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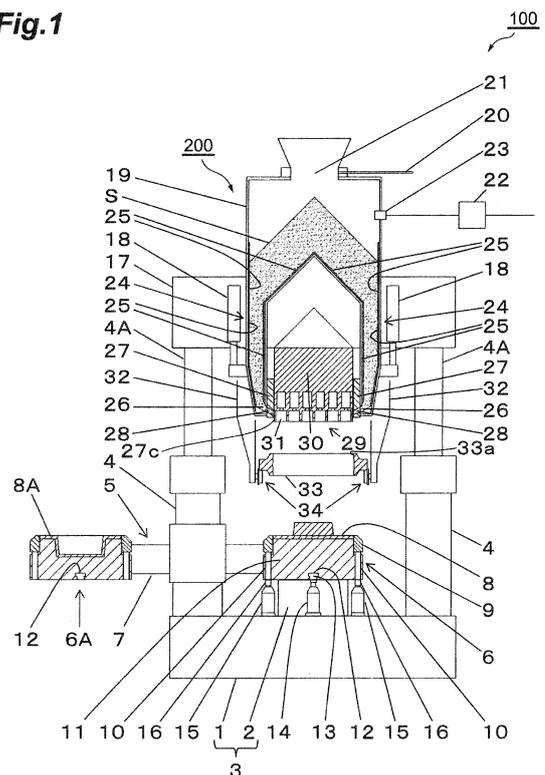
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(54) **MOLD FORMING MACHINE, SAND-FILLING COMPRESSION UNIT, AND MOLD FORMING METHOD**

(57) A molding machine forms a mold by using transferred molding flask and pattern plate, and includes: a filling frame provided with a lower opening connectable to an upper opening of the molding flask; a squeeze head mechanism including a squeeze board movable into and out from the filling frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the squeeze head mechanism, and the pattern plate; and a sand injection nozzle provided in a side portion of the filling frame to enable the sand injection port and the molding space to communicate with each other.

**Fig.1**



## Description

### Technical Field

[0001] The present disclosure relates to a molding machine, a sand-filling compression unit, and a mold forming method, for forming a mold by squeezing molding sand filled in a molding flask.

### Background Art

[0002] Conventionally, there is publicly known a molding machine for forming a mold by filling a molding flask with molding sand by aeration and squeezing the filled molding sand (e.g., refer to Patent Document 1).

### Citation List

#### Patent Document

[0003] Patent Document 1: Japanese Unexamined Patent Publication No. 2002-1491

### Summary of Invention

#### Technical Problem

[0004] The molding machine of Patent Document 1 includes a squeeze board (lid member) provided with a sand injection nozzle (refer to Figure 5 of Patent Document 1). This causes a problem in that a placement of a squeeze foot to the squeeze board is restricted. When the placement of a squeeze foot to the squeeze board is restricted, effect of the squeeze foot may not be sufficiently achieved depending on a shape of a pattern plate. In this technical field, there are desired a molding machine, a sand-filling compression unit, and a mold forming method, for forming an excellent mold.

#### Solution to Problem

[0005] A molding machine according to an aspect of the present invention forms a mold by using a transferred molding flask and pattern plate, and comprises: a filling frame provided with a lower opening connectable to an upper opening of the molding flask; a squeeze head mechanism including a squeeze board movable into and out from the filling frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the squeeze head mechanism, and the pattern plate; and a sand injection nozzle provided in a side portion of the filling frame to enable the sand injection port and the molding space to communicate with each other.

[0006] A molding machine according to another aspect

of the present invention forms a mold by using a transferred molding flask and pattern plate, and comprises: a filling frame provided with a lower opening connectable to an upper opening of the molding flask; an injection frame disposed above the filling frame, being provided with a lower opening connectable to an upper opening of the filling frame; a squeeze head mechanism including a squeeze board movable into and out from the injection frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the injection frame, the squeeze head mechanism, and the pattern plate; and a sand injection nozzle provided in a side portion of the injection frame to enable the sand injection port and the molding space to communicate with each other.

[0007] According to the molding machine according to the aspect or the other aspect of the present invention, the sand injection nozzle communicating with the molding space is formed in the filling frame or the injection frame, and molding sand is injected from a lateral side of the molding space. This enables the molding machine to use a layout of the squeeze feet determined from a viewpoint of uniform compression as a whole, without considering a placement of the sand injection nozzle. As a result, the molding machine can form an excellent mold.

[0008] In an embodiment, the sand injection nozzle may include an inner flow channel inclined to become lower from its inlet toward its outlet. In this case, molding sand is supplied from obliquely above, so that the molding sand can be prevented from colliding with the squeeze feet descending in accordance with projections and depressions of the pattern plate. As a result, filling ability of the molding sand can be improved.

[0009] In an embodiment, the sand injection nozzle may include an inner flow channel provided with a ceiling surface including an inclination angle larger than that of its bottom surface. In this case, crosswise squeezing force is less likely to be applied to molding sand in the sand injection nozzle, so that the molding sand in the sand injection nozzle is further less likely to be compressed. This enables sand clogging to be prevented from occurring.

[0010] In an embodiment, the at least one sand injection port may include an inclined bottom surface. In this case, molding sand is easily supplied to the sand injection nozzle.

[0011] In an embodiment, the at least one sand injection port may include a bottom surface made of ultra-high molecular weight polyethylene. In this case, molding sand can be prevented from adhering to and being deposited on the bottom surface.

[0012] In an embodiment, the sand injection hopper may include a lower portion formed of forked chutes. In this case, sand injection can be performed from two directions, so that molding sand can be filled more uniform-

ly than when sand injection is performed from one direction.

**[0013]** In an embodiment, the sand injection hopper may include a lower portion formed of forked chutes, and the filling frame may be disposed between the chutes. In this case, an apparatus can be compactly formed.

**[0014]** In an embodiment, the filling frame may be fixed to a chute. In this case, the filling frame and the sand injection hopper can use a drive assembly in common.

**[0015]** In an embodiment, the sand injection hopper may include a lower portion formed of forked chutes, and the injection frame may be disposed between the chutes. In this case, an apparatus can be compactly formed.

**[0016]** In an embodiment, the injection frame may be fixed to a chute. In this case, the injection frame and the sand injection hopper can use a drive assembly in common.

**[0017]** In an embodiment, the squeeze head mechanism may be disposed between chutes. In this case, an apparatus can be compactly formed.

**[0018]** In an embodiment, the molding machine may comprise a frame surrounding an outer periphery of the pattern plate to be slid up and down, and a part of the molding space may be defined by the frame. This case enables additional squeezing from a pattern plate side, so that strength of an outer peripheral portion of a mold is increased to enable a mold with uniform strength to be acquired.

**[0019]** In an embodiment, the squeeze head mechanism may be configured to be supported by two flask setting cylinders so that the squeeze head mechanism descends to perform a flask setting step and a squeezing step. In an embodiment, the sand injection hopper may be coupled to a plurality of lifting cylinders attached to a lifting support frame provided between upper ends of piston rods of respective flask setting cylinders.

**[0020]** A sand-filling compression unit according to yet another aspect of the present invention is used in a molding machine configured to form a mold by using a transferred molding flask and pattern plate, and fills a molding space with molding sand, the sand-filling compression unit comprising: a filling frame provided with a lower opening connectable to an upper opening of the molding flask; a squeeze head mechanism including a squeeze board movable into and out from the filling frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the squeeze head mechanism, and the pattern plate; and a sand injection nozzle provided in a side portion of the filling frame to enable the sand injection port and the molding space to communicate with each other.

