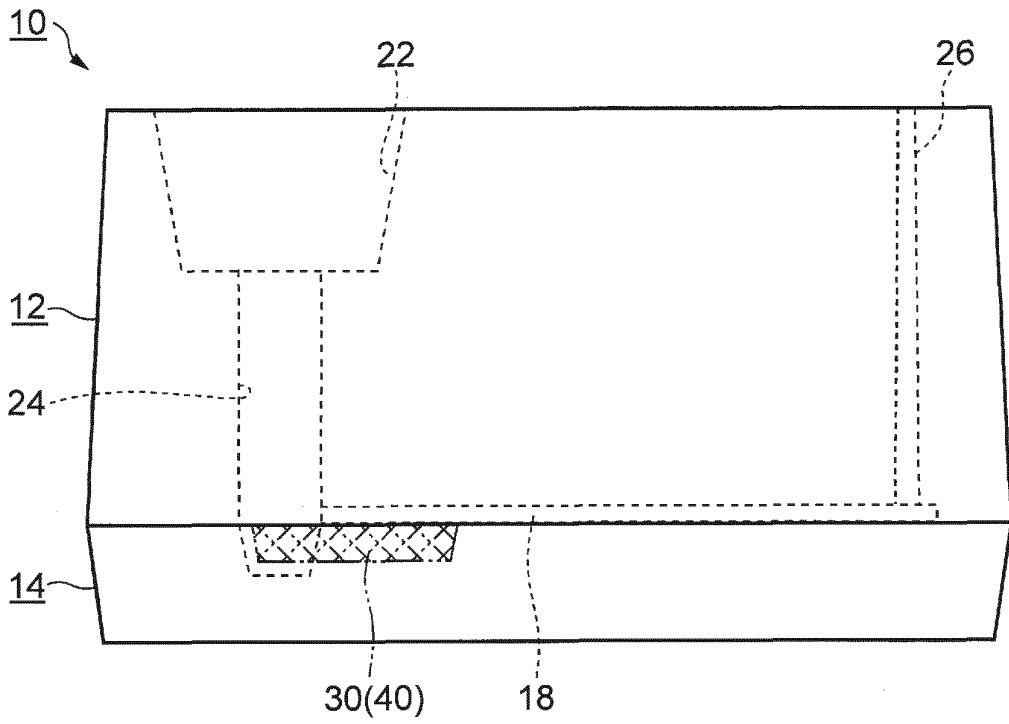


FIG.7

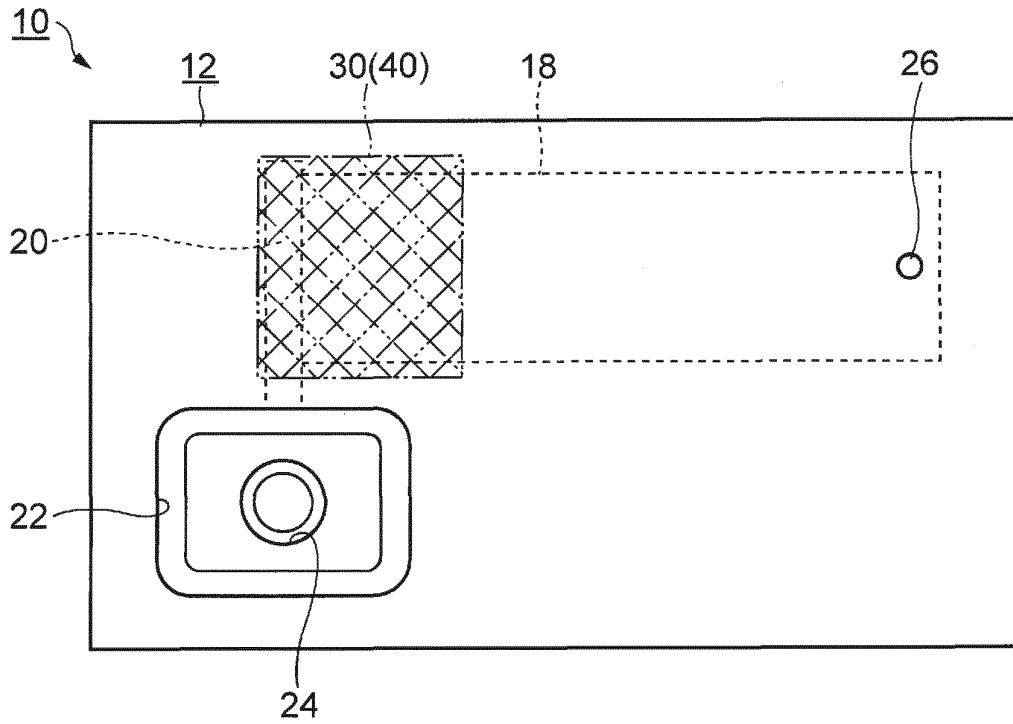


FIG.8

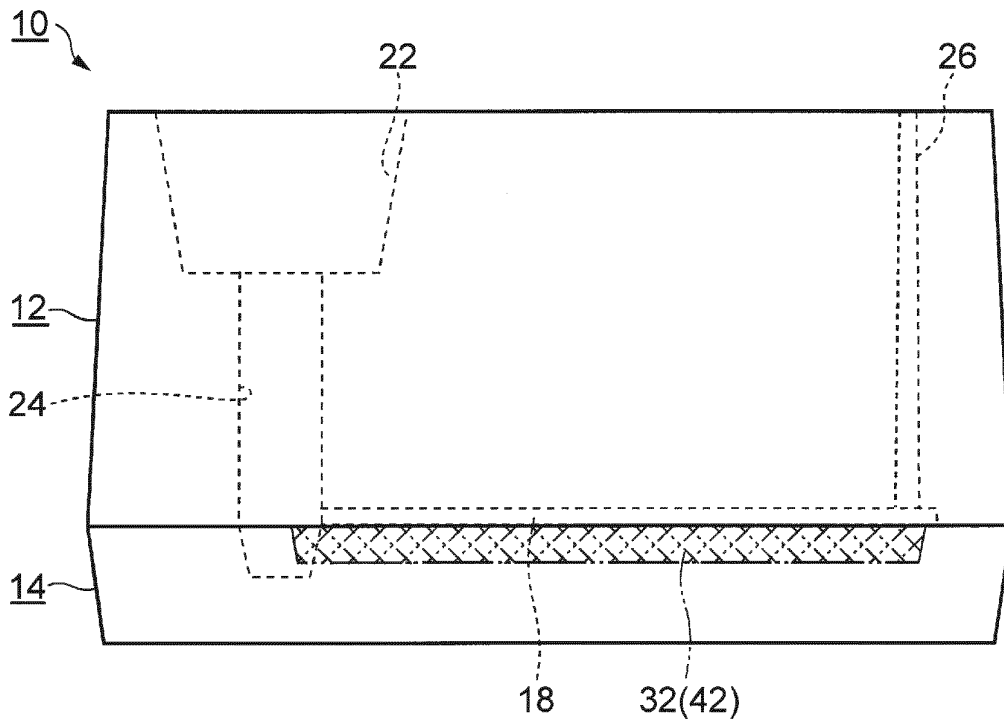


FIG.9

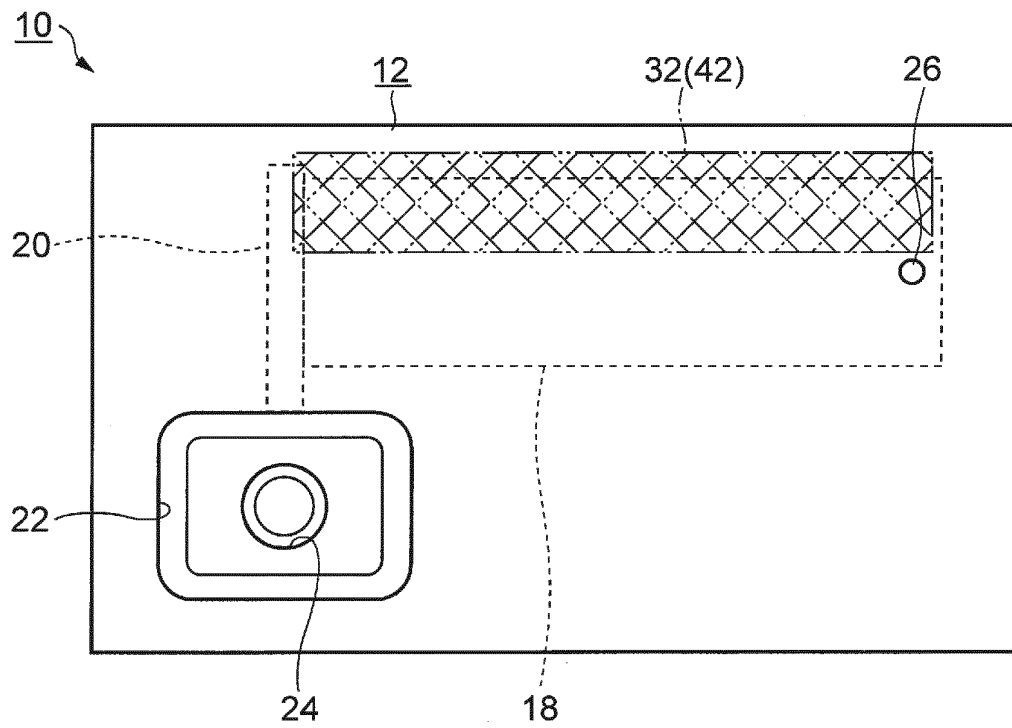


FIG.10

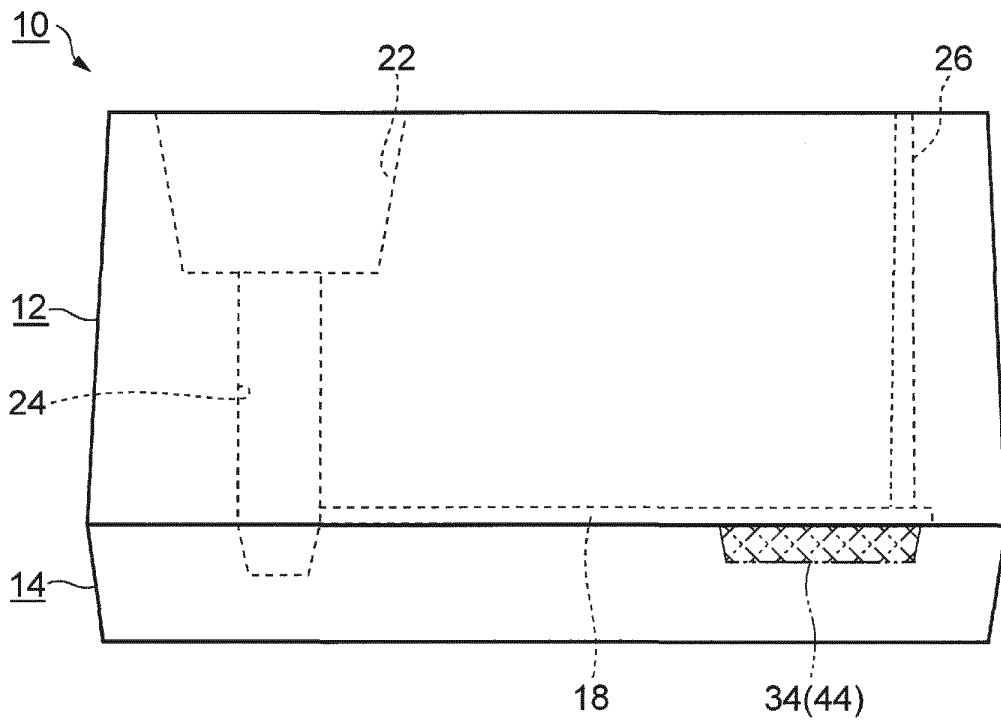


FIG.11

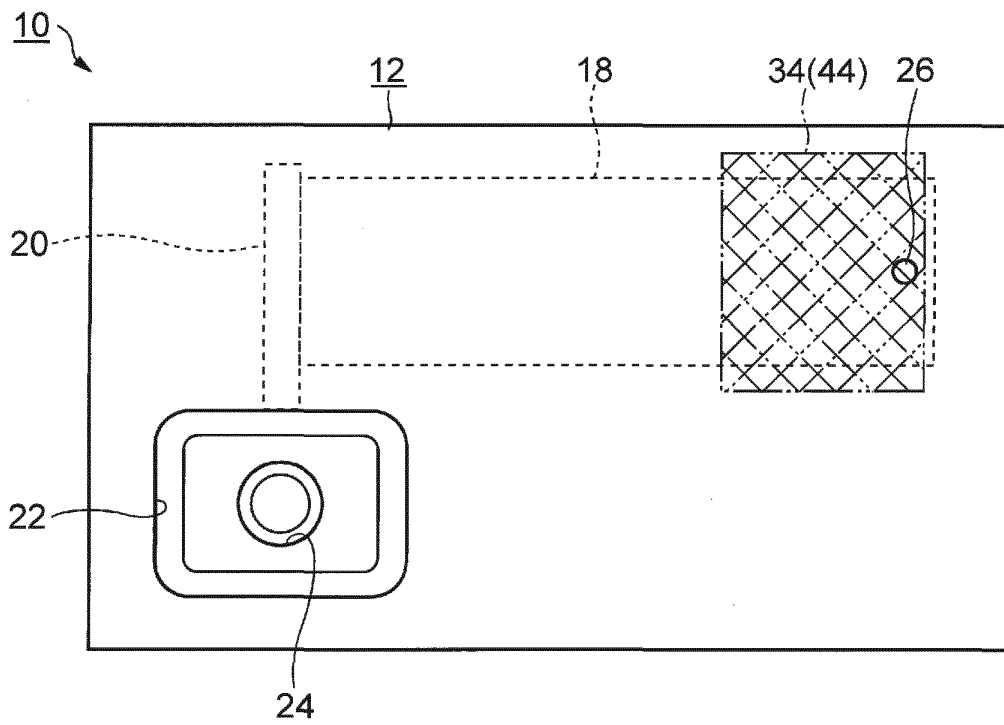


FIG.12

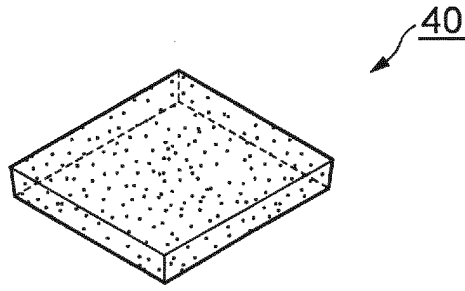


FIG.13

