(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 092 491 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(43) Date of publication:
18.04.2001 Bulletin 2001/16

(21) Application number: **00913044.4**

(22) Date of filing: **31.03.2000**

(51) Int. Cl.[7]: **B22D 29/00**, B22D 29/04, B22C 5/00

(86) International application number:
PCT/JP00/02101

(87) International publication number:
WO 00/59659 (12.10.2000 Gazette 2000/41)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **01.04.1999 JP 9460199**
17.08.1999 JP 23053099
19.08.1999 JP 23276699
08.09.1999 JP 25396899

(71) Applicant: **Sintokogio, Ltd.**
Nagoyashi, Aichi 450-0002 (JP)

(72) Inventors:
- **Masuno, Osamu,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Kanayama, Ryoji,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Mori, Kuniyasu,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Yamamoto, Shigeaki,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Kaneto, Kimikazu,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Tokita, Hiroaki,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Ono, Yasushi,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Sugimoto, Kazuo,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Harada, Hisashi,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Matsumoto, Takehiko,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)
- **Yoshida, Yasunori,**
  Sintokogio, Ltd.
  Toyokawa-shi, Aichi 442-0061 (JP)

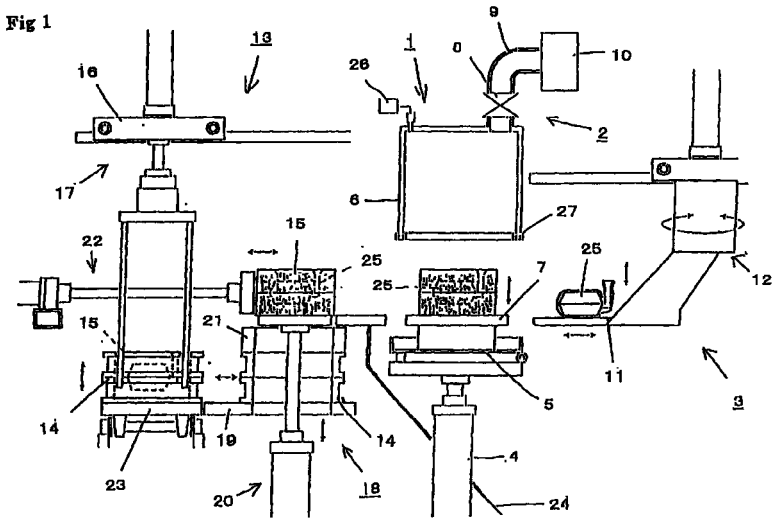
(74) Representative:
Behrens, Dieter, Dr.-Ing.
Wuesthoff & Wuesthoff
Patent- und Rechtsanwälte
Schweigerstrasse 2
81541 München (DE)

(54) METHOD FOR SEPARATING GREEN SAND MOLD AND AS-CAST PRODUCT AND APPARATUS THEREFOR

(57) An as-cast mold and a green-sand mold can be surely separated. Also, a green-sand mold can be surely broken. The green-sand mold that has been filled with a melted material and that does not have a flask is gas-tightly surrounded. The pressure in a structure gas-tightly surrounding the green-sand mold is reduced within a period of 0.5 second to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less, thereby reducing the boiling temperature of the water being present within the entire green-sand mold, including a condensed moisture layer formed around the as-cast product in the green-sand mold, to bring this water to a boil, so that the green-sand mold is broken and separated from the as-cast product, and to restore the original pressure of the structure to take out the as-cast product.

EP 1 092 491 A1

Fig 1


13
1
9
10
26
8
2
16
17
6
27
22
15
25
25
7
25
12
15
21
11
3
14
19
14
5
4
23
20
18
24

Description

Field of Invention

[0001] This invention relates to a proper method and apparatus for separating an as-cast product from a green-sand mold that has been supplied with a melted material

Background

[0002] As conventional methods for separating a green-sand mold that has been supplied with a melted material and that has a flask from an as-cast product after the green-sand mold is broken, these methods have been generally known: for example, 1) a method for taking a green-sand mold out of a flask, and then using the falling impact on the green-sand mold caused by the gravity or a vibrator, so that the green sand mold is broken and separated from an as-cast product by the weight of the green-sand mold and the vibrations of the vibrator; 2) a method for using impacts given by mechanical forces caused by, for example, inserting a wedge-like projection into a green-sand mold when a green-sand mold is taken out of a flask, so that the green-sand mold is broken and separated from an as-cast product, and 3) a method for taking a green-sand mold out of a flask to supply the green-sand mold into a rotating drum or a vibrating drum, so that the green-sand mold is broken and separated from an as-cast product by the weight or fall of the green-sand mold and its heat.

[0003] However, those methods use strong impacts on a green-sand mold and an as-cast product to separate them, so that they may cause the as-cast product to have defects such as breakages, chips, and deformations, essentially when the as-cast product contacts other products. Recently, since complications of shapes and high accuracy of dimensions of as-cast products are needed so that green-sand molds having high hardness and strength may be formed and cast, stronger forces are needed to separate the green-sand mold and the as-cast product.

[0004] Also, it is difficult to break the green-sand molds having high strength as stated above, so that the green-sand molds cannot be fully separated from the as-cast products. Then the as-cast products are conveyed to a following step with parts of the green-sand molds attached to the as-cast products. Thus, the efficiency of the retrieval of the green-sand molds has been low in a green-sand molding plant where the green sands are repeatedly used. Also, costs of the green sands increase. Core sands are mixed with the recycled sands so that the treatment of the sands becomes difficult Since a plurality of as-cast products are transmitted to a following processing step at the same time, the background of each product cannot be identified. Thus, when defective products are found, it is difficult to make a definite determination of the reasons for the defects. Thus, it is difficult to fully overcome their defects.

[0005] This invention was conceived to overcome those disadvantages. The object of this invention is to provide a method and apparatus for perfectly separating a green-sand mold and an as-cast product, and definitely breaking the green-sand mold.

Disclosure of Invention

[0006] To achieve that object; this invention provides a method and apparatus for separating an as-cast product from a green-sand mold that has been filled with a melted material. The method is characterized by the steps of gas-tightly surrounding a green-sand mold that has been filled with a melted material and that has no flask, rapidly aspirating the inner pressure in a structure gas-tightly surrounding the green-sand mold within a period of 0.5 second to reduce the pressure to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less, thereby reducing the boiling temperature of the water present within the entire green-sand mold that includes a condensed moisture layer formed around the as-cast product in the green-sand mold to bring this water to a boil, so that the green-sand mold is broken and separated from the as-cast product, and restoring the structure to the original pressure to take out the as-cast product.

[0007] Generally, around an as-cast product in an upper and lower green-sand mold a condensed moisture layer is formed, at which layer much moisture has a temperature higher than the other parts of the upper and lower green-sand mold due to the heat of the as-cast product. Thus, in this invention a green-sand mold that has been filled with a melted material and that does not have a flask is gas-tightly surrounded, and then the pressure in the structure gas-tightly surrounding the green-sand mold is rapidly reduced to a pressure of —200 mmHg or less within a period of 0.5 second as expressed in gauge pressure and finally to a pressure of —360 mmHg or less as expressed in gauge pressure. As a result, the boiling point of the water decreases, and the water heated by the as-cast product is boiled. Thus, the green-sand mold is broken and separated from the as-cast product. Then, this negative pressure condition is released and the as-cast product is taken out. The reason the pressure is rapidly reduced to a pressure of —200 mmHg or less within a period of 0.5 second is that if the pressure were slowly reduced, the gas generated in boiling would slowly be diffused from the green-sand mold, so that the enough forces to rapidly break the green-sand mold would not be generated. Also, another reason is that if the reduced pressure were higher than —360 mmHg, the boiling that could break the green-sand mold would not be generated.