**[0021]** A sand-filling compression unit according to yet another aspect of the present invention is used in a molding machine configured to form a mold by using a trans-

ferred molding flask and pattern plate, and fills a molding space with molding sand, the sand-filling compression unit comprising: a filling frame provided with a lower opening connectable to an upper opening of the molding flask; an injection frame disposed above the filling frame, being provided with a lower opening connectable to an upper opening of the filling frame; a squeeze head mechanism including a squeeze board movable into and out from the injection frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the injection frame, the squeeze head mechanism, and the pattern plate; and a sand injection nozzle provided in a side portion of the injection frame to enable the sand injection port and the molding space to communicate with each other.

**[0022]** A mold forming method according to yet another aspect of the present invention is for forming a mold by using a molding flask and a pattern plate, transferred to a molding machine, the mold forming method comprising: a step of defining a molding space by using: the molding flask; a filling frame provided with a lower opening connectable to an upper opening of the molding flask; a squeeze head mechanism including a squeeze board movable into and out from the filling frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; and the pattern plate; and a step of filling the molding space with molding sand using a sand injection nozzle enabling at least one sand injection port provided in a sand injection hopper provided in a side portion of the filling frame to store molding sand, and the molding space, to communicate with each other.

**[0023]** A mold forming method according to yet another aspect of the present invention is for forming a mold by using a molding flask and a pattern plate, transferred to a molding machine, the mold forming method comprising: a step of defining a molding space by using: the molding flask; a filling frame provided with a lower opening connectable to an upper opening of the molding flask; an injection frame disposed above the filling frame, being provided with a lower opening connectable to an upper opening of the filling frame; a squeeze head mechanism including a squeeze board movable into and out from the injection frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; and the pattern plate; and a step of filling the molding space with molding sand using a sand injection nozzle enabling at least one sand injection port provided in a sand injection hopper provided in a side portion of the injection frame to store molding sand, and the molding space, to communicate with each other.

**[0024]** The sand-filling compression unit and the mold forming method, described above, achieve the same effect as that of the molding machine described above.

### Advantageous Effects of Invention

[0025] According to various aspects of the present invention, it is possible to provide a molding machine, a sand-filling compression unit, and a mold forming method, for forming an excellent mold.

### Brief Description of Drawings

#### [0026]

[Figure 1] Figure 1 is a longitudinal sectional view illustrating a molding machine of an embodiment in a state before start (home position).

[Figure 2] Figure 2 is a longitudinal sectional view illustrating a molding machine in a state where a molding space is defined.

[Figure 3] Figure 3 is a flowchart of a mold forming method.

[Figure 4] Figure 4 is a longitudinal sectional view illustrating a molding machine in a state where molding sand is injected by aeration.

[Figure 5] Figure 5 is a longitudinal sectional view illustrating a molding machine in a state where molding sand is in a first squeeze state.

[Figure 6] Figure 6 is a longitudinal sectional view illustrating a molding machine in a state where molding sand is in a second squeeze state.

[Figure 7] Figure 7 is a longitudinal sectional view illustrating a molding machine in a state where a formed mold is removed and molding sand is supplied.

[Figure 8] Figure 8 is a longitudinal sectional view illustrating a molding machine in a state where a pattern plate (pattern carrier) is switched.

[Figure 9] Figure 9 is a longitudinal sectional view illustrating a sand injection nozzle and a sand injection port, on the left in Figure 2, in an enlarged manner.

[Figure 10] Figure 10 is a partially enlarged longitudinal sectional view of a frame of another embodiment

[Figure 11] Figure 11 is a partially enlarged longitudinal sectional view of another embodiment in which a molding space is defined.

### Description of Embodiments

[0027] Hereinafter, a molding machine according to each of the present embodiments will be described with reference to drawings. Figure 1 is a longitudinal sectional view illustrating a molding machine 100 of the embodiment in a state before start (home position). Figure 2 is a longitudinal sectional view illustrating the molding machine 100 in a state where a molding space is defined. The molding machine 100 forms a mold by using a transferred molding flask and pattern plate.

[0028] As illustrated in Figures 1 and 2, the molding

machine 100 includes a base board frame 1, for example. A fixed stopper 2 is fixed to the base board frame 1. The base board frame 1 and the fixed stopper 2 constitute a molding base board 3 on which flask setting cylinders 4 and 4 are provided upward on its both respective right and left sides (refer to Figure 1). In a lower portion of one of the flask setting cylinders 4 and 4 (on the left in Figure 1), a central portion of a pattern changer 5 is rotatably supported in a horizontal plane. The flask setting cylinder 4 on the left in Figure 1 also serves as a main shaft (rotating shaft) of the pattern changer 5.

[0029] The pattern changer 5 transfers a pattern plate 8. The pattern changer 5 includes a plurality of support units (not illustrated) such as a main shaft, a turn table 7, and pattern carriers 6 and 6A. The turn table 7 is rotatably supported by the main shaft in a horizontal plane to alternately transfer the pattern carriers 6 and 6A to and from above a central portion of the molding base board 3. The turn table 7 is rotated by an actuator (not illustrated). The actuator is a hydraulic cylinder or the like, for example. The plurality of support units is mounted in a mounting portion of each of the pattern carriers 6 and 6A in the turn table 7.

[0030] The pattern carrier 6 includes a frame 9, a plurality of guide pins 10, a body frame 11, and an urging unit (not illustrated). The frame 9 slides up and down while surrounding an outer periphery of the pattern plate 8. The plurality of guide pins 10 is coupled to a lower portion of the frame 9. The guide pins 10 are vertically slidably inserted into the body frame 11, and the pattern plate 8 is mounted on an upper surface of the body frame 11. The urging unit has opposite ends each hooked to the frame 9 and the body frame 11, and applies urging force in a direction lowering the frame 9. The urging unit is a plurality of tension coil springs, for example. The pattern carrier 6A has the same structure as that of the pattern carrier 6.

[0031] On the central portion of the molding base board 3, a hydraulic cylinder (oil-absorbing cylinder) 14 is provided. The hydraulic cylinder 14 includes a piston rod provided at its upper end with an engaging head 13. The engaging head 13 is fitted into an engaging groove 12 provided in a central portion at lower end of each of the pattern carriers 6 and 6A. In addition, a plurality of lifting cylinders 15 is provided on the molding base board 3, below the corresponding plurality of guide pins 10. Each of the lifting cylinders 15 moves up and down the frame 9 with the guide pin 10. The lifting cylinder 15 includes a piston rod including an upper end to which a rod head 16 is coupled.

[0032] When the lifting cylinder 15 extends to its extension end, the frame 9 projects such that its upper surface is slightly (e.g., 30 mm) above a parting surface of the pattern plate 8 (refer to Figure 2). The upper surface of the frame 9 is almost flush with the parting surface of the pattern plate 8 when the lifting cylinder 15 is contracted to its contraction end (refer to Figure 1).

[0033] A lifting support frame 17 is provided between

upper ends of piston rods 4A of the respective flask setting cylinders 4 and 4. To the lifting support frame 17, a plurality of sand injection hopper lifting cylinders 18 is attached. Each of the sand injection hopper lifting cylinders 18 includes a piston rod including a leading end coupled to a sand injection hopper 19.

**[0034]** The sand injection hopper 19 stores molding sand in its inside. The sand injection hopper 19 is provided at its upper end with a sand supply port 21 that is opened and closed by a slide gate 20. The sand injection hopper 19 has an upper portion with which an air supply pipe 23 communicates, the air supply pipe 23 allowing low-pressure air (e.g., 0.05 to 0.18 MPa) to be guided through an on-off valve 22. The sand injection hopper 19 has a lower portion formed of forked chutes 24. Each of the chutes 24 has an inner surface provided with a plurality of air injection chambers 25 and 25 communicating with a compressed air source (not illustrated) through an on-off valve (not illustrated).