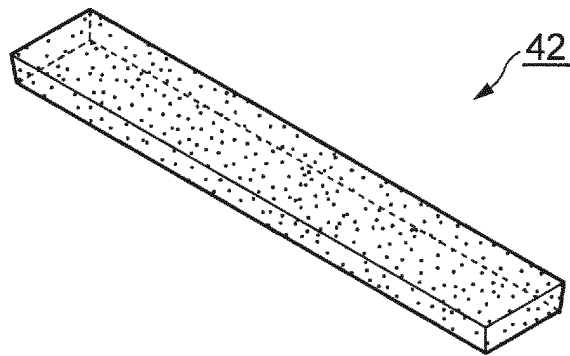


FIG.14

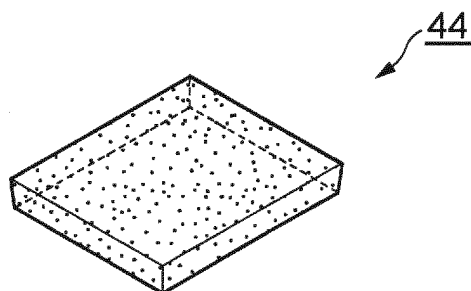


FIG.15

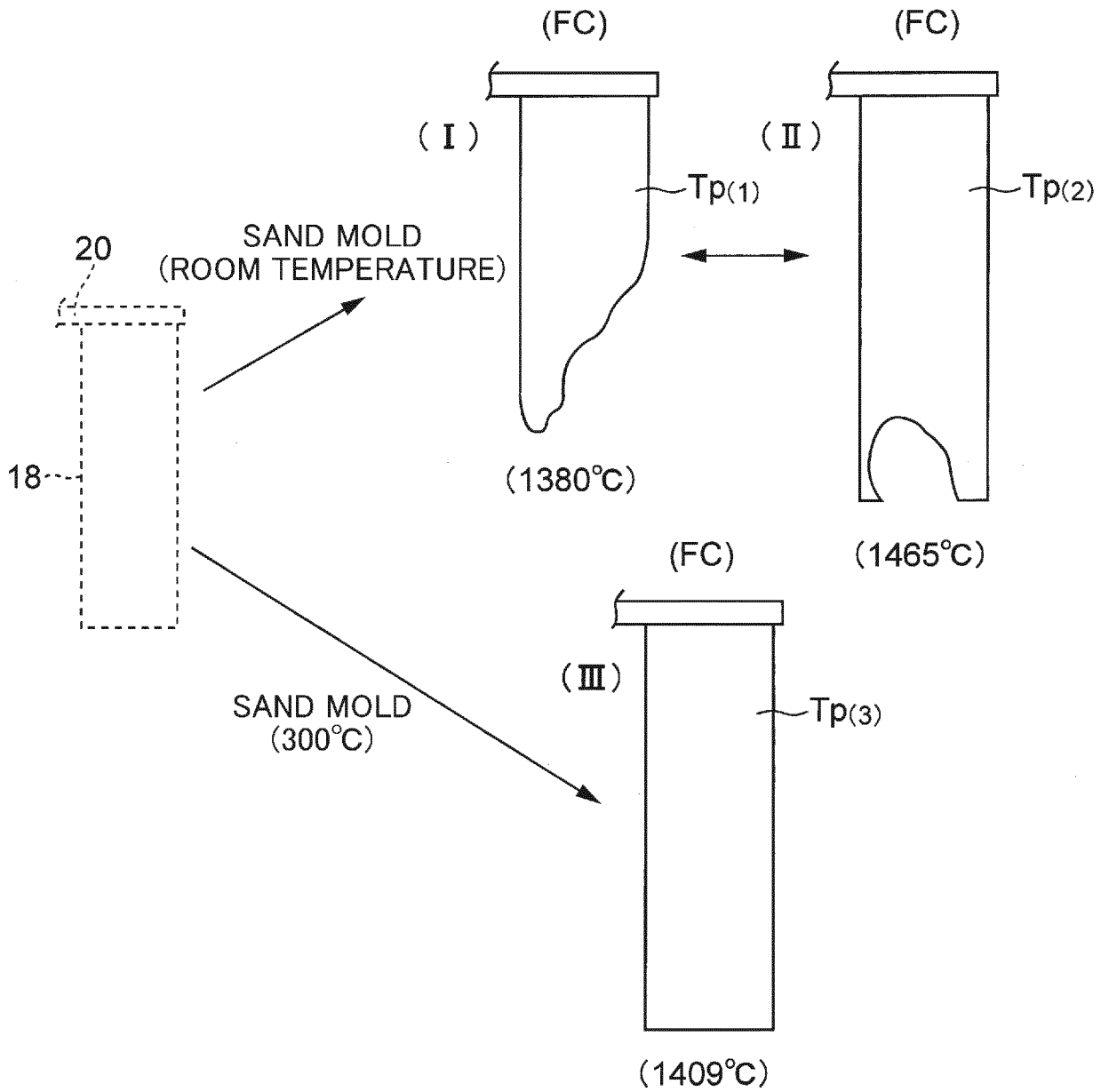


FIG.16

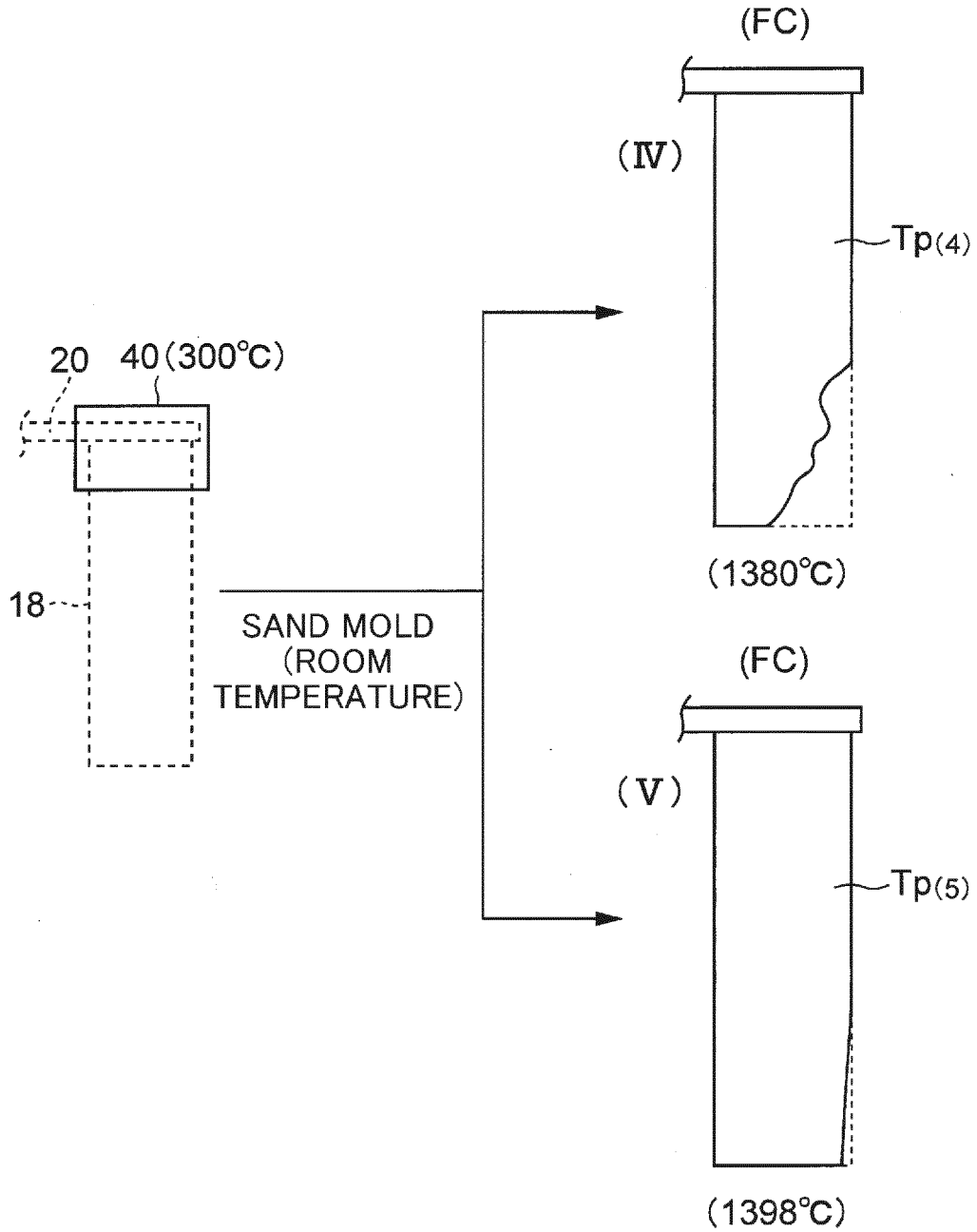


FIG.17

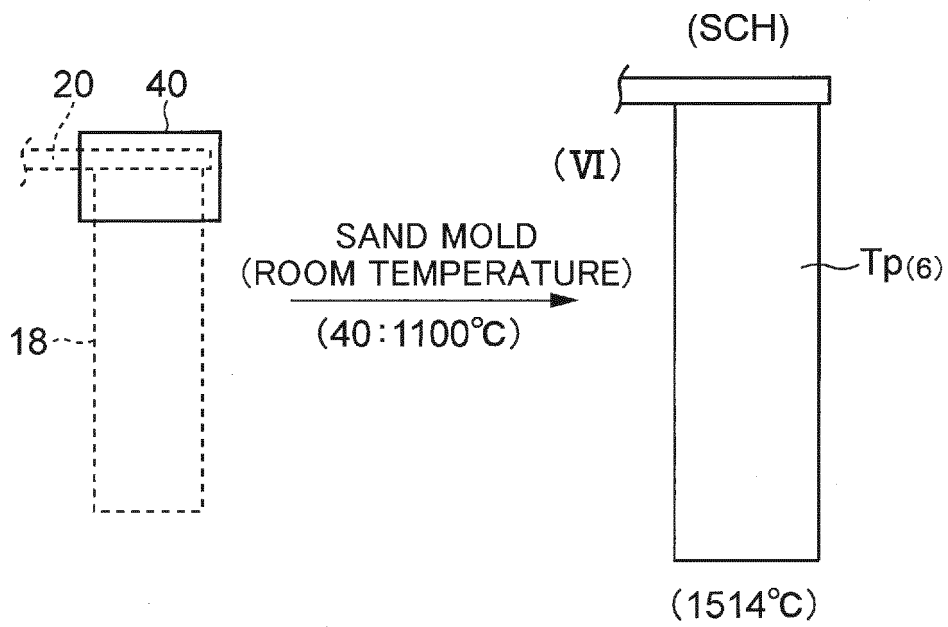


FIG.18

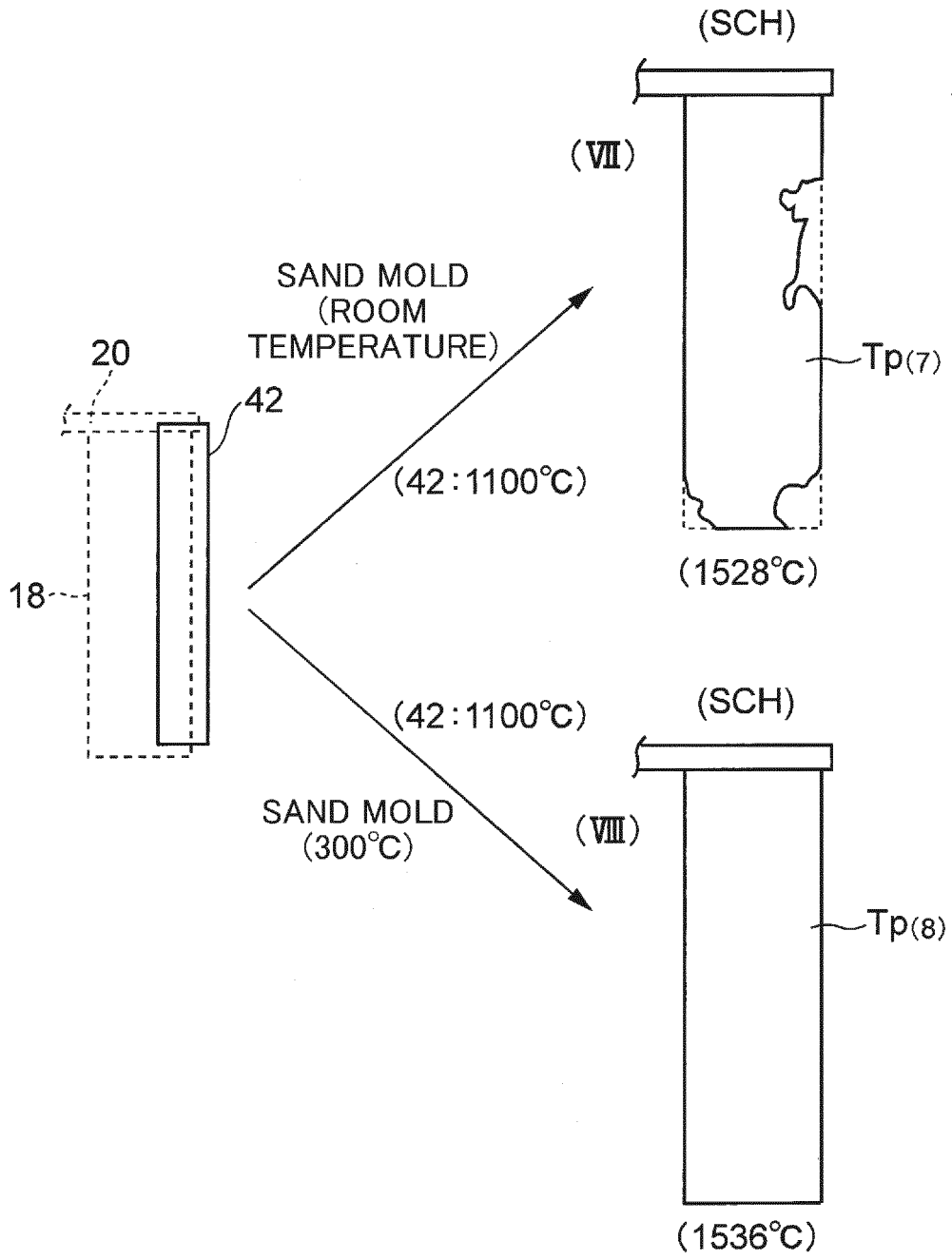


FIG.19

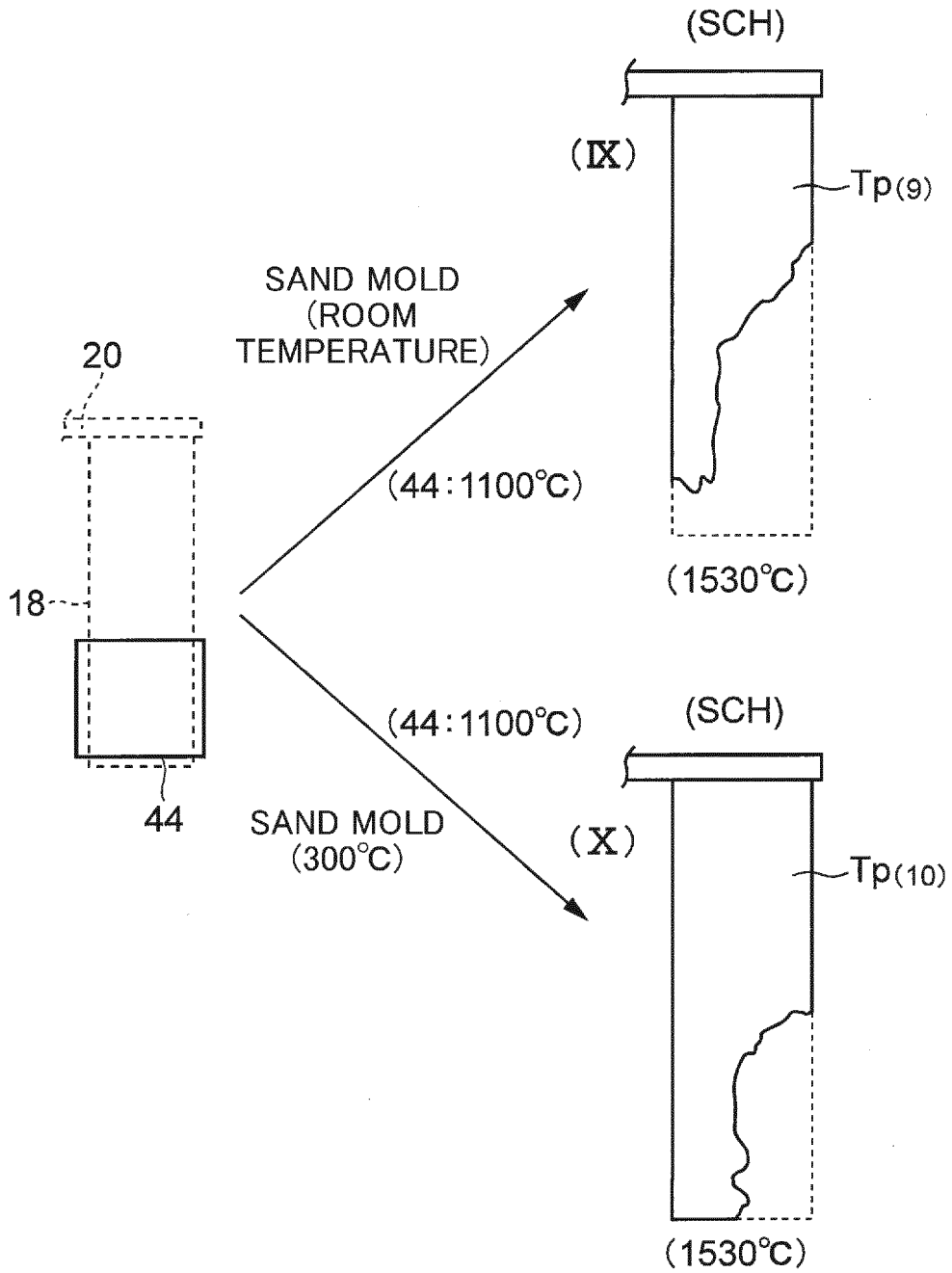


FIG.20