[0008] In the method for separating a green-sand mold and an as-cast product of the invention of claim 1, a green-sand mold that has been filled with a melted

material and that does not have a flask means a mold that is separated from the flask of a green-sand mold that contains the flask just after a molding is made, or a mold that does not contain a flask just after a molding is made.

Brief Description of Drawings

[0009]

Fig. 1 is a front view of an embodiment of this invention.
Fig. 2 is a view to explain the working of the embodiment of Fig. 1.
Figs. 3 and 4 are views to explain the workings of the main part of the embodiment of Fig. 2.
Fig. 5 is a graph indicative of the pressure conditions during the suction and decompression in a structure in relation to the progress over time.
Fig. 6 is a front view of the second embodiment of this invention.
Fig. 7 is a view to explain the working of the embodiment of Fig. 6.
Fig. 8 is an expanded plan view of the main part of the embodiment of Fig. 6.
Fig. 9 is an expanded front view of the main part of the embodiment of Fig. 6.
Figs. 10 and 11 are views to explain the workings of the main part of the embodiment of Fig. 6.

Preferred Embodiment of Invention

[0010] Now, based on Figs. 1 and 2 an embodiment of this invention is detailed. As in Fig. 1, an apparatus for separating an as-cast product from a green-sand mold that has been filled with a melted material is comprised of an airtight-surrounding member 1 to air-tightly surround a green-sand mold that has been filled with a melted material and that does not have a flask, a suction member 2, which exhausts and decompresses the space that is defined by the airtight-surrounding member 1 to a negative pressure condition, and which member maintains the negative-pressure condition over a certain time, and a taking-out member 3, which takes the as-cast product out of the green-sand mold that has been broken after the negative-pressure condition is restored.

[0011] As in Fig. 1, the airtight-surrounding member 1 is comprised of a box-like tray 5, which can be lifted up or down by a cylinder 4, and a reversely-positioned box-like cover 6, which is fixed above the tray 5. A base member 7 is positioned on the tray 5. On the base member a green-sand mold is put. The base member is comprised of a plurality of belt-like plates that are arranged in the right and left directions in Fig. 1. The tray 5 and the base member 7 can be rotated counterclockwise and inclined at an angle so that a green-sand mold may slide on the member 7. A pressure-detection mechanism 26 is located on the cover 6 to sense the inner pressure of it. A sealing member 27 is embedded at the lower end of the cover 6. Also, the suction member 2 is connected to the cover 6. The suction member 2 includes a valve 8, a conduit 9, and a vacuum source 10.

[0012] The taking-out member 3 is comprised of a fork member 11, which can be moved up, down, right, and left; and rotated horizontally, and a driving mechanism 12, which moves the fork member 11 right, left, up, and down, and rotates it horizontally.

[0013] The number 13 denotes a transmitting apparatus to horizontally carry a set of upper and lower green-sand molds 15, having a set of upper and lower flask 14. The transmitting apparatus 13 is comprised of a moving carriage 16, which can be reciprocated in the right and left directions in Fig. 1, and a lifting mechanism 17, which is located on the moving carriage 16 to lift the upper and lower flasks 14. The number 18 denotes a taking-out apparatus to take the upper and lower green-sand molds 15 out of the upper and lower flasks 14. The taking-out apparatus is comprised of a cast base 19, on which the upper and lower flasks 14 are put, a taking-out mechanism 20, which takes the upper green-sand molds 15 out of the upper and lower flasks 14, and a stopper 21, to prevent the upper and lower flasks 14 from rising. The number 23 denotes a surface-table carrier. The number 24 denotes a chute for recycling material.

[0014] Next, the function of the system constructed above is explained. The upper and lower green-sand molds 15 having the upper and lower flasks 14 that have been filled with a melted material are put on the surface-table carrier 23 and are conveyed through a cooling line of this casting line. The upper and lower green-sand molds 15 are lifted by the lifting mechanism 17 of the transmitting apparatus 13, and transmitted to the base 19 of the taking-out apparatus 18. Then, the upper and lower green-sand molds 15, including the as-cast product 25, are taken out of the upper and lower flasks 14 by the taking-out mechanism 20 of the taking-out apparatus 18. Then, the upper and lower green-sand molds 15, which have been taken out of the upper and lower flasks 14, are pushed and put on the base member 7 of the airtight-surrounding member 1 by an extruding apparatus 22. Then, the base member 7, on which the upper and lower green-sand molds 15 are located, is lifted by extending the cylinder 4 of the airtight-surrounding member 1 to contact the sealing member 27 with the tray 7, so that, as in Fig. 2, the upper and lower green-sand molds 15 are gas-tightly surrounded by the tray 5 and the cover 6.

[0015] Generally, as in Fig. 3, a layer (a moisture-condensed layer) 28 is formed around the as-cast product 25 in the upper and lower green-sand molds 15. Much moisture is condensed at the layer. The moisture is higher in temperature than the other parts of the upper and lower green-sand molds 15 due to the heat of

the as-cast product 25. Thus, the moisture-condensed layer 28 is weak. While the pressure in the cover 6 is sensed by the pressure-detection mechanism 26, the valve 8 of the suction member 2 is opened to abruptly exhaust the airtight space defined by both the tray 5 and the cover 6 and reduce its pressure such that the space is changed to a negative pressurized condition. That is, as in Fig. 5, the inner pressure in the structure forming the space is rapidly aspirated to reduce the pressure to a pressure of —200 mmHg or less as expressed in gauge pressure within a period of 0.5 second and finally to a pressure of —360 mmHg or less as expressed in gauge pressure (below, all the pressure is referred to in gauge pressure). The reason the pressure is rapidly reduced to a pressure of —200 mmHg or less within a period of 0.5 second is that if the pressure were slowly reduced, gas generated by the boiling would be slowly diffused from the green-sand mold, so that the forces that would be generated would not be enough to rapidly break the green-sand mold. Also, another reason is that if the reduced pressure were higher than —360 mmHg, the boiling that could break the green-sand mold would not be generated. When the pressure in the space is reduced, the boiling point of the moisture included in the entire green-sand mold 15 that includes the condensed moisture layer 28 decreases, so that the moisture is boiled away. Thus, the green-sand molds 15 are broken and separated from the as-cast product 25 (as in Fig. 4). The pieces of the broken green-sand molds are deposited on the tray 5. A core sand is not broken by the boiling. Thus, the core sand is kept in the as-cast product 25, so that it is never mixed with the pieces of the green-sand mold.

[0016] Then, after the valve 8 is closed, an atmospheric-pressure restoring valve (not shown) that is located on the cover 6 is opened to restore the pressure in the cover 6 to the atmospheric pressure. Then, the cylinder 4 is retracted to move down the tray 5, the upper and lower green-sand molds 15, the as-cast product 25, etc. Then, the driving mechanism 12 of the taking-out member 3 for as-cast products is driven to move the fork member 11 leftward in relation to Fig. 1 and below the as-cast product 25. Then, the driving mechanism 12 is driven to raise the fork member 11 to lift the as-cast member 25 from the base member 7. Then, the driving mechanism 12 is driven to move the fork member 11 and the as-cast product 25 rightward in relation to Fig. 1. Then, the as-cast product 25 is conveyed to a following processing step. Then, the tray 5 and the cast-base member 7 are inclined so that any pieces of the green-sand mold that are deposited on the tray 5 may be expelled to the restoring chute 24 to a sand treatment line.