**[0035]** The plurality of air injection chambers 25 and 25 is configured to form aeration for floating and fluidizing molding sand S by injecting low-pressure air (e.g., 0.05 to 0.18 MPa) into the sand injection hopper 19. Each of the chutes 24 in the sand injection hopper 19 has a lowermost portion provided with a sand injection port 26.

**[0036]** Each of the chutes 24 has a lower portion inside which a filling frame 27 is provided while being fixed. The filling frame 27 includes a lower opening 27c connectable to an upper opening 33a of a molding flask 33. The filling frame 27 has a lower portion (side portion) provided with a sand injection nozzle 28. The sand injection nozzle 28 has one end communicating with the sand injection port 26, and the other end communicating with a molding space described below. The filling frame 27 is provided in its inside with a squeeze head mechanism 29. The squeeze head mechanism 29 includes a squeeze board 30 being able to be moved into and out from the filling frame 27, and a plurality of squeeze feet 31. The plurality of squeeze feet 31 is formed by a segment method, and is attached by passing through the squeeze board 30 to enable control of moving up and down of the squeeze board 30. The squeeze board 30 has an upper end fixed to a lower end of the lifting support frame 17. The filling frame 27 described above surrounds an outer periphery of the squeeze head mechanism 29 in a vertically movable manner. The squeeze head mechanism 29 is surrounded by the sand injection hopper 19. The squeeze head mechanism 29 is surrounded by the sand injection hopper 19 from at least two directions.

**[0037]** The lifting support frame 17 includes a transfer frame 32 extending to a position below the squeeze head mechanism 29, and a transfer conveyor 34 of the molding flask 33, being hung from the transfer frame 32. The transfer conveyor 34 transfers the molding flask 33.

**[0038]** As described above, the squeeze head mechanism 29 is configured to be supported by the two flask setting cylinders 4 and 4 so that the squeeze head mechanism 29 descends to perform a flask setting step and a

squeezing step.

**[0039]** The above-described filling frame 27, squeeze head mechanism 29, sand injection hopper 19, and sand injection nozzle 28 constitute a sand-filling compression unit 200. The sand-filling compression unit 200 is acquired by unitizing the components described above, and can be exchanged per unit

**[0040]** Then, operation (mold forming method) of the molding machine 100 configured as described above will be described. Figure 3 is a flowchart of a mold forming method. The flowchart illustrated in Figure 3 starts from a state of Figure 1. The state of Figure 1 shows that molding sand S is supplied into the sand injection hopper 19, and that the molding flask 33 being empty is transferred to the transfer conveyor 34. The pattern carriers 6 and 6A each are set on the pattern changer 5 while being lifted by about 5 mm from the molding base board 3 with a compression spring (not illustrated) in a support unit (not illustrated). Figure 1 illustrates a state where the pattern carrier 6 is transferred to a position above a central portion of the molding base board 3. There is a clearance of about 5 mm between an upper surface of the fixed stopper 2 of the molding base board 3 and a lower surface of the pattern carrier 6.

**[0041]** In the state illustrated in Figure 1, a flask setting step (S10) of defining a molding space is performed. First, the hydraulic cylinder 14 is operated to contract to cause the engaging head 13 to descend, so that the engaging head 13 and the engaging groove 12 formed in the central portion of the lower end of the pattern carrier 6 are fitted to each other. Then, the pattern carrier 6 is pulled down against the compression spring (not illustrated), so that the lower surface of the pattern carrier 6 is pressed on the upper surface of the fixed stopper 2 of the molding base board 3. After that, the lifting cylinder 15 is operated to extend to raise the frame 9 with the guide pins 10. This causes the upper surface of the frame 9 to be positioned slightly above the parting surface of the pattern plate 8.

**[0042]** In a molding machine in which a frame is set upward from the bottom, the pattern carrier 6 is lifted by a table when a flask setting step is started. When a deceleration step is provided in a lifting step to prevent an impact from occurring, a cycle time may increase. Meanwhile, in the molding machine 100 of the present embodiment, the pattern carrier 6 is pressed on the fixed stopper 2 by the hydraulic cylinder 14 when a flask setting step is started, and at the same time, flask setting operation from above can be overlapped. This enables a cycle time to be reduced by time required for the deceleration step, as compared with a conventional molding machine in which a frame is set upward from the bottom, because there is not a deceleration step when the flask setting step is started.

**[0043]** After the sand supply port 21 is closed by operating the slide gate 20, the flask setting cylinders 4 and 4 is operated to contract. This causes the molding flask 33 to be mounted on the upper surface of the frame 9 projecting upward around the outer periphery of the pat-

tern plate 8. Then, each of the sand injection hopper lifting cylinders 18 is operated to extend. This causes the sand injection hopper 19 and the filling frame 27 to descend, so that the filling frame 27 is pressed on and brought into close contact with an upper surface of the molding flask 33. In addition, each of the squeeze feet 31 is operated. Then, projections and depressions are formed respectively corresponding to projections and depressions of the pattern plate 8 below the molding flask 33, so that the state illustrated in Figure 2 is achieved. In the meantime, the pattern plate 8 mounted on the pattern carrier 6, the frame 9, the molding flask 33, the filling frame 27, and the squeeze head mechanism 29, define a molding space, and the other end of the sand injection nozzle 28 communicates with the molding space.

**[0044]** Subsequently, an aeration filling step (S12) of injecting molding sand by using aeration is performed. Figure 4 is a longitudinal sectional view illustrating the molding machine 100 in a state where molding sand is injected by aeration. First, low-pressure air is injected into the sand injection hopper 19 through each of the plurality of air injection chambers 25 and 25. This causes molding sand S in the sand injection hopper 19 to be floated and fluidized. In this state, low-pressure air is supplied to the sand injection hopper 19 from the air supply pipe 23 through the on-off valve 22. The low-pressure air causes the molding space to be filled with the molding sand S through the sand injection port 26 and the sand injection nozzle 28 (aeration filling). During the aeration filling, the low-pressure air is discharged through a vent hole (not illustrated) or the like of the pattern plate 8.

**[0045]** Subsequently, a squeezing step (S14) is performed. In the squeezing step, the flask setting cylinders 4 and 4 are operated to further contract. This causes the sand injection hopper lifting cylinders 18 to contract. The flask setting cylinders 4 and 4 cause the lifting support frame 17 and components supported thereby (e.g., the squeeze head mechanism 29, the transfer frame 32, the transfer conveyor 34, and the like) to descend. As described above, a first squeeze of the molding sand S is performed until all of lower surfaces of the squeeze feet 31 become flat, so that the state illustrated in Figure 5 is achieved. Figure 5 is a longitudinal sectional view illustrating the molding machine 100 in a state where molding sand is in the first squeeze state. In the meantime, the flask setting cylinder 4 is continuously operated to contract until a squeeze pressure detected by a pressure sensor (not illustrated) reaches a set pressure of the first squeeze, or until an encoder position (not illustrated) of the flask setting cylinder 4 reaches a set position of the first squeeze.

**[0046]** Subsequently, the lifting cylinders 15 each are switched to a state where operation fluid is relieved. Then, the flask setting cylinders 4 and 4 each are operated to contract by a pressure higher than that in the first squeeze. This causes the molding flask 33, the filling frame 27, the sand injection hopper 19, and the squeeze head mechanism 29 to integrally descend to apply a sec-

ond squeeze to the entire molding sand S. Figure 6 is a longitudinal sectional view illustrating the molding machine 100 in a state where molding sand is in the second squeeze state. The frame 9 descends by using contraction of each of the lifting cylinders 15, and the upper surface of the frame 9 and the parting surface of the pattern plate 8 are almost flush with each other. This increases strength of an outer peripheral portion of a mold to enable uniform mold strength to be acquired. When a squeeze pressure does not reach a set pressure of the second squeeze at the time when the frame 9 reaches its descending end, the flask setting cylinders 4 and 4 are operated to further contract while the sand injection hopper lifting cylinders 18 are operated to contract, thereby achieving further squeeze.