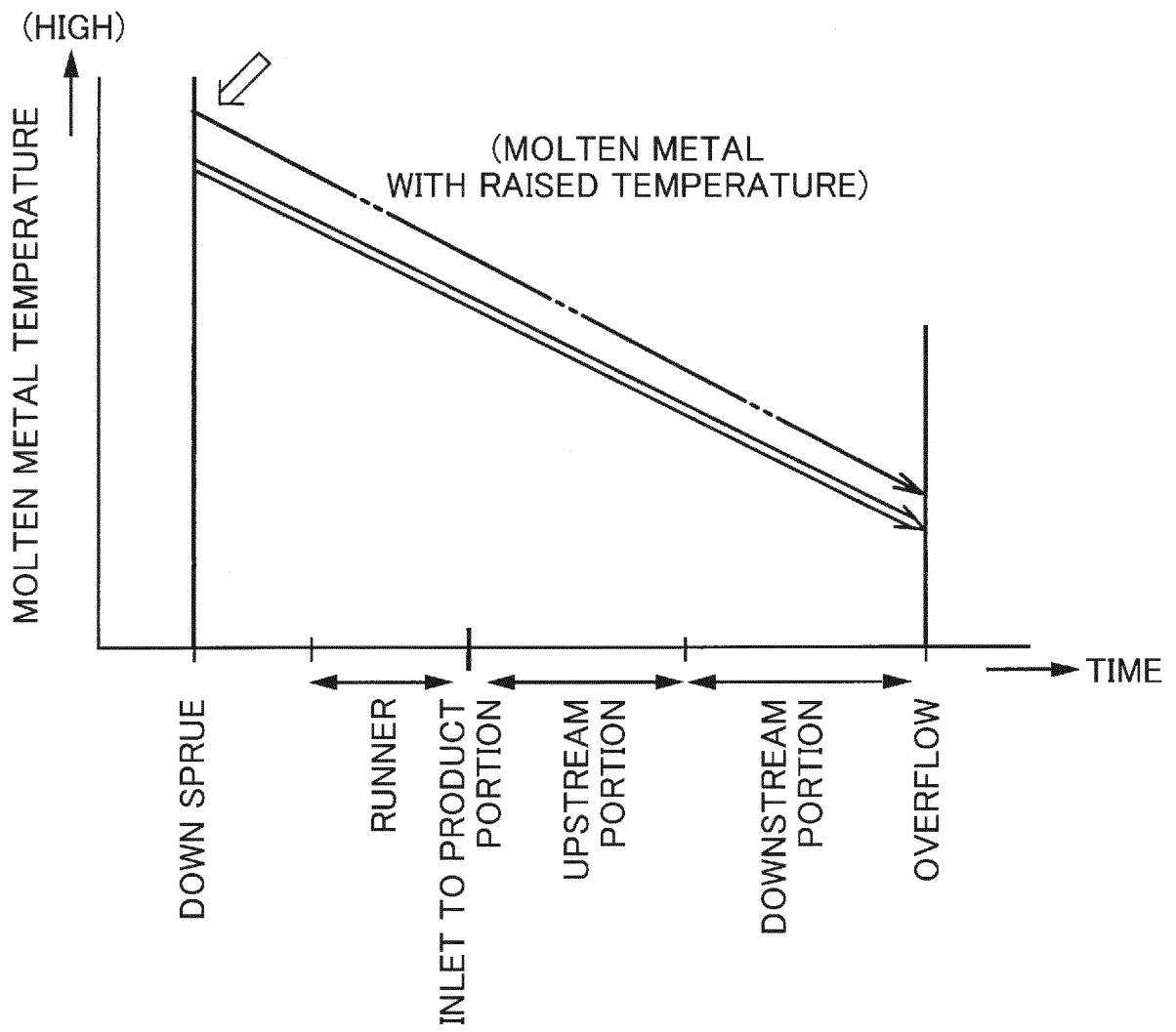


FIG.21

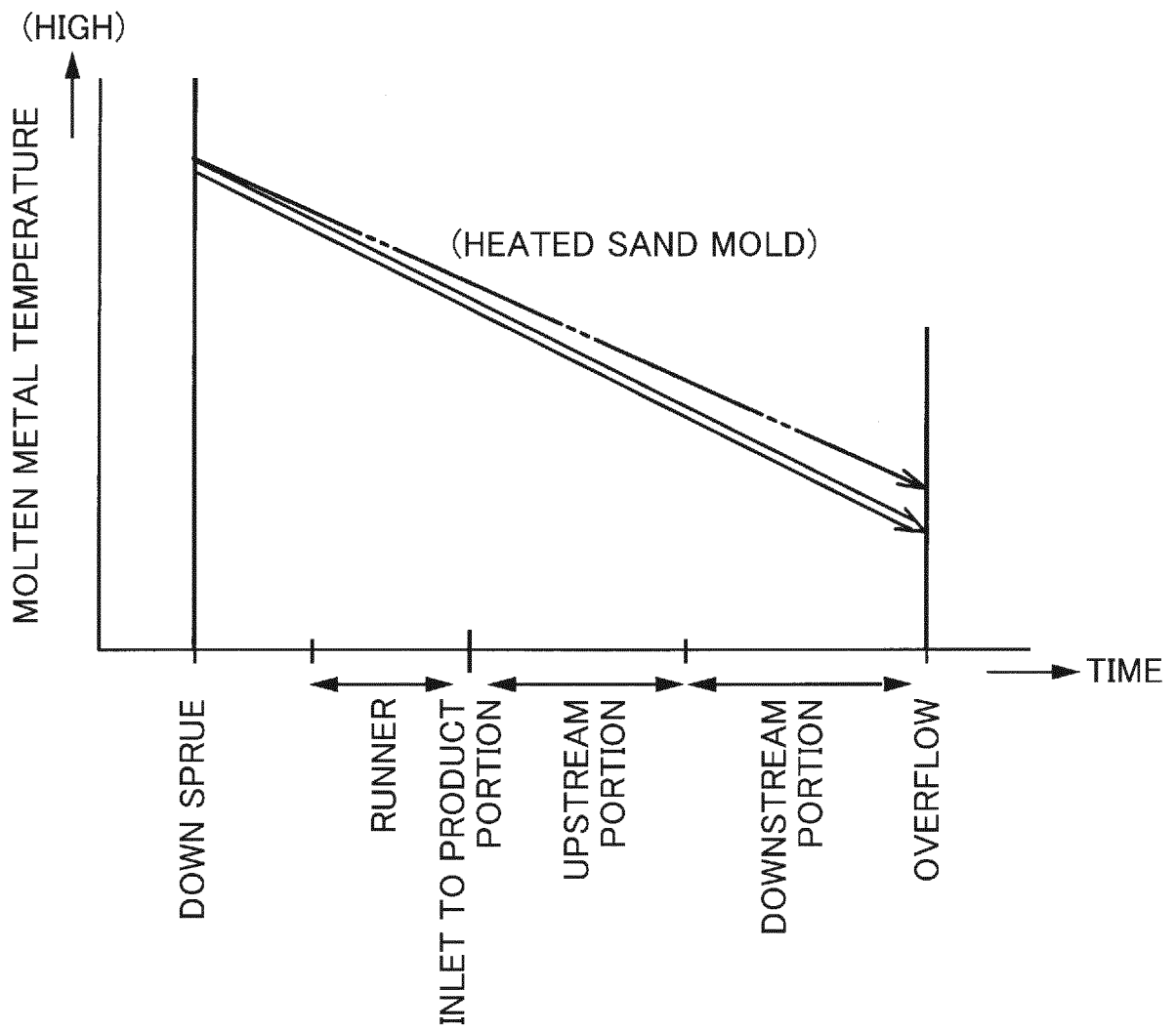


FIG.22

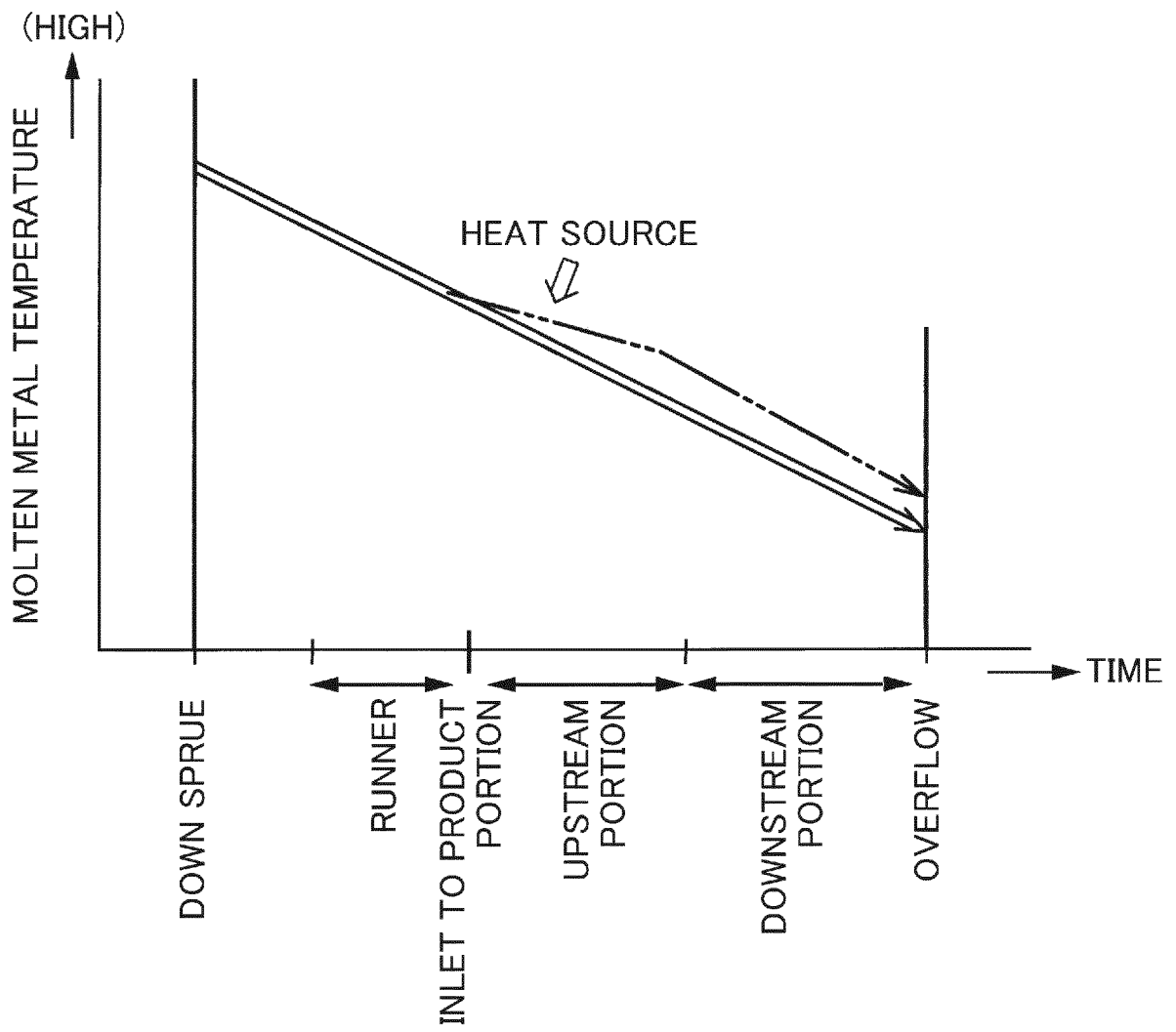


FIG.23

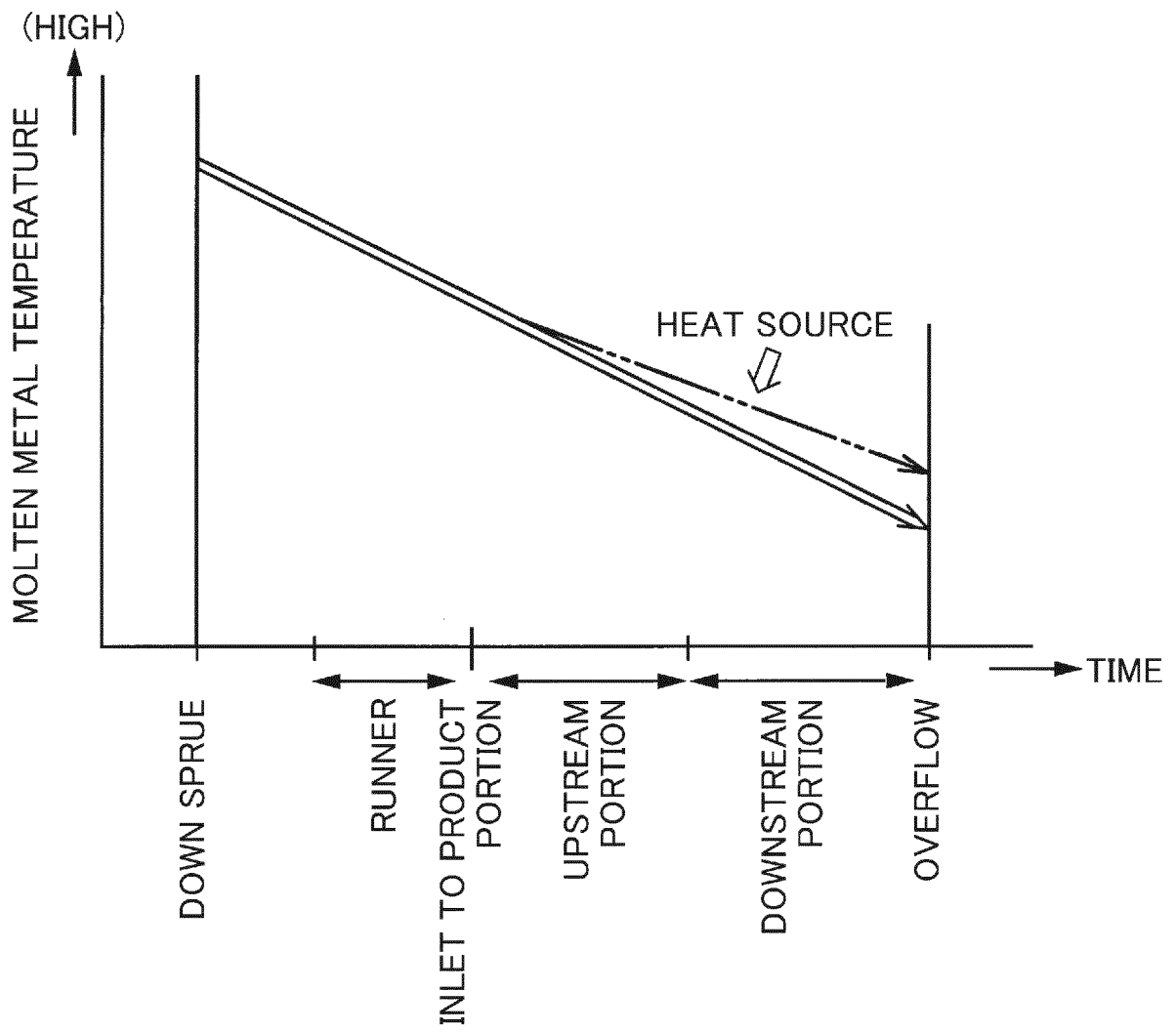


FIG.24

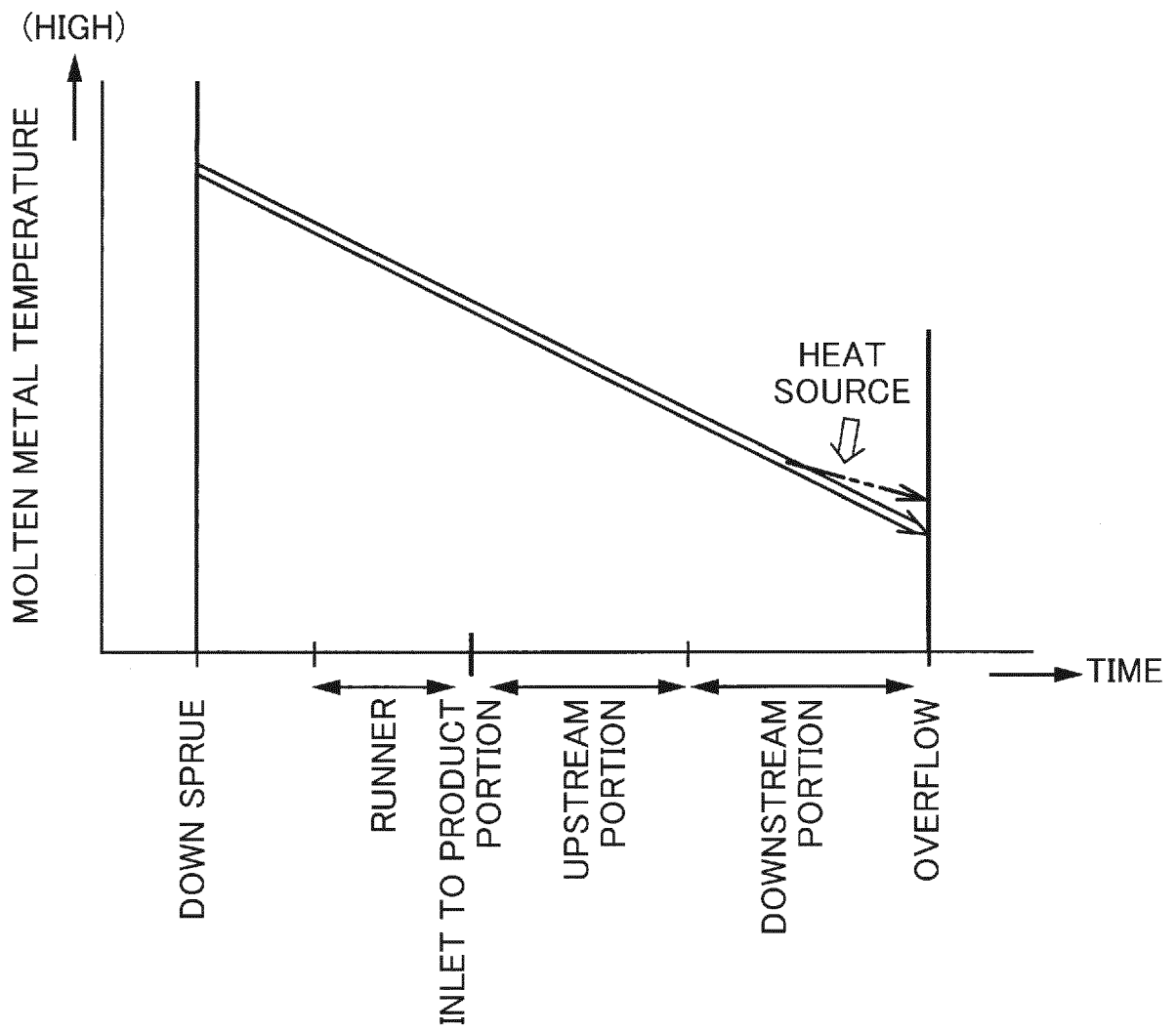


FIG.25

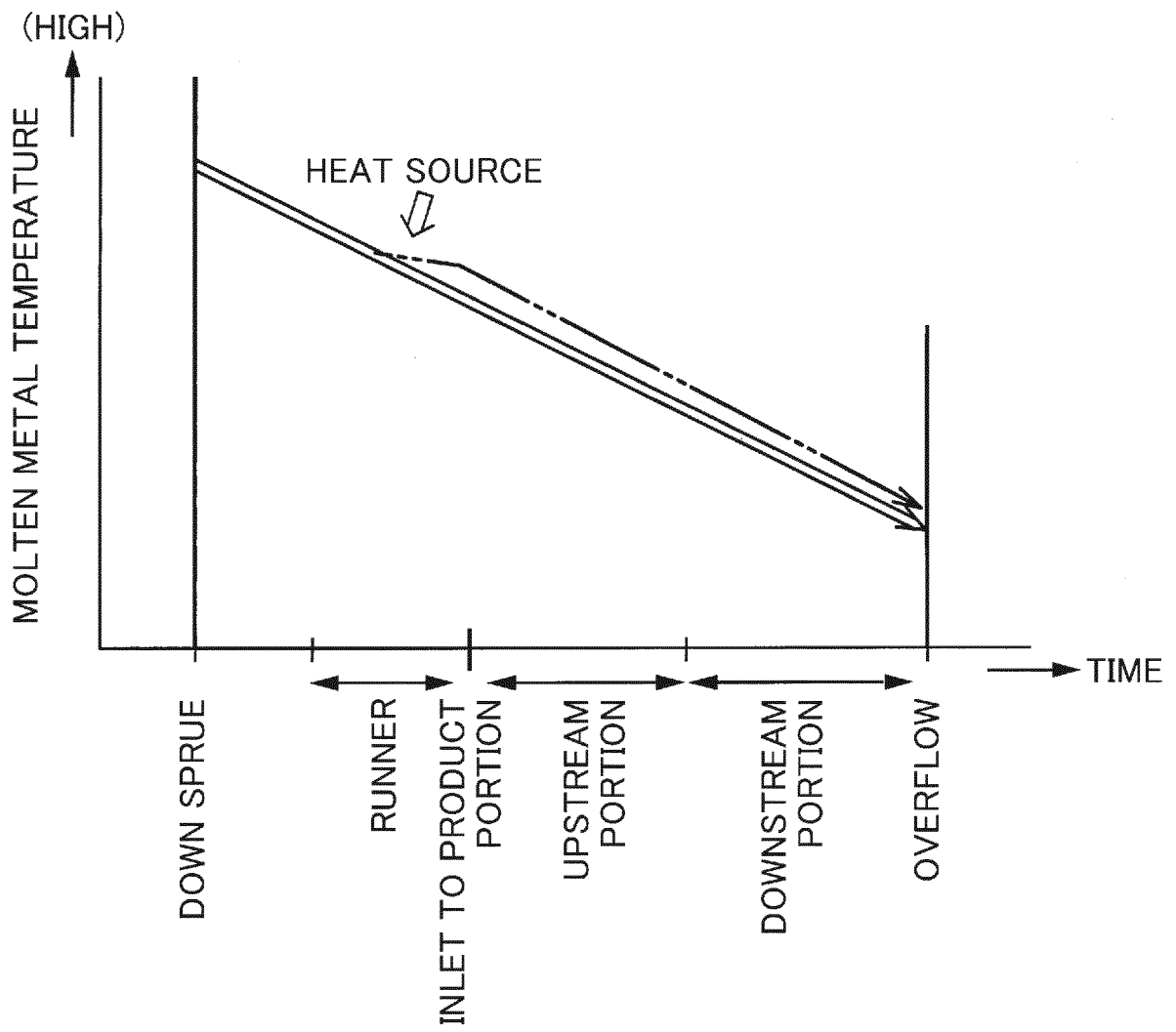


FIG.26

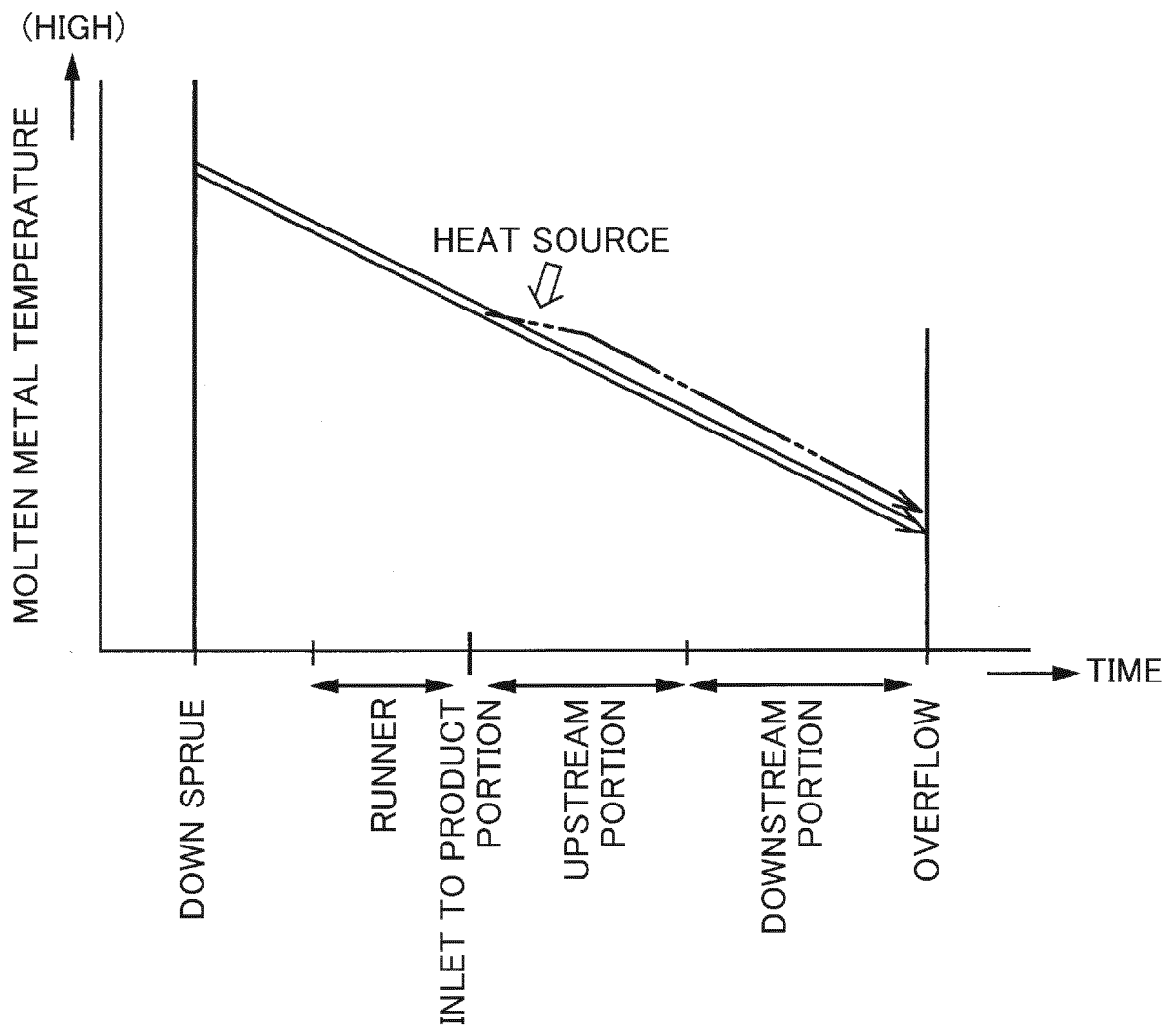


FIG.27