[0017] In the embodiment as explained above, the green-sand mold contained flasks just after the molding had finished. The green-sand mold that has been filled with a melted material and that does not contain a flask is made by taking the upper and lower green-sand molds having the upper and lower flasks out of the upper and lower flasks after the melted material is supplied. The green-sand mold is not limited to one made by that method. For example, green-sand molds that do not have a flask just after they are molded by a so-called snap flask-type molding apparatus can generate the same effects. In this case, generally a jacket covers the upper and lower green-sand molds while melted material is supplied. Also, in the embodiment stated above, the green-sand mold that has been filled with a melted material and that has no flask can be divided along the horizontal plane. But, the embodiment is not limited to that carried out by that method. For example, even if the upper and lower green-sand molds stand vertically to supply a melted material, the same effect can be generated.

[0018] From the explanations stated above, it is seen that the invention of claim 1 relates to a method for separating an as-cast product from a green-sand mold that has been filled with a melted material. The method includes the steps for gas-tightly surrounding a green-sand mold that has been filled with a melted material and that has no flask, rapidly aspirating the inner pressure in a structure gas-tightly surrounding the green-sand mold within a period of 0.5 second to reduce the pressure to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less, thereby reducing the boiling temperature of the water present within the entire green-sand mold that includes a condensed moisture layer formed around the as-cast product in the green-sand mold to bring this water to a boil, so that the green-sand mold is broken and separated from the as-cast product, and restoring the structure to the original pressure to take out the as-cast product. Thus, this method can generate several effects. For example, it does not make dents in the as-cast products. Also, it makes sure that the as-cast product and the green-sand mold are easily separated, and that the green-sand mold is also easily broken.

[0019] Next, based on Figs. 6-11, a second embodiment of this invention is now explained. As in Fig. 6, the apparatus for separating an as-cast product from a green-sand mold that has been filled with a melted material has a supporting apparatus 40 to support a green-sand mold on the smallest area on it that can be contacted. The other members and apparatuses are the same as those denoted by the same reference numbers in Fig. 1. The supporting apparatus 40 has a plurality of bar members 45, which stand on the upper surface of the box-like tray 5, as explained below. The tray 5 and the bar members 45 are rotated counterclockwise and inclined to an angle such that the green-sand mold can slide down on them.

[0020] As in Figs. 8 and 9, bar members 45a of the plurality of the bar members 45, which members 45a are positioned both at the center and near the periphery of the tray 5, are the longest (as in Fig. 9). At least three bar members 45a are needed to support the green-

sand mold. Bar members 45b of the remainder of the plurality of the bar members 45 are slightly shorter than the bar members 45a. They can support the as-cast product by their upper ends when the green-sand mold is broken (Fig. 9).

[0021] Also, the supporting apparatus 40 has a supporting-assistance mechanism 30 to temporarily support a green-sand mold when it is transmitted to the supporting apparatus 40. The supporting-assistance mechanism 30 is comprised of a supporting member 31, which horizontally extends through spaces between the bar members 45, and cylinders 32, which lift upward the supporting member 31. The supporting member 31 can be extended or extracted above or below the horizontal level defined by the upper ends of the plurality of the bar members 45.

[0022] Next, this embodiment is now explained As in Fig. 6, the cylinders 32 of the supporting-assistance mechanism 30 are extended to elevate the supporting member 31 above the horizontal level that is defined by the upper ends of the bar members 45. Under this condition the upper and lower green-sand molds 15, which include the as-cast product 25, are pulled out of the upper and lower flasks 14 by the taking-out mechanism 20.

[0023] Then, the upper and lower green-sand molds 15, which have been pulled out of the upper and lower flasks 14, are pushed by the extruding apparatus 22 to the supporting member 31. Then, the cylinders 32 are extracted to make the upper and lower green-sand molds 15, the supporting member 31, etc. descend and to put the upper and lower green-sand molds 15 on the upper ends of the bar members 45. Then, the cylinder 4 of the airtight-surrounding member 1 is extended to make the bar members 45 etc. ascend and contact the seal member 27 with the tray 5, so that, as in Fig. 7, the upper and lower green-sand molds 15 are surrounded by the tray 5 and the cover 6.

[0024] Similar to the first embodiment, as in Fig. 10, generally around the as-cast product 25 in the upper and lower green-sand molds 15 a condensed moisture layer 28 is formed, at which layer much moisture has a temperature higher than the other parts of the upper and lower green-sand molds 15 due to the heat of the as-cast product 25. The moisture condensed layer 28 is weak. Thus, as the pressure in the cover 6 is sensed by the pressure-detection mechanism 26, the valve 8 of the suction member 2 is opened to abruptly exhaust the airtight space defined by both the tray 5 and the cover 6 and to reduce its pressure, such that the space is changed to a negative pressurized condition. For example, as in Fig. 5, like the first embodiment, the inner pressure in the structure forming the space is rapidly aspirated to reduce the pressure to a pressure of —200 mmHg or less within a period of 0.5 second and finally to a pressure of —360 mmHg or less. As a result, the boiling point of the moisture included in the entire green-sand molds 15, which include the moisture condensed layer 28, decreases, so that the moisture is boiled away. At that time, the upper and lower green-sand molds 15 are supported on the tip ends of the bar members 45, so that the area of the molds 15 contacted with the tip ends is very small. Thus, the lower part of the mold is supported such that it can be easily broken. As a result, the upper and lower green-sand molds 15 are made to be surely and easily broken and separated from the as-cast product 25 (as in Fig. 11). The pieces of the green-sand molds are deposited on the tray 5. No core sand is broken by the boiling. Thus, the core sand is kept in the as-cast product 25, so that it is never mixed with the pieces of the green-sand mold.

[0025] Then, after the valve 8 is closed, an atmospheric-pressure restoring valve (not shown) that is located on the cover 6 is opened to restore the pressure in the cover 6 to the atmospheric pressure. Then, the cylinder 4 is retracted to move down the tray 5, the upper and lower green-sand molds 15, the as-cast product 25, etc. Then, the driving mechanism 12 of the taking-out member 3 for as-cast products is driven to move the fork member 11 leftward in relation to Fig. 6 and below the as-cast product 25. Then, the driving mechanism 12 is driven to raise the fork member 11 to lift the as-cast member 25 from the bar members 45. Then, the driving mechanism 12 is driven to move rightward (as in Fig. 6) the fork member 11 and the as-cast product 25. Then, the as-cast product 25 is conveyed to a following processing step. Then, the tray 5 and the bar members 45 are inclined so that any pieces of the green-sand molds that are deposited on the tray 5 may be expelled to convey them to a sand treatment line.

[0026] In the second embodiment, the upper and lower green-sand molds 15 do not have any flask after they are taken out of the upper and lower flask 14 after melted material has been supplied However, that embodiment is not limited to being carried out by that method. Green-sand molds that have flasks can generate the same effects. Also, in the second embodiment the upper and lower green-sand molds that have been filled with a melted material and that do not have any flask are a cast that includes an upper flask and a lower flask. However, those molds are not limited to that The upper flask that is separated from the lower flask can generate the same effects.