**[0047]** Subsequently, when the squeeze pressure reaches the set pressure of the second squeeze, a squeeze stability timer is operated to maintain squeeze for a predetermined time. At the time, to respond to when the frame 9 does not reach the descending end, the sand injection hopper lifting cylinders 18 are operated to extend to cause the filling frame 27 to descend so that the molding flask 33 is pressed down until the frame 9 reaches the descending end. This enables the lower surface of the molding flask 33 and a lower surface of a mold to be almost flush with each other every time.

**[0048]** Subsequently, a mold removal step (S16) is performed. In the mold removal step, while the lifting cylinders 15 are operated to extend to cause the molding flask 33 to be pressed on the filling frame 27 with the guide pins 10 and the frame 9, the flask setting cylinders 4 and 4 are reversely operated to remove a mold. In the meantime, the molding flask 33, the filling frame 27, the sand injection hopper 19, and the squeeze head mechanism 29 integrally rise. After that, the molding flask 33 including formed a mold is removed and supported with the guide pins 10 and the frame 9 by operation of the lifting cylinders 15. Then, each of the filling frame 27, the sand injection hopper 19, and the squeeze head mechanism 29 rises. In midway through rising, the molding flask 33 including formed a mold is picked up by the transfer conveyor 34 to be completely separated from the pattern plate 8. In the meantime, the filling frame 27 and the sand injection hopper 19 rise by using contract operation of the sand injection hopper lifting cylinders 18. After the slide gate 20 is reversely operated to open the sand supply port 21, molding sand S is supplied into the sand injection hopper 19 to achieve the state of Figure 7. Figure 7 is a longitudinal sectional view illustrating the molding machine 100 in a state where a formed mold is removed and molding sand is supplied. In the meantime, the formed mold is raised slightly together with the molding flask 33 from a stopped state to be removed. Then, the formed mold is removed while a piston rod 4A of the flask setting cylinder 4 most contracts. This enables high accuracy of mold removal to be achieved.

**[0049]** Subsequently, a transfer step (S18) is performed. In the transfer step, the lifting cylinders 15 are

operated to contract to cause the guide pins 10 and the frame 9 to descend. In the meantime, the plurality of tension coil springs (not illustrated) applies urging force in a direction in which the frame 9 descends, so that the frame 9 can reliably descend to its descending end. Subsequently, the hydraulic cylinder 14 is operated to extend to raise the engaging head 13, so that the compression spring (not illustrated) in the support unit (not illustrated) lifts the pattern carrier 6 by about 5 mm from the molding base board 3 to release pressing of the molding base board 3 to the fixed stopper 2.

**[0050]** Subsequently, the molding flask 33 including formed a mold is transferred out with the transfer conveyor 34 and the molding flask 33 being empty is transferred in therewith. In addition, the pattern changer 5 is operated by the actuator (not illustrated), so that the pattern plate 8 and the pattern plate 8A are switched. Figure 8 is a longitudinal sectional view illustrating the molding machine 100 in a state where a pattern plate (pattern carrier) is switched. Up to this point, a series of steps of the mold forming method is finished. In the mold forming method, the above operation is defined as one cycle and is repeatedly performed. As operation of the pattern changer 5, it is also possible to switch the pattern plates 8 and 8A by transferring the pattern carriers 6 and 6A in and out in a lateral or longitudinal direction at a station outside the molding base board 3 of the turn table 7 after the pattern carriers 6 and 6A are lifted by a lifter with a driving roller (not illustrated). This enables mold change during forming of a mold to enable mold change in cycle.

**[0051]** The above-described molding machine 100 includes the sand injection nozzle 28 communicating with the molding space, being formed in the filling frame 27, and allows molding sand to be injected from a lateral side of the molding space. This enables the molding machine 100 to use a layout of the squeeze feet 31 determined from a viewpoint of uniform compression as a whole without considering a placement of the sand injection nozzle 28. For example, the squeeze feet 31 can be disposed in the periphery of the molding flask 33 to enable more uniform mold strength throughout the squeeze board to be acquired. As a result, the molding machine 100 can form an excellent mold.

**[0052]** Subsequently, details of the sand injection nozzle 28 and the sand injection port 26 will be described. Figure 9 illustrates the sand injection nozzle 28 and the sand injection port 26, on the left in Figure 2 illustrating a state where the molding space is defined, in an enlarged manner. Description of the sand injection nozzle 28 and the sand injection port 26 on the right is omitted because they are bilaterally symmetric.

**[0053]** The sand injection nozzle 28 is formed in the filling frame 27. The sand injection nozzle 28 is inclined to become lower from its inlet formed in an outer surface 27a of the filling frame 27 toward its outlet formed in an inner surface 27b thereof. This structure allows molding sand S to be injected from obliquely above with respect to the pattern plate 8. Thus, there is an advantage in that

the molding sand S injected is less likely to collide with the squeeze feet 31 in which projections and depressions are respectively formed corresponding to projections and depressions of the pattern plate 8, thereby improving filling ability of molding sand S. To the inner surface of the filling frame 27, an exchangeable filling frame liner can be attached. As a material of the exchangeable filling frame liner, a material with high wear resistance, such as urethane, is available along with a material all of which is steel such as stainless steel. This enables wear prevention of the filling frame.

**[0054]** In addition, the sand injection nozzle 28 has a ceiling surface 28a with an inclination angle (30 degrees in the present embodiment) that is larger than an inclination angle (15 degrees in the present embodiment) of its bottom surface 28b. This structure provides an advantage in that crosswise squeezing force is less likely to be applied to molding sand S in the sand injection nozzle 28, so that the molding sand S in the sand injection nozzle 28 is further less likely to be compressed. There is also an advantage in that the molding sand S in the sand injection nozzle 28 is further less likely to fall.

**[0055]** The sand injection port 26 has an inclined bottom surface 26a. This structure provides an advantage in that molding sand S passing through the sand injection port 26 is liable to be guided into the sand injection nozzle 28. The bottom surface 26a has an inclination angle that is larger than an inclination angle of the bottom surface 28b of the sand injection nozzle 28, and that is defined as 30 degrees in the present embodiment.

**[0056]** In addition, a material of the bottom surface 26a of the sand injection port 26 is ultra-high molecular weight polyethylene (e.g., "Saxin New Right" made by Saxin Corp.). This structure provides an advantage in that adhesion of molding sand S to the bottom surface 26a is inhibited to enable the molding sand S to be prevented from being deposited. In the embodiment, a block component 35 formed by processing ultra-high molecular weight polyethylene material is provided in a lowermost portion of the chute 24 such that the bottom surface 26a is made of ultra-high molecular weight polyethylene. In the embodiment, the sand injection nozzle 28 is attached to a side surface of the filling frame, and is exchangeable. As a material of the sand injection nozzle 28, a resin all of which is high molecule polyethylene with high wear resistance, or the like, may be used, other than a material all of which is steel. In addition, a part of steel may be thermally sprayed with a wear-resistant material. These structures enable maintenance of molding and wear prevention of a nozzle.

**[0057]** In the molding machine 100 according to the embodiment, the filling frame 27 is fixed to the inside of the forked chutes 24. This structure causes the filling frame 27 to be lifted together with the sand injection hopper 19 by the sand injection hopper lifting cylinders 18, so that an actuator for directly lifting the filling frame 27 itself is unnecessary. This provides an advantage of reducing the number of actuators.