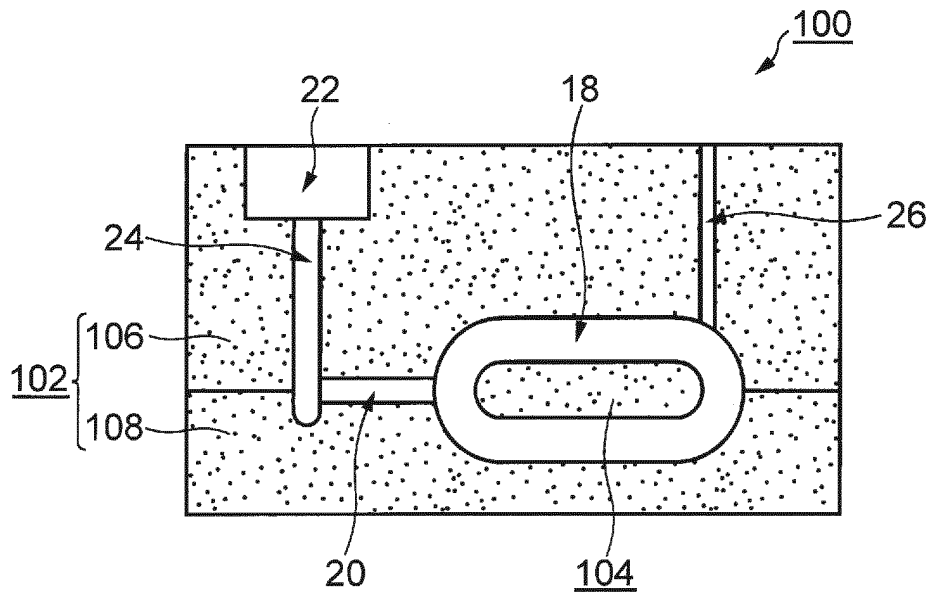


FIG.28

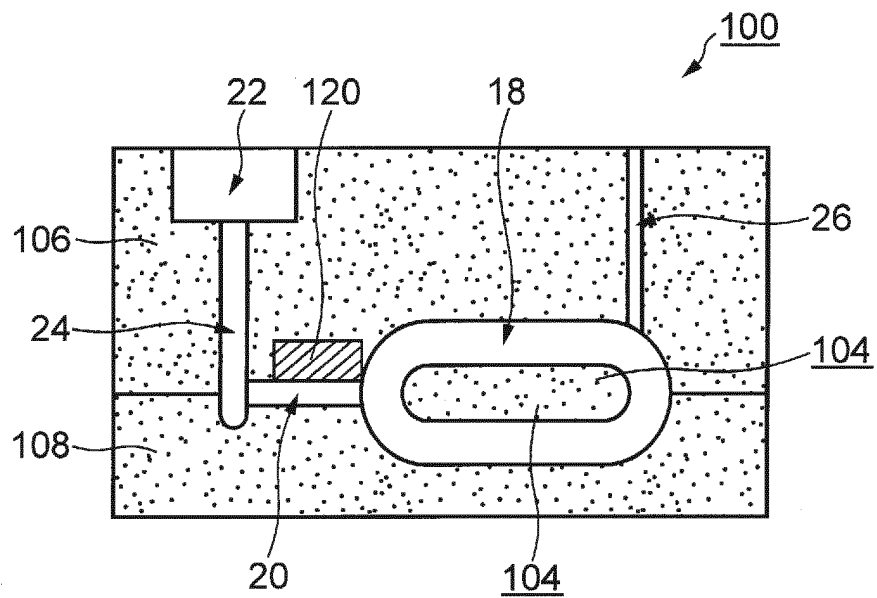


FIG.29

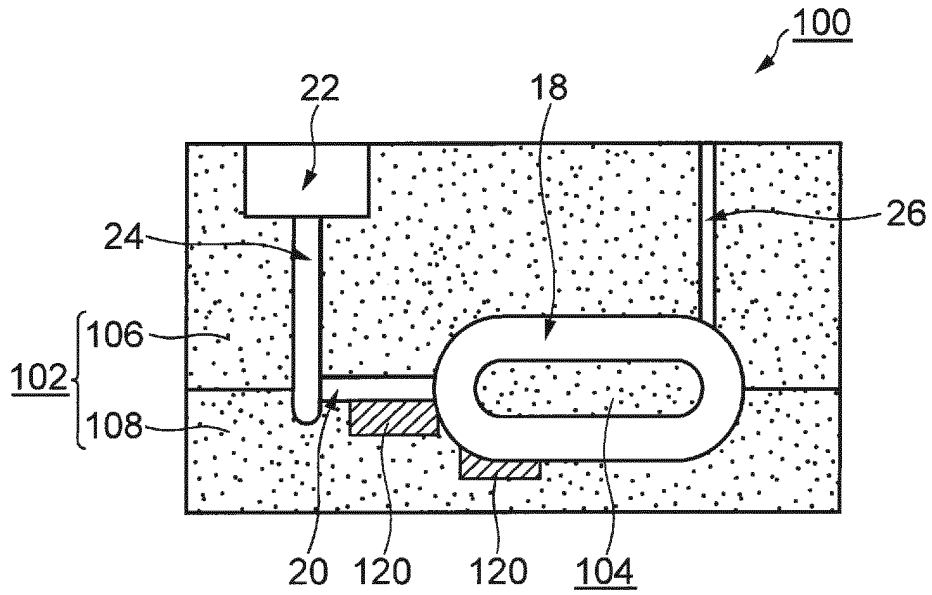


FIG.30

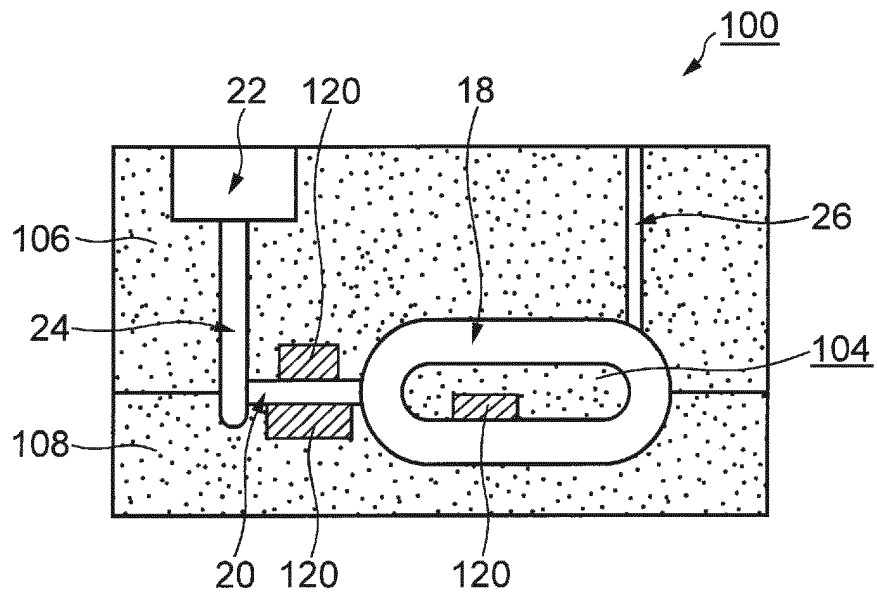


FIG.31

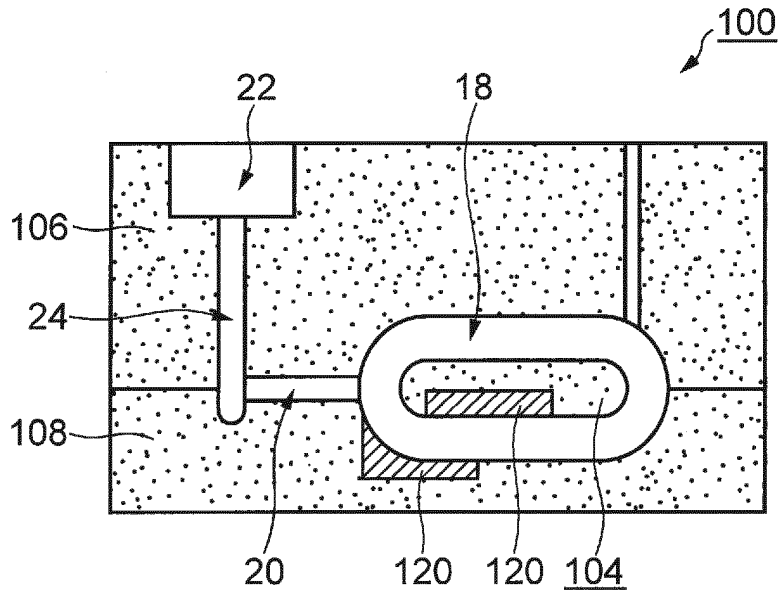
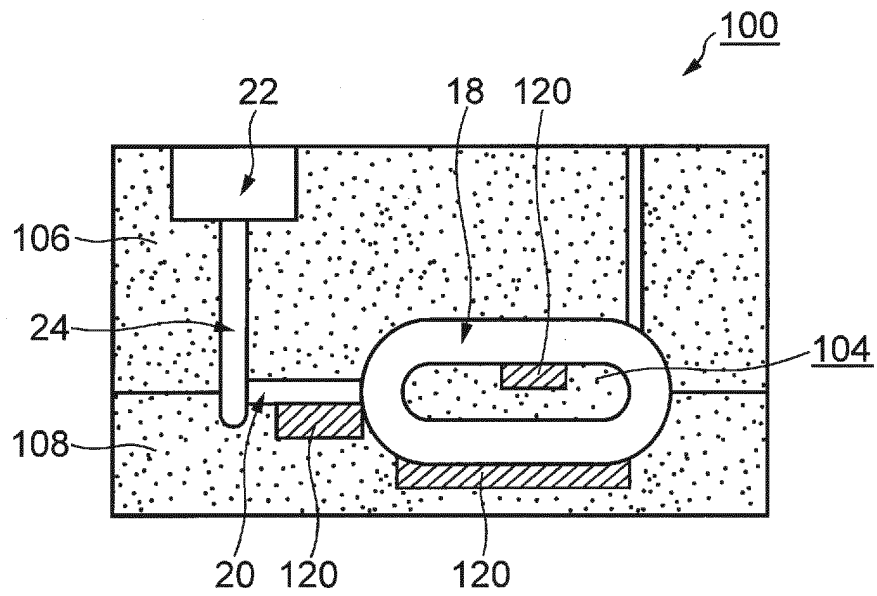


FIG.32



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/057416