[0027] Thus, the method in claim 8 for separating an as-cast product from a green-sand mold that has been filled with a melted material, which includes the steps for gas-tightly surrounding a green-sand mold that has been filled with a melted. material by the smallest area that can be contacted, rapidly aspirating the inner pressure in a structure gas-tightly surrounding the green-sand mold to a negative pressure, thereby reducing the boiling temperature of the water being present within the entire green-sand mold that includes a condensed-moisture layer formed around the as-cast product in the green-sand mold to bring this water to a boil, so that the green-said mold is broken and separated

from the as-cast product, and restoring the structure to the original pressure to take out the as-cast product. Thus, this method can generate several effects. For example, it does not make dents in the as-cast products. Also, it makes sure that the as-cast product and the green-sand mold are easily separated and the green-sand mold is also easily broken.

Claims

1. A method for separating an as-cast product from a green-sand mold that has been filled with a melted material including the steps of

gas-tightly surrounding a green-sand mold that has been filled with a melted material.
rapidly lowering the inner pressure in a surrounding gas-tight structure within a period of 0.5 second to reduce the pressure to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less, thereby reducing the boiling temperature of the water present within the entire green-sand mold, including a condensed moisture layer formed around the as-cast product in the green-sand mold, to bring this water to a boil, so that the green-sand mold is broken and separated from the as-cast product, and
restoring the original pressure of the structure to take out the as-cast product

2. A method for separating an as-cast product from a green-sand mold that has been filled with a melted material including the steps for

gas-tightly surrounding a green-sand mold that has been filled with a melted material and that does not have a flask,
rapidly lowering the inner pressure in a structure gas-tightly surrounding the green-sand mold within a period of 0.5 second to reduce the pressure to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less, thereby reducing the boiling temperature of the water being present within the entire green-sand mold, including a condensed moisture layer formed around the as-cast product in the green-sand mold to bring this water to a boil, so that the green-sand mold is broken and separated from the as-cast product, and
restoring the original pressure of the structure to take out the as-cast product.

3. The method of claim 2 wherein the green-sand mold that has been filled with a melted material and that does not contain a flask is separated from a flask of a green-sand mold that contains a flask just after a molding step, is finished.

4. The method of claim 2 wherein the green-sand mold that has been filled with a melted, material and that does not contain a flask is a green mold that does not contain a flask just after a molding step is finished.

5. The method of any one of claims 2 - 4 wherein the green-sand mold that has been filled with a melted material and that does not contain a flask is divided into two parts.

6. An apparatus for separating an as-cast product from a green-sand mold that has been filled with a melted, material comprising:

an airtight-surrounding means for gas-tightly surrounding a green-sand mold that has been filled with a melted material and that does not contain a flask,
a suction means rapidly reducing a space defined by the airtight-surrounding means within a period of 0.5 second to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less, and
a taking-out means restoring the original pressure of the structure to take the as-cast product out of the broken green-sand mold.

7. An apparatus for separating an as-cast product from a green-sand mold that has been filled with a melted material comprising:

an airtight-surrounding means for gas-tightly surrounding a green-sand mold that has been filled with a melted material,
a suction means rapidly reducing the pressure in a space defined by the airtight-surrounding means within, a period of 0.5 second to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less, and
a taking-out means restoring the original pressure of the structure to take the as-cast product out of the broken green-sand mold.

8. A method for separating an as-cast product from a green-sand mold that has been filled with a melted material including the steps of

gas-tightly surrounding a green-sand mold that has been filled with a melted material and supporting the green-sand mold by the smallest area that can be contacted,
rapidly reducing the inner pressure in a structure gas-tightly surrounding the green-sand mold to a negative pressure, thereby reducing the boiling temperature of the water present within the entire green-sand mold, including a condensed moisture layer formed around the

as-cast product in the green-sand mold, to bring this water to a boil, so that the green-sand mold is broken and separated from the as-cast product, and

restoring the original pressure of the structure to take out the as-cast product

9. The method of claim 8 wherein the green-sand mold that has been filled with a melted material is supported by a plurality of bar members on their tip ends, the bar members extending upward.

10. The method of claim 8 wherein the step for reducing the inner pressure in the structure includes a step for reducing the inner pressure in a structure gas-tightly surrounding the green-sand mold within a period of 0.5 second to reduce the pressure to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less.

11. An apparatus for separating an as-cast product from a green-sand mold that has been filled with a melted material comprising:

a supporting means for supporting the green-sand mold that has been filled with a melted material under a condition where an area of the green-sand mold that is made to contact the supporting means is the smallest possible,

an airtight-surrounding means for gas-tightly surrounding a green-sand mold that has been filled with a melted material and that is supported by the supporting means,

a suction means rapidly reducing the pressure in a space defined by the airtight-surrounding means to a negative pressure, and

a taking-out means taking the as-cast product out of the broken green-sand mold after the negative pressure is brought back to the original pressure.

12. The apparatus of claim 11 wherein the supporting means includes a plurality of bar members that stand to support on their tip ends the green-sand mold that has been filled with a melted material.

13. The apparatus of claim 11 wherein the suction means reduces the pressure in a space defined by the airtight-surrounding means within a period of 0.5 second to a pressure of —200 mmHg or less and finally to a pressure of —360 mmHg or less.