**[0058]** While the molding machine 100 according to the embodiment is configured to allow the pattern carrier 6 to include the frame 9 that slides up and down while surrounding the outer periphery of the pattern plate 8, the molding machine 100 is not limited to this. For example, the frame 9 may be omitted. As described in the above embodiment, when the pattern carrier 6 includes the frame 9 to define a molding space by the pattern plate 8 mounted on the pattern carrier 6, the frame 9, the molding flask 33, the filling frame 27, and the squeeze head mechanism 29, the above-described second squeeze (squeeze from a model surface side) becomes possible.

**[0059]** The frame 9 is not limited to that described in the above embodiment. Next, another embodiment of the frame will be described. Figure 10 is a partially enlarged view of the frame of the other embodiment, and illustrates only one side of the bilateral symmetry. Figure 10 illustrates a state where an upper surface of the frame is positioned 30 mm above the parting surface of the pattern plate 8.

**[0060]** As illustrated in Figure 10, the frame 36 is provided in its inside with a detachable liner 37. The liner 37 is configured to slide up and down while surrounding the outer periphery of the pattern plate 8. The liner 37 is formed by fixing an urethane rubber 39 to a metal component 38. As illustrated in Figure 10, the liner 37 has an upper end surface and an inward surface to each of which the urethane rubber 39 is attached. This structure provides an advantage in that when the molding space is filled with the molding sand S, the lower surface of the molding flask 33 and the urethane rubber 39 on the upper end surface of the liner 37 are brought into contact with each other to improve sealability between the lower surface of the molding flask 33 and the upper surface of the frame 36, thereby preventing the molding sand S from blowing and leaking. There is also an advantage in that the urethane rubber 39 on the inward surface of the liner 37 improves wear resistance of a surface of the liner 37 to be slid on the outer periphery of the pattern plate 8. When the liner 37 with the upper end surface and the inward surface cannot be attached to the pattern carrier 6, a liner with an I-shaped cross section can be attached to only the outer periphery of the pattern plate 8. This also enables the outer periphery of the pattern plate 8 to be prevented from wearing.

**[0061]** The urethane rubber 39 may have a heat-resistant temperature of 70 to 90°C, for example. In the present embodiment, the urethane rubber 39 has a heat-resistant temperature of 80°C. When it is expected that the molding flask 33 has a temperature higher than a normal temperature, the urethane rubber 39 may have a heat-resistant temperature of 110 to 130°C. For example, the urethane rubber 39 has a heat-resistant temperature of 120°C.

**[0062]** While the molding machine 100 according to the embodiment is configured to provide the block component 35 formed by processing ultra-high molecular weight polyethylene material in the lowermost portion of

the chute 24, the molding machine 100 is not limited to this. For example, the air injection chambers 25 may be provided in place of the block component 35 so that the above-described low-pressure air is injected from the bottom surface 26a of the sand injection port 26.

**[0063]** In the molding machine 100 according to the embodiment, sand is injected by using low-pressure air to enable uniform sand filling. Sand filling by low-pressure air has a feature in which sand is injected at a low flow rate under pressure (e.g., 0.05 to 0.18 MPa) lower than that in sand filling (e.g., 0.2 to 0.5 MPa) by a blow method, thereby reducing wear of a model.

**[0064]** Sand filling by a blow method has a high filling rate of sand, so that a blocking phenomenon occurs particularly in a pocket portion, thereby deteriorating filling ability of sand. In contrast, the molding machine 100 according to the present embodiment also enables setting in which a filling rate of sand is reduced in an initial stage of low-pressure air by an electric pneumatic high-regulating valve to improve filling ability, and pressure is increased from midway to reduce a filling time. A filling rate decreases when pressure is kept low, so that a filling time of sand may increase to increase cycle time. To acquire mold forming at high speed while reducing wear, it is preferable that a filling rate of low-pressure air is initially reduced and is increased from midway.

**[0065]** In the molding machine 100 according to the above embodiment, the sand injection nozzle 28 is provided in the filling frame 27. However, in another embodiment, the sand injection nozzle 28 may be provided in an injection frame BF that is provided separately from the filling frame 27, and that is able to be separately operated, as illustrated in Figure 11. This enables the sand injection nozzle 28 to be formed with a simple structure to facilitate its exchange. This achieves effect in which the filling frame 27 can be provided with an exhaust port of low-pressure air (not illustrated) so that low-pressure air can be discharged through the exhaust port to achieve more excellent filling, for example. In addition, one sand injection port may be provided.

## Reference Signs List

**[0066]** 6, 6A ... pattern carrier, 8, 8A ... pattern plate, 9, 36 ... frame, 19 ... sand injection hopper, 24 ... chute, 26 ... sand injection port, 26a ... bottom surface, 27 ... filling frame, 27a ... outer surface, 27b ... inner surface, 28 ... sand injection nozzle, 28a ... ceiling surface, 28b ... bottom surface, 29 ... squeeze head mechanism, 33 ... molding flask, 37 ... liner, 39 ... urethane rubber, 100 ... molding machine, BF ... injection frame.

## Claims

1. A molding machine forming a mold by using a transferred molding flask and pattern plate, the molding machine comprising:

- a filling frame provided with a lower opening connectable to an upper opening of the molding flask;
- a squeeze head mechanism including a squeeze board movable into and out from the filling frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board;
- a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the squeeze head mechanism, and the pattern plate; and
- a sand injection nozzle provided in a side portion of the filling frame to enable the sand injection port and the molding space to communicate with each other.
2. A molding machine forming a mold by using a transferred molding flask and pattern plate, the molding machine comprising:
- a filling frame provided with a lower opening connectable to an upper opening of the molding flask;
- an injection frame disposed above the filling frame, being provided with a lower opening connectable to an upper opening of the filling frame;
- a squeeze head mechanism including a squeeze board movable into and out from the injection frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board;
- a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the injection frame, the squeeze head mechanism, and the pattern plate; and
- a sand injection nozzle provided in a side portion of the injection frame to enable the sand injection port and the molding space to communicate with each other.
3. The molding machine according to claim 1 or 2, wherein the sand injection nozzle is inclined to become lower from its inlet toward its outlet.
4. The molding machine according to claim 3, wherein the sand injection nozzle includes a ceiling surface including an inclination angle larger than that of its bottom surface.
5. The molding machine according to claim 1 or 2, wherein the at least one sand injection port includes an inclined bottom surface.
6. The molding machine according to claim 5, wherein the at least one sand injection port includes a bottom surface made of ultra-high molecular weight polyethylene.
7. The molding machine according to claim 1 or 2, wherein the sand injection hopper includes a lower portion formed of forked chutes.
8. The molding machine according to claim 1, wherein the sand injection hopper includes a lower portion formed of forked chutes, and the filling frame is disposed between the chutes.
9. The molding machine according to claim 8, wherein the filling frame is fixed to the chutes.
10. The molding machine according to claim 2, wherein the sand injection hopper includes a lower portion formed of forked chutes, and the injection frame is disposed between the chutes.
11. The molding machine according to claim 10, wherein the injection frame is fixed to the chutes.
12. The molding machine according to any one of claims 8 to 11, wherein the squeeze head mechanism is disposed between the chutes.
13. The molding machine according to claim 1 or 2, further comprising a frame surrounding an outer periphery of the pattern plate to be slid up and down, wherein a part of the molding space is defined by the frame.
14. The molding machine according to claim 1 or 2, wherein the squeeze head mechanism is supported by two flask setting cylinders such that the squeeze head mechanism descends to perform a flask setting step and a squeezing step.
15. The molding machine according to claim 14, wherein the sand injection hopper is coupled to a plurality of lifting cylinders attached to a lifting support frame provided between upper ends of piston rods of the respective flask setting cylinders.
16. A sand-filling compression unit used in a molding machine configured to form a mold by using a transferred molding flask and pattern plate, and filling a molding space with molding sand, the sand-filling compression unit comprising:
- a filling frame provided with a lower opening connectable to an upper opening of the molding flask;
- a squeeze head mechanism including a squeeze board movable into and out from the

filling frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board;

a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the squeeze head mechanism, and the pattern plate; and  
 a sand injection nozzle provided in a side portion of the filling frame to enable the sand injection port and the molding space to communicate with each other.