A. CLASSIFICATION OF SUBJECT MATTER

B22C9/02(2006.01) i, B22C9/08(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B22C9/02, B22C9/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 56-500681 A (Foseco International Ltd.), 21 May 1981 (21.05.1981), claims & GB 2063126 A & EP 30940 A & WO 1980/002811 A1 & DE 3045300 A & AU 5991280 A & ES 492411 A & BR 8008710 A & CA 1128255 A & IT 8067928 A & ZA 8002394 A & IT 8067928 D & KR 10-1984-0000602 B1 & AU 534430 B & IT 8067928 A0	1-8
A	WO 2011/154561 A1 (IBERIA ASHLAND CHEMICAL, S.A.), 15 December 2011 (15.12.2011), entire text & US 2013/0139994 A1 & EP 2581149 A1	1-8

 Further documents are listed in the continuation of Box C.
 See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
02 June, 2014 (02.06.14)Date of mailing of the international search report
17 June, 2014 (17.06.14)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2-160163 A (Toyota Motor Corp.), 20 June 1990 (20.06.1990), claims; fig. 1 (Family: none)	1-8
A	JP 3-133538 A (Hitachi Metals, Ltd.), 06 June 1991 (06.06.1991), claims (Family: none)	1-8
A	JP 8-332547 A (Juki Corp.), 17 December 1996 (17.12.1996), claims (Family: none)	1-8
A	JP 2012-236230 A (Cadic Corp., Techno-Metal Co., Ltd.), 06 December 2012 (06.12.2012), entire text & JP 2010-42985 A	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7090502 A [0007]
- JP 3139918 B [0007] [0022]
- JP 2010042985 A [0007]
- JP 2012035269 A [0007]
- JP 2002143983 A [0007]