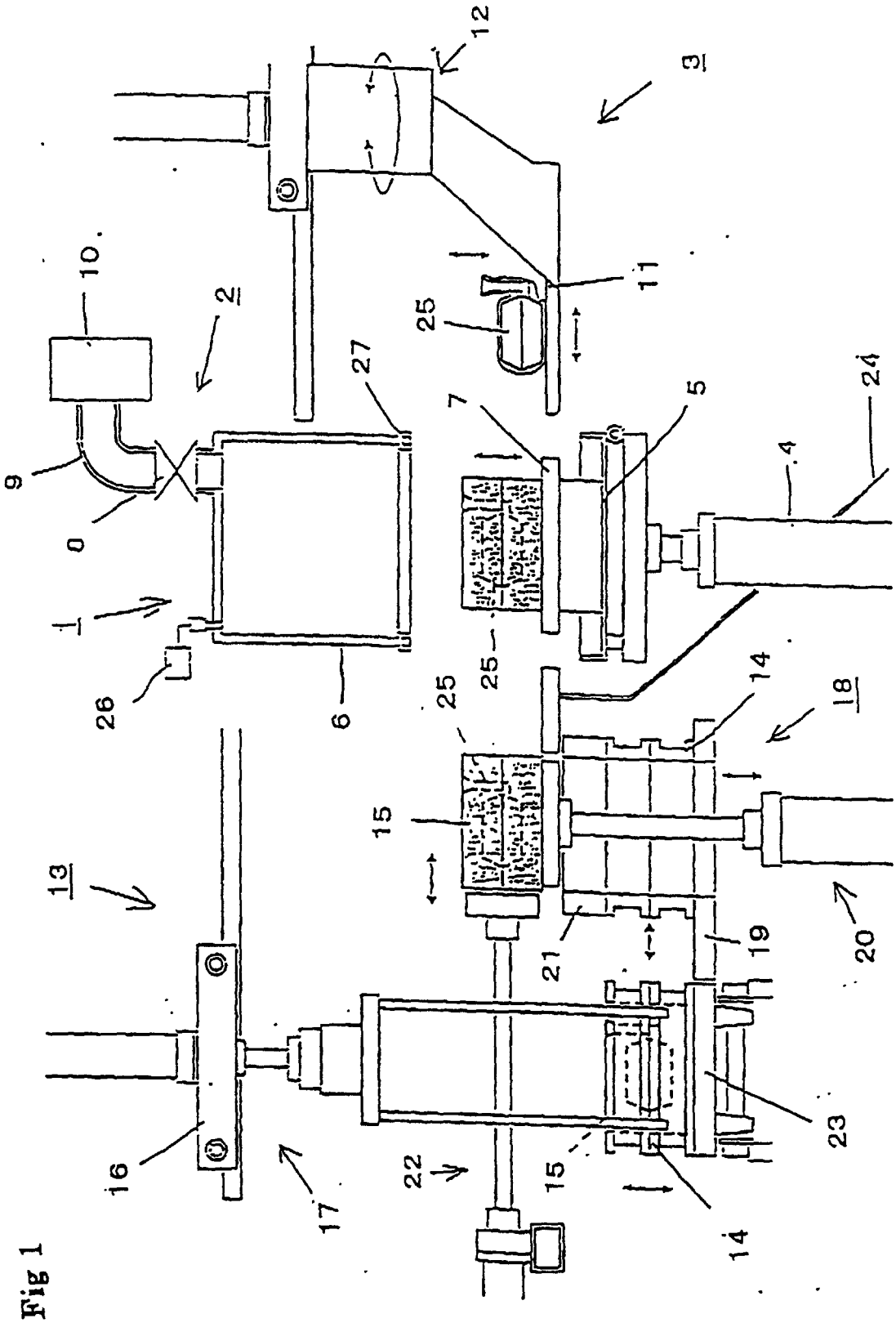

12
3
10
2
11
25
27
7
5
24
9
4
1
26
6
25
25
14
18
15
13
21
19
20
16
17
22
15
23
14