17. A sand-filling compression unit used in a molding machine configured to form a mold by using a transferred molding flask and pattern plate, and filling a molding space with molding sand, the sand-filling compression unit comprising:

a filling frame provided with a lower opening connectable to an upper opening of the molding flask;

an injection frame disposed above the filling frame, being provided with a lower opening connectable to the upper opening of the filling frame; a squeeze head mechanism including a squeeze board movable into and out from the injection frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board;

a sand injection hopper including at least one sand injection port for injecting molding sand into a molding space defined by the molding flask, the filling frame, the injection frame, the squeeze head mechanism, and the pattern plate; and  
 a sand injection nozzle provided in a side portion of the injection frame to enable the sand injection port and the molding space to communicate with each other.

18. A mold forming method for forming a mold by using a molding flask and a pattern plate, transferred to a molding machine, the mold forming method comprising:

a step of defining a molding space by using: the molding flask; a filling frame provided with a lower opening connectable to an upper opening of the molding flask; a squeeze head mechanism including, a squeeze board movable into and out from the filling frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; and the pattern plate; and  
 a step of filling the molding space with molding

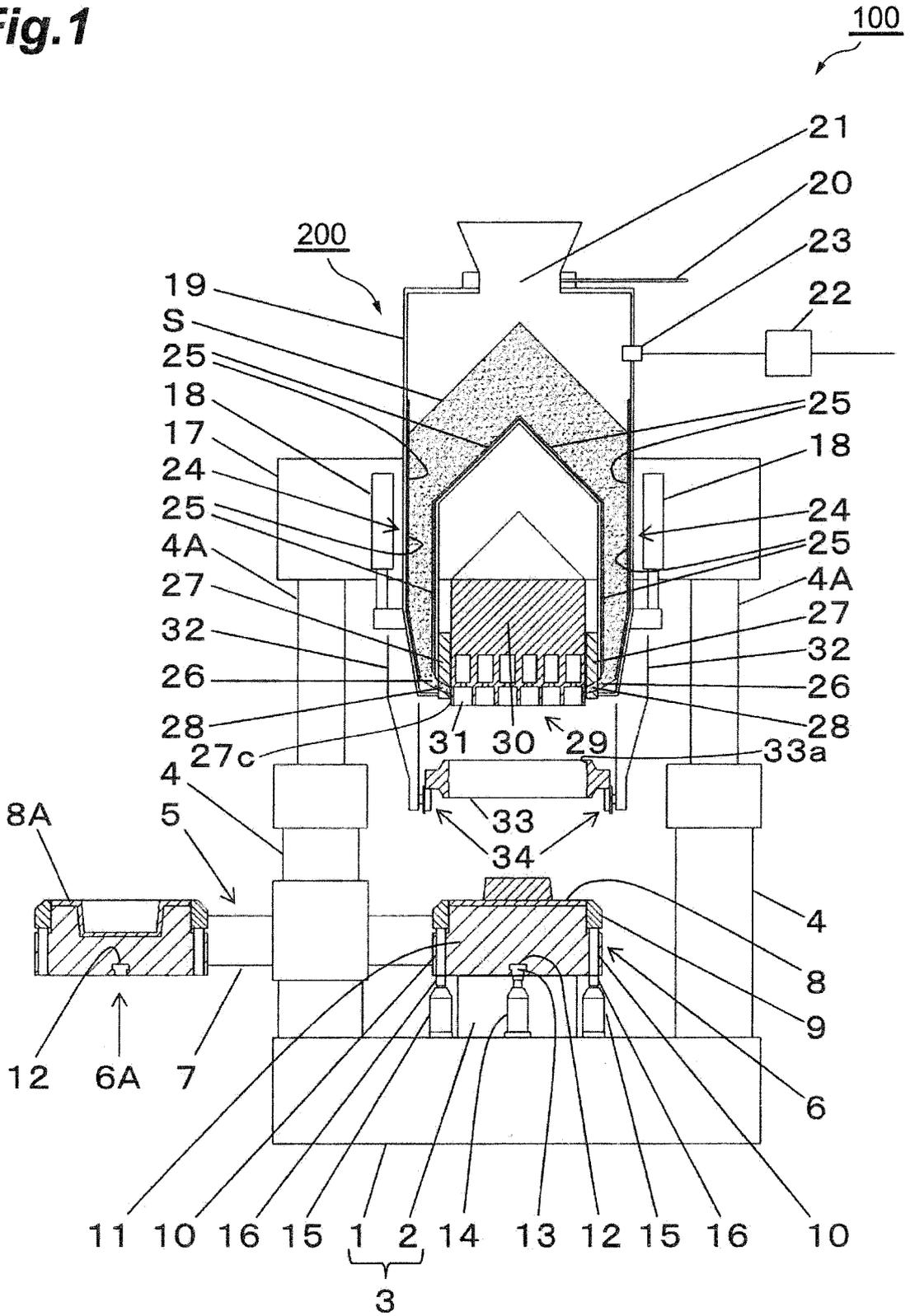
sand using a sand injection nozzle enabling at least one sand injection port provided in a sand injection hopper provided in a side portion of the filling frame to store molding sand, and the molding space, to communicate with each other.

19. A mold forming method for forming a mold by using a molding flask and a pattern plate, transferred to a molding machine, the mold forming method comprising:

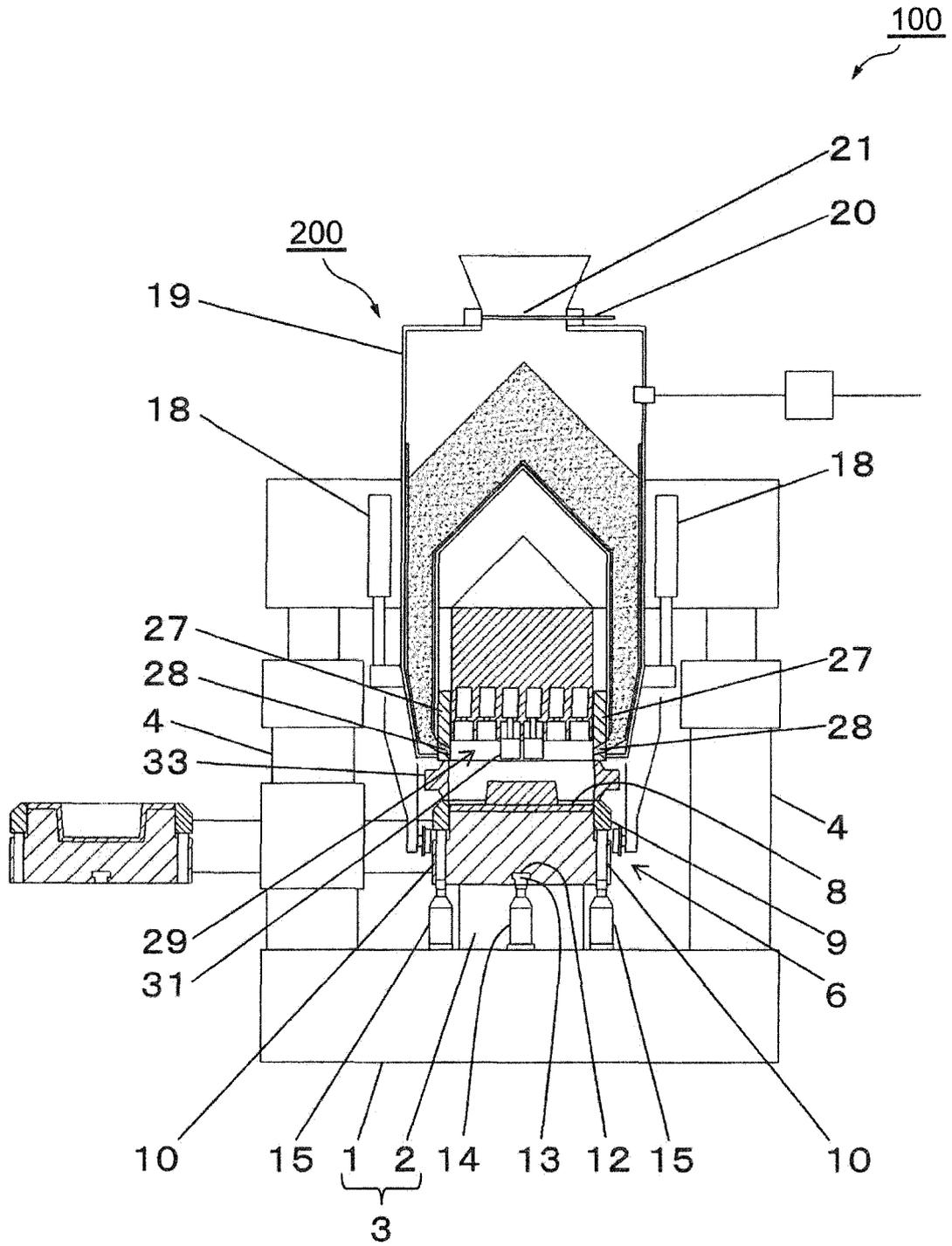
a step of defining a molding space by using: the molding flask; a filling frame provided with a lower opening connectable to an upper opening of the molding flask; an injection frame disposed above the filling frame, being provided with a lower opening connectable to an upper opening of the filling frame; a squeeze head mechanism including a squeeze board movable into and out from the injection frame, and a plurality of squeeze feet passing through the squeeze board, being able to move up and down with respect to the squeeze board; and the pattern plate; and

a step of filling the molding space with molding sand using a sand injection nozzle enabling at least one sand injection port provided in a sand injection hopper provided in a side portion of the injection frame to store molding sand, and the molding space, to communicate with each other.