Fig 1

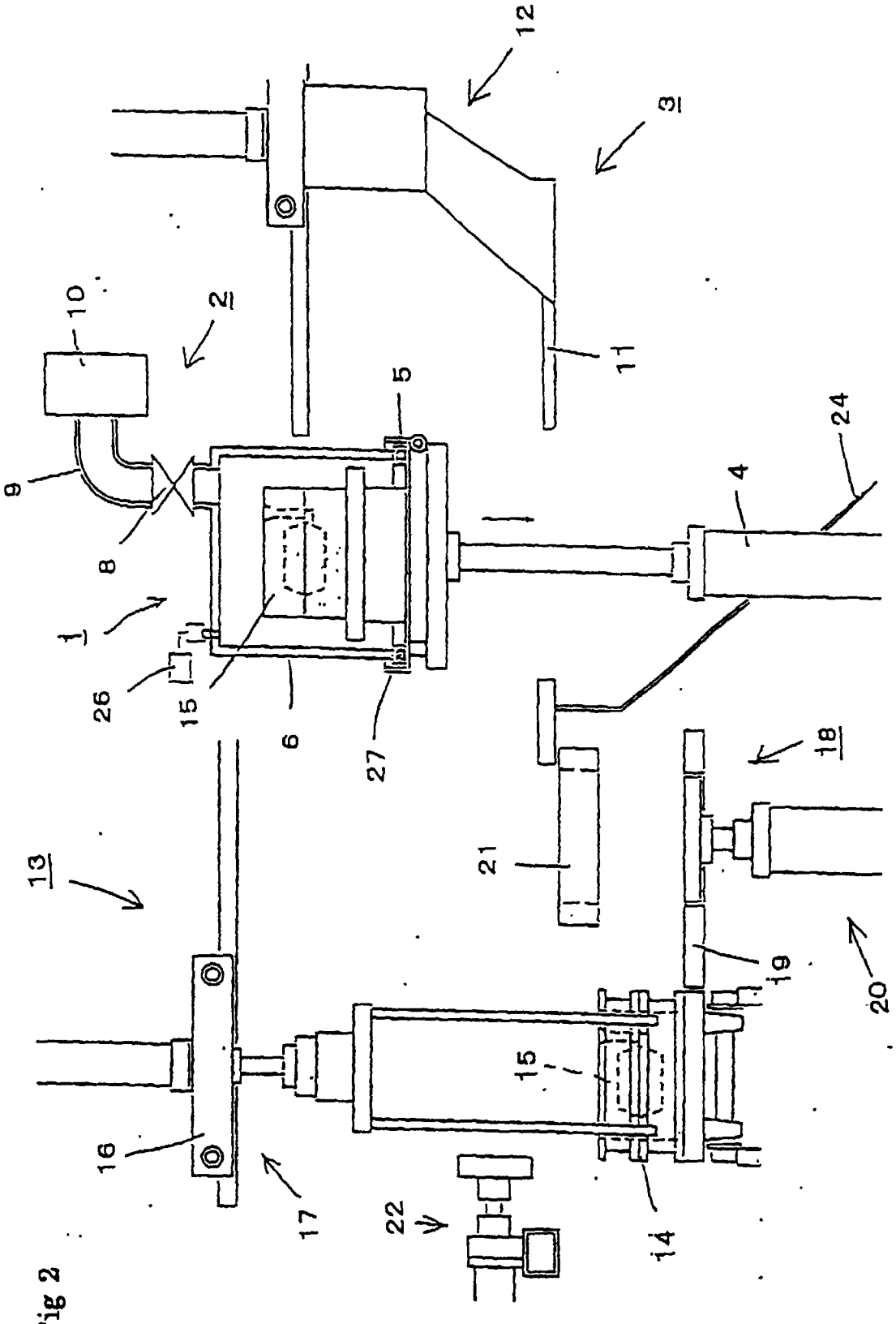


Fig 2

Fig 3

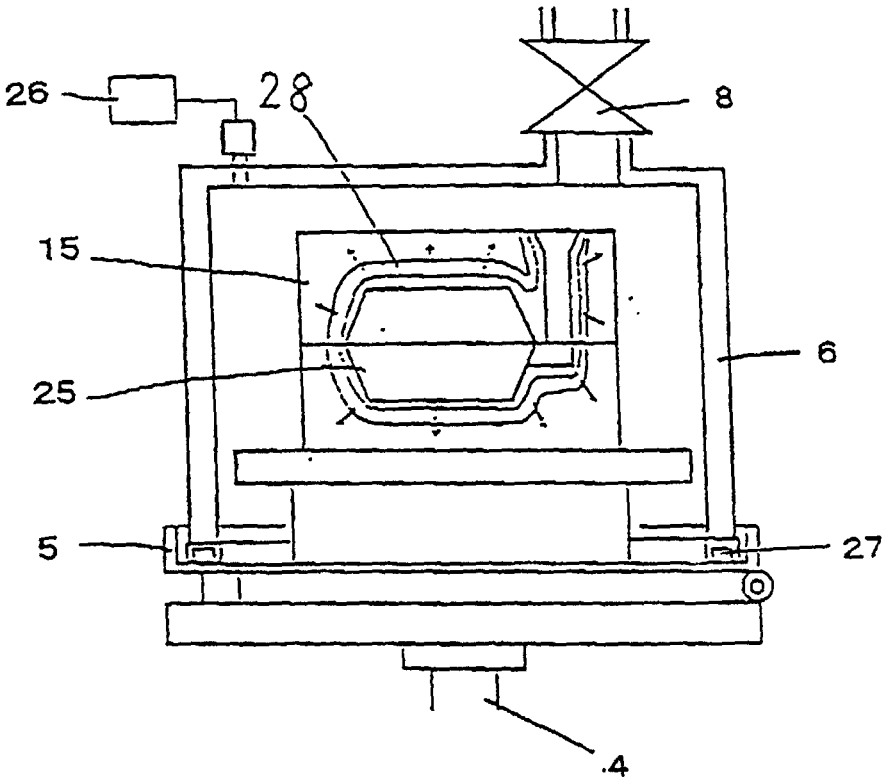


Fig 4

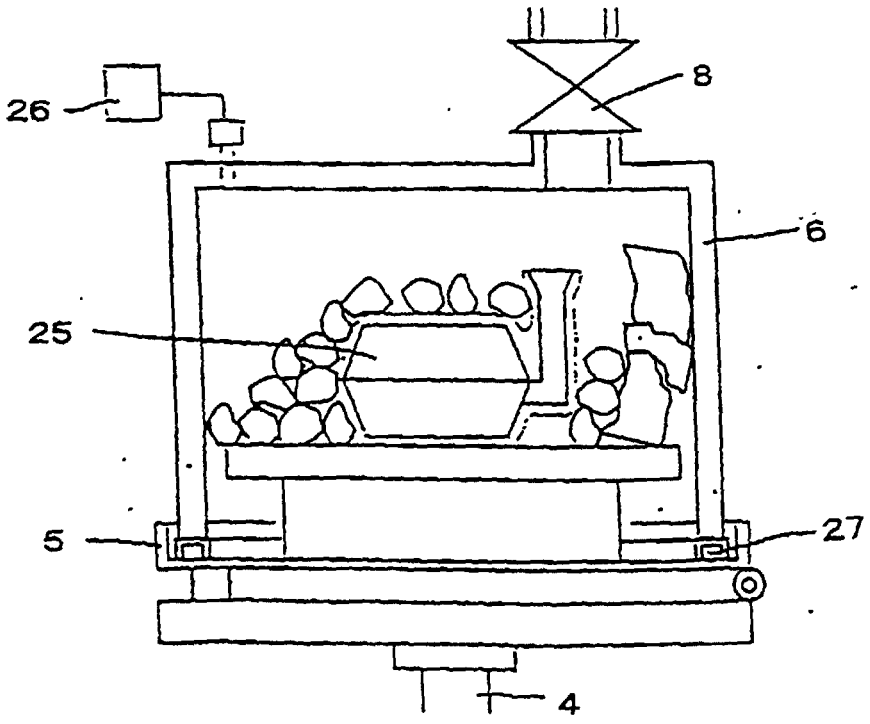
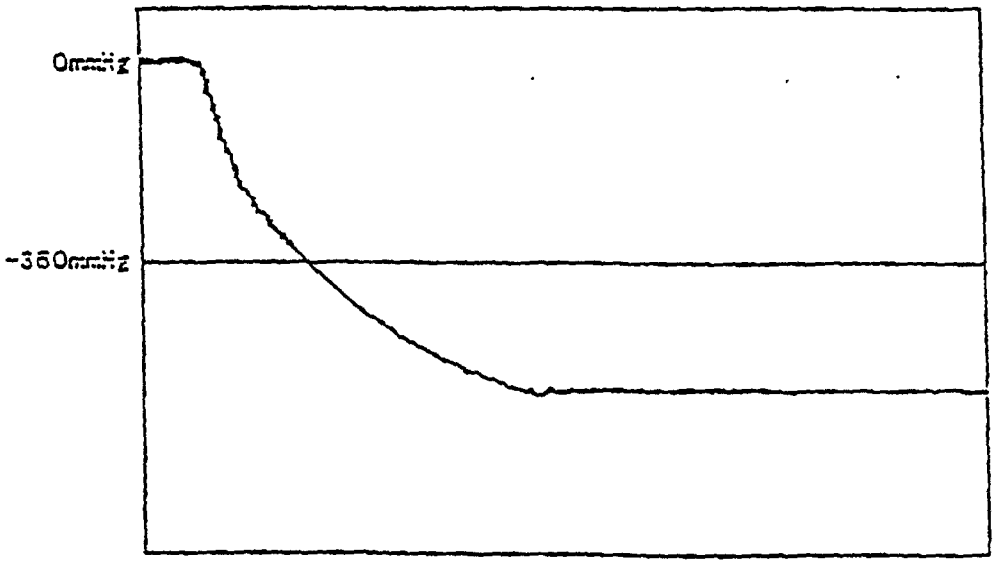


Fig 5



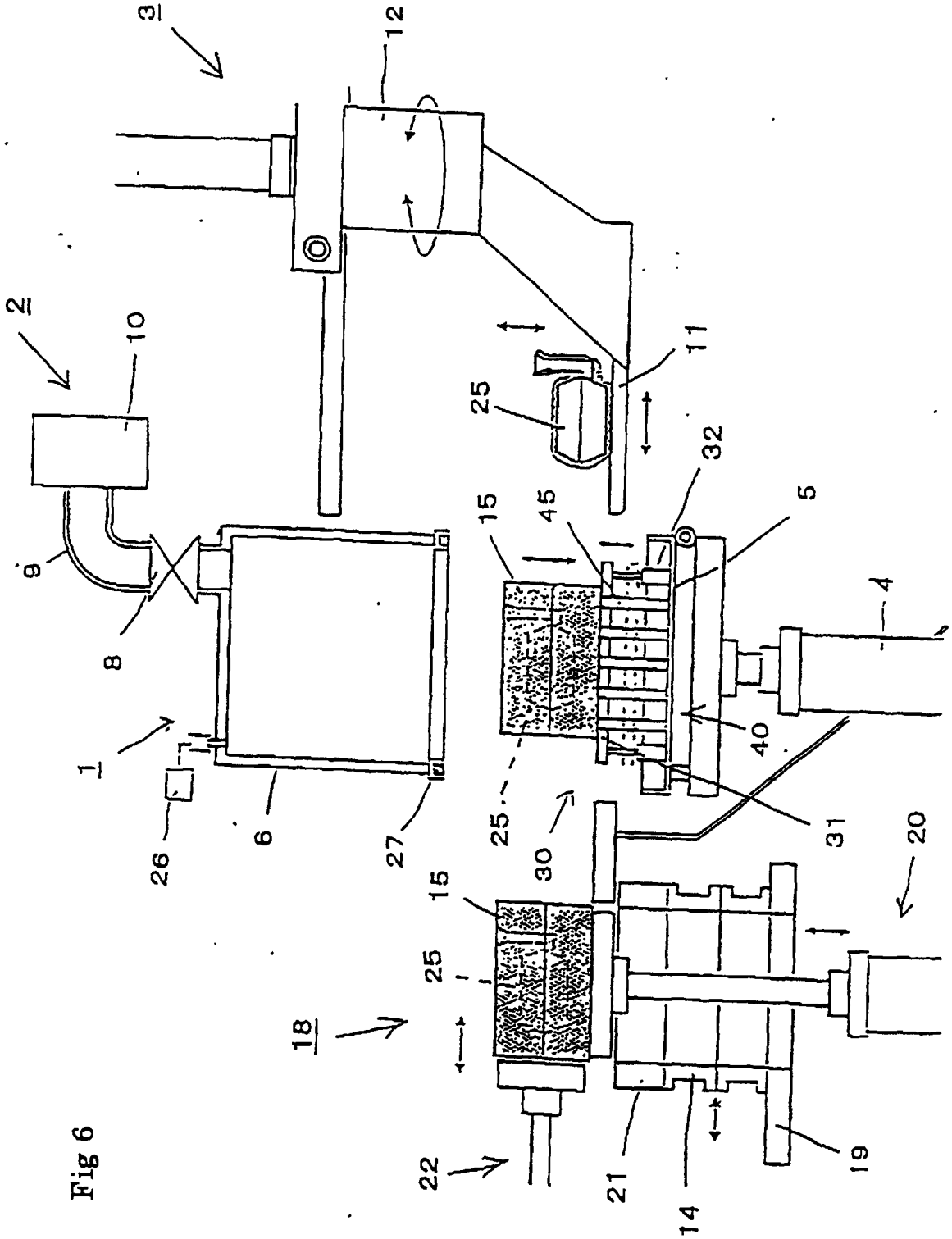

3
12
2
10
11
25
32
5
15
45
9
8
4
1
7
40
31
26
6
27
25
30
20
15
25
18
22
21
14
19

Fig 6

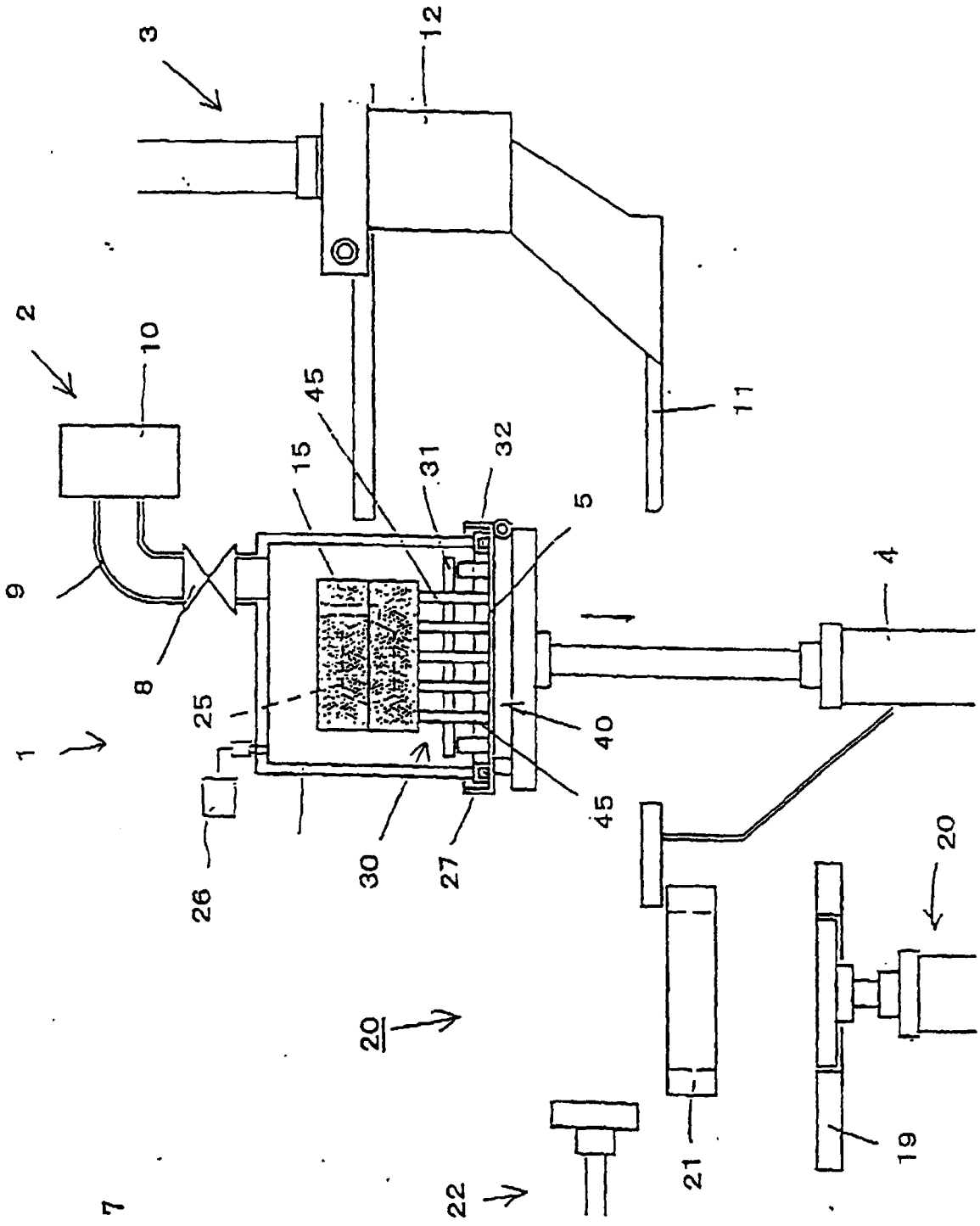


Fig 7

Fig 8

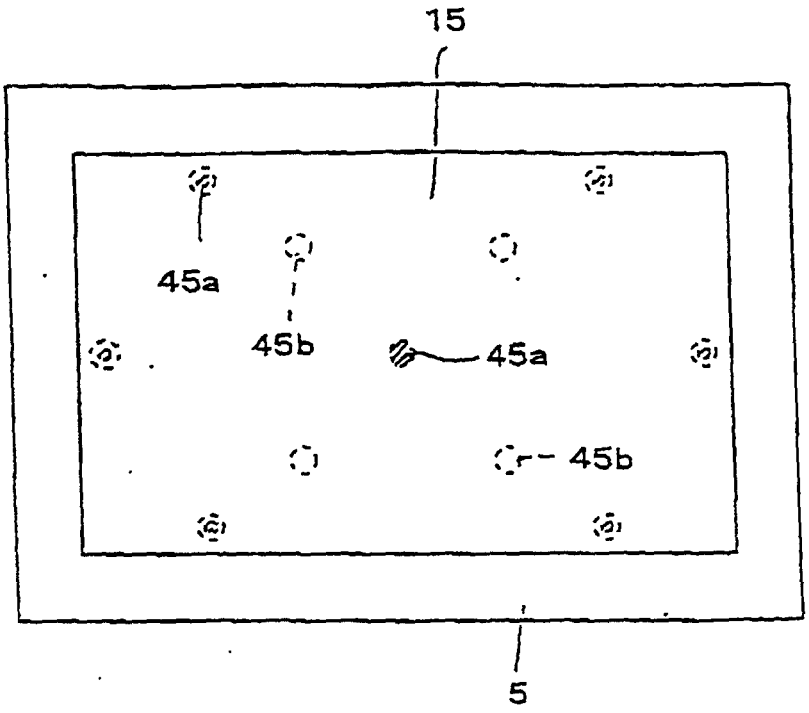


Fig 9

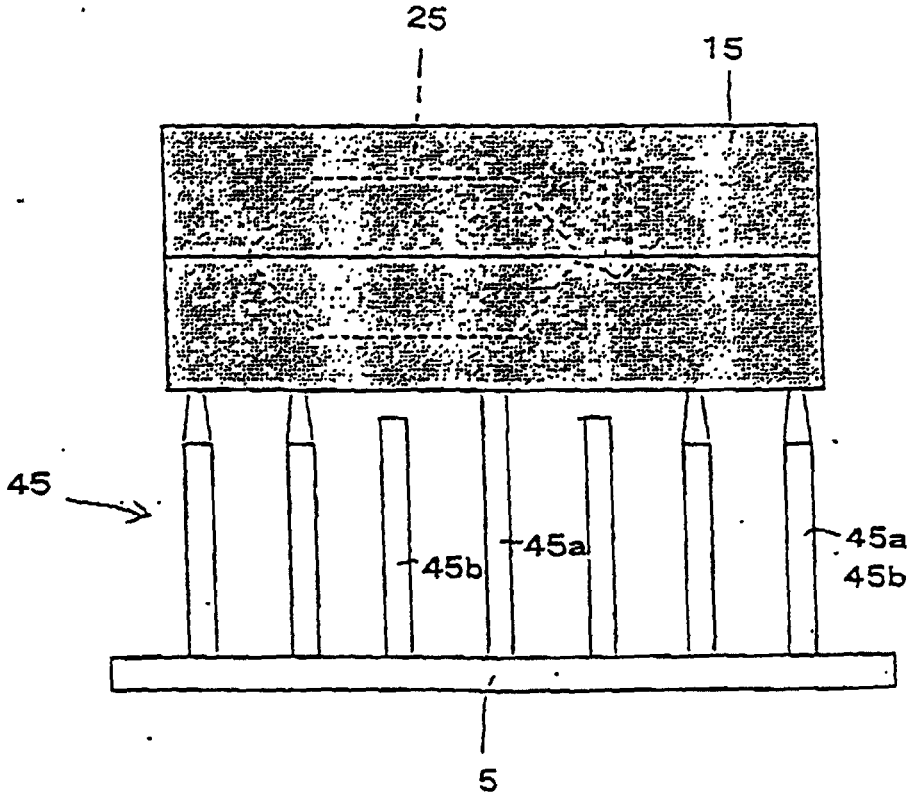


Fig 10

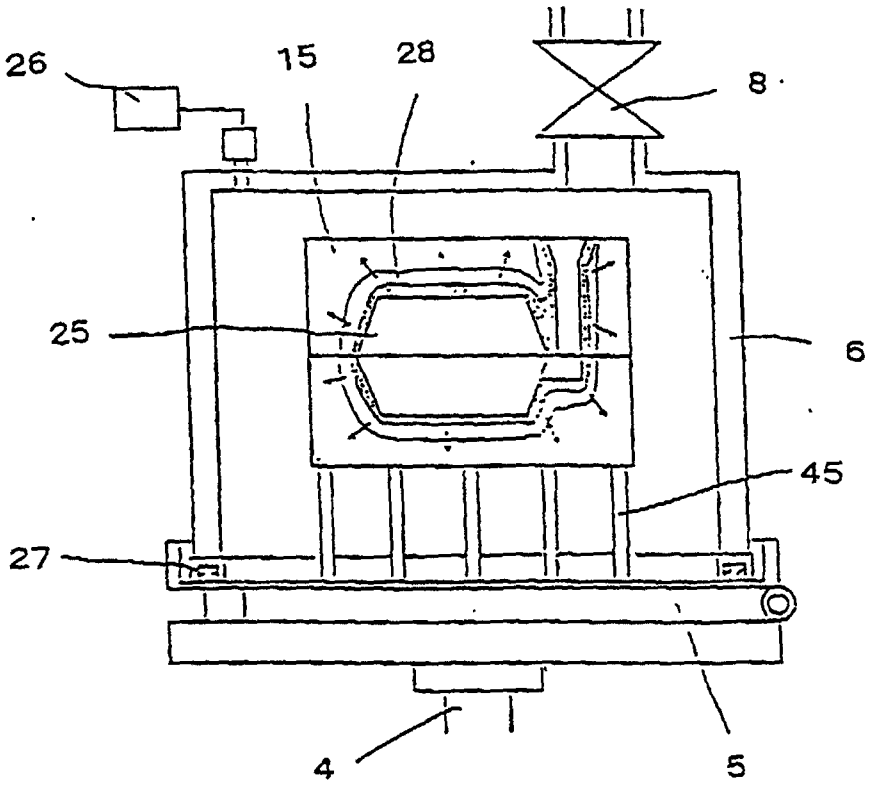
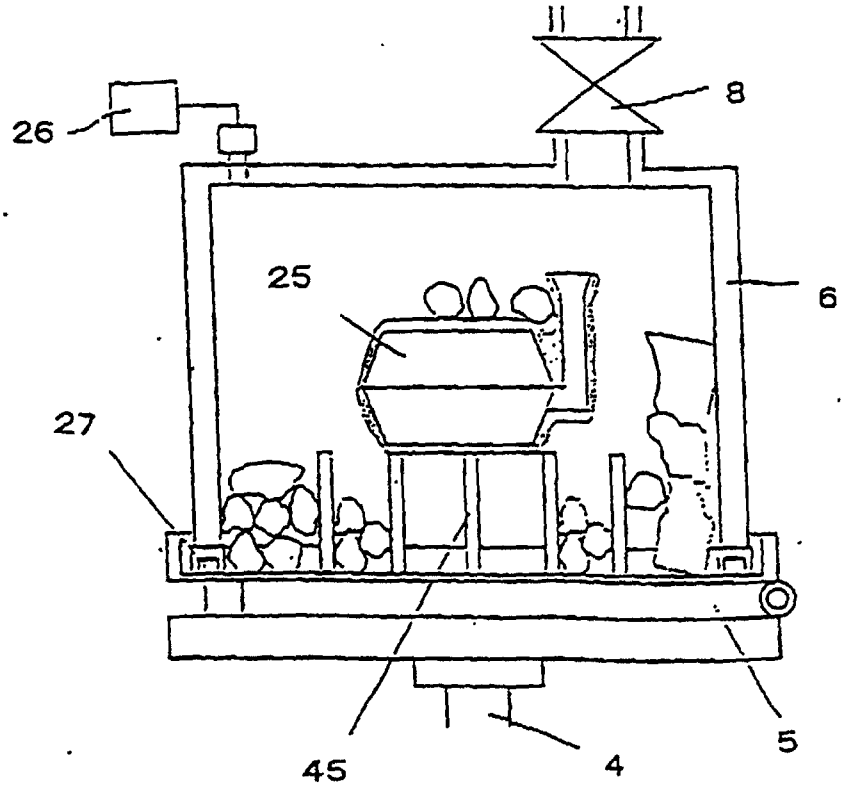


Fig 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/02101

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B22D29/00 B22D29/04 B22C5/00

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)
Int.Cl[7] B22D29/00 B22D29/04 B22C5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2000
Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US, 4620586, A (Albert Musschoot), 04 November, 1986 (04.11.86), Claims; Column 3, line 24 to Column 5, line 61; Figs. 1 to 5 & JP, 53-93118, A & BE, 863143, A &DE,2802419.A	1,7 2-6,8-13
A	JP, 53-125935, A (Asahi Malleable Iron Co. Ltd.), 02 November, 1978 (02.11.78), Claims; Figs (Family: none)	1-13
A	JP, 6-262339, A (Nissan Motor Co., Ltd.), 20 September, 1994 (20.09.94), Claims; Figs (Family: none)	1-13

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"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)
"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
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 May, 2000 (29.05.00)	06 June, 2000 (06.06.00)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)