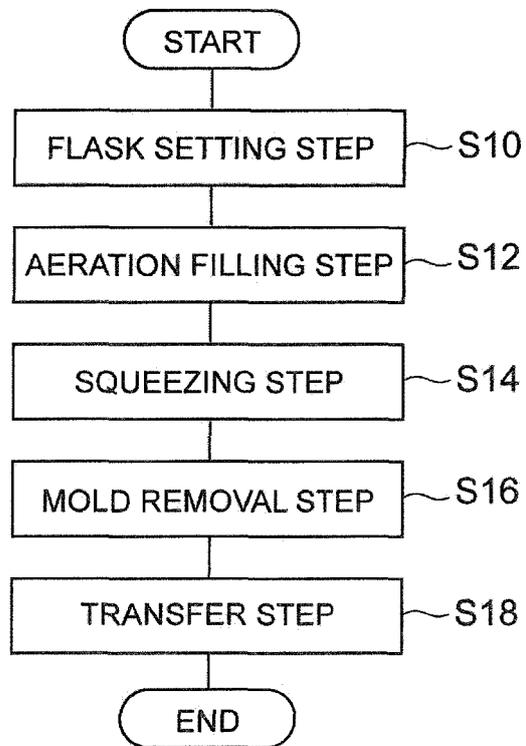
**Fig.1**



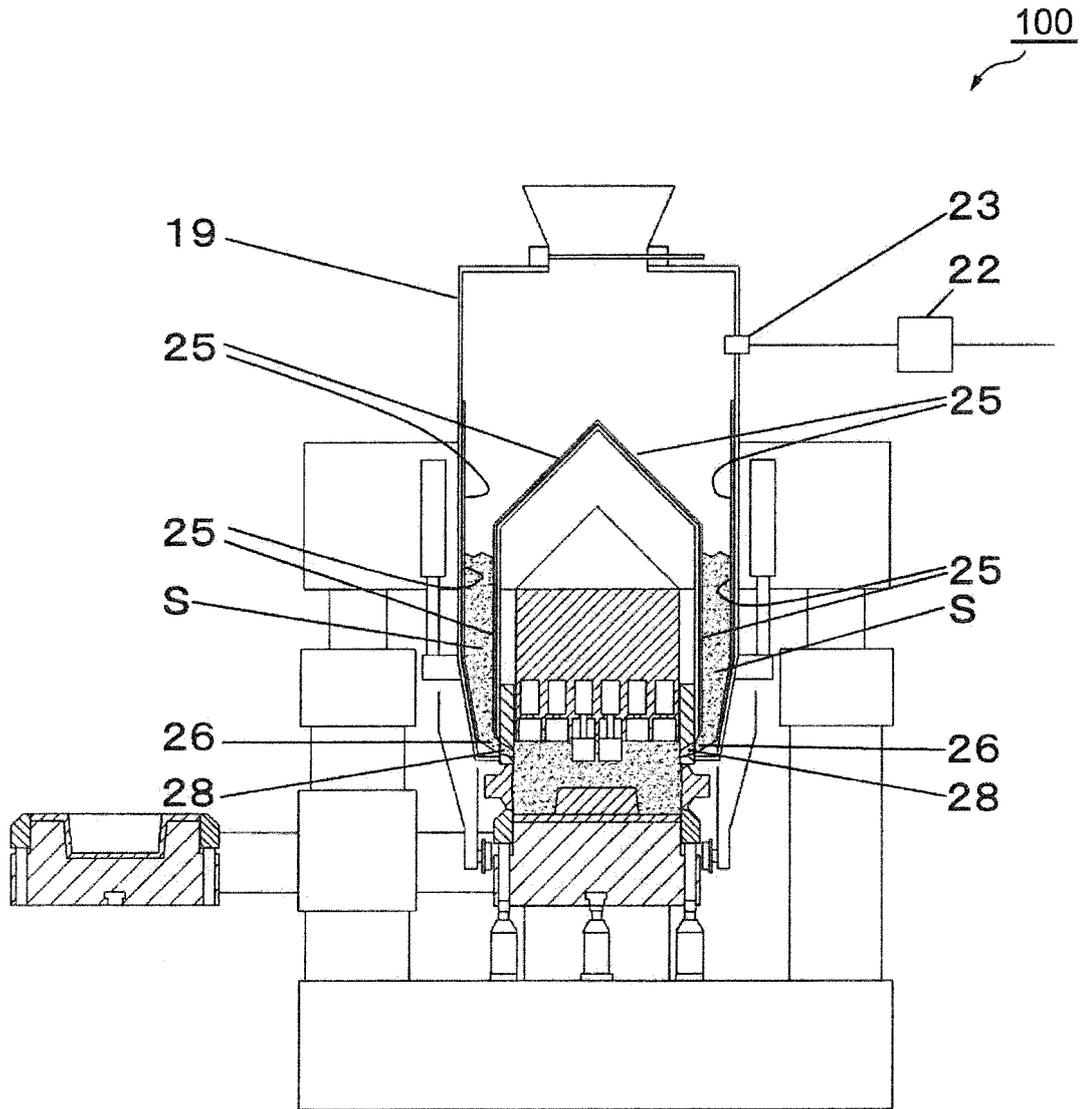
**Fig.2**



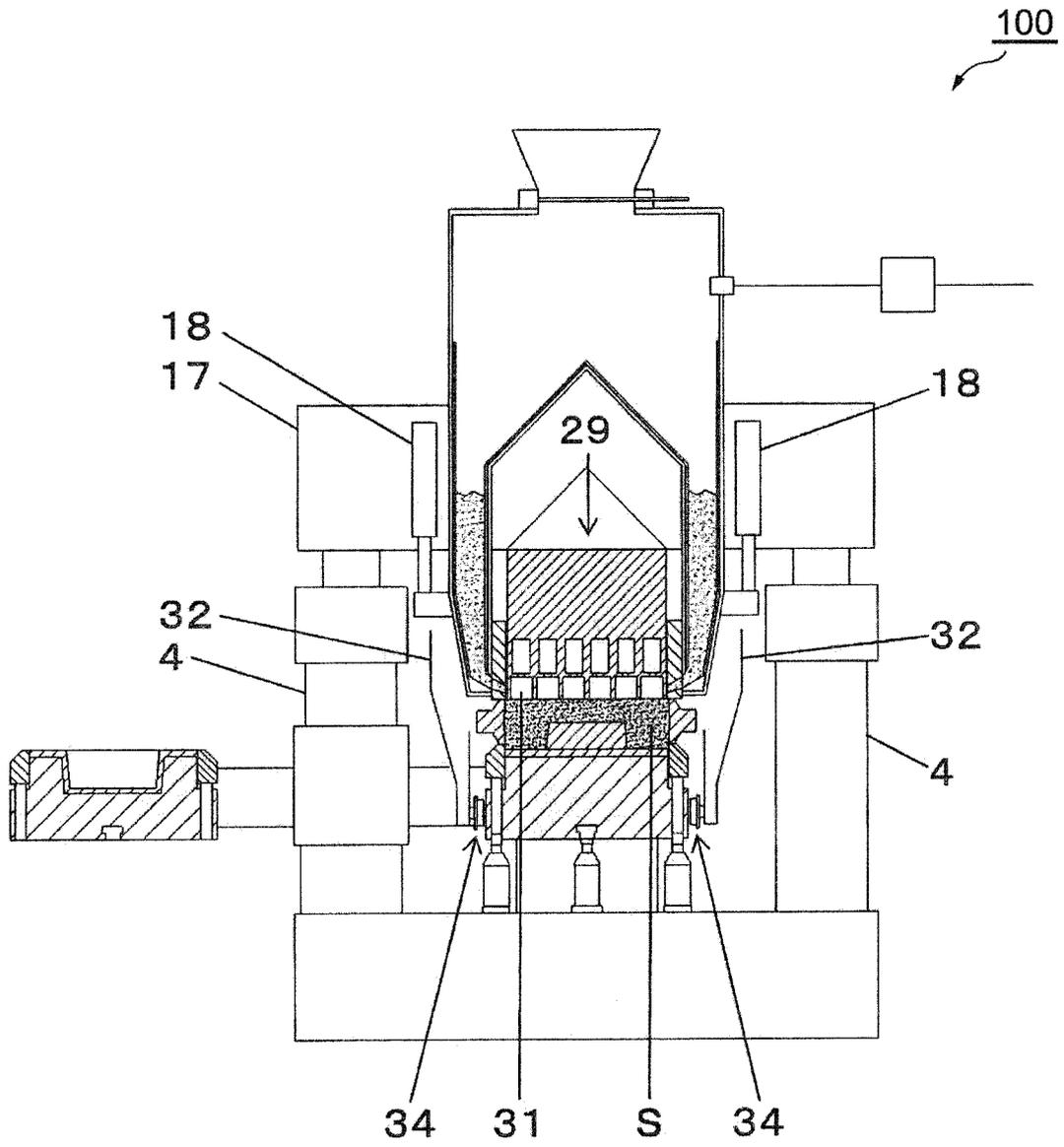
**Fig.3**



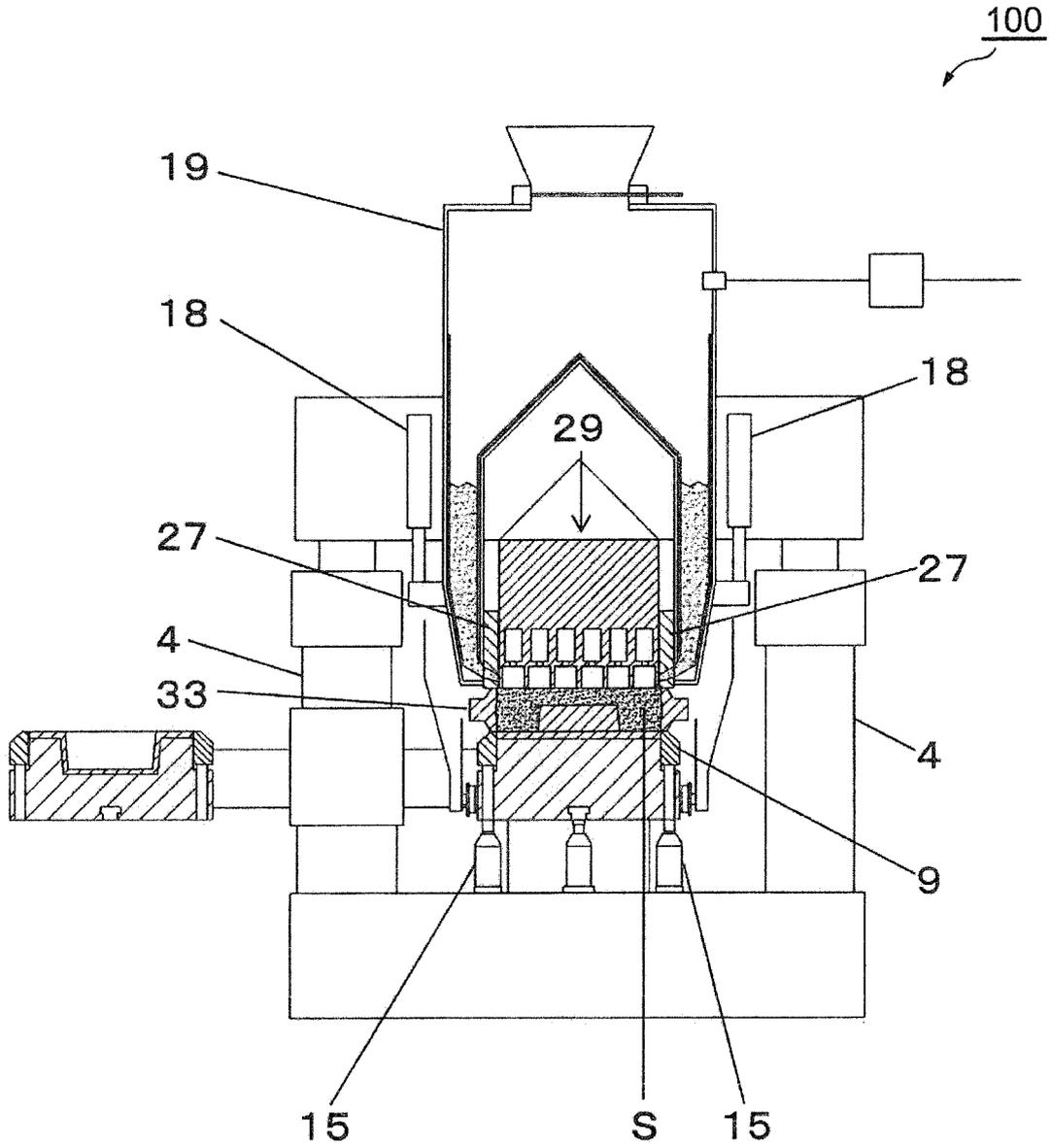
**Fig.4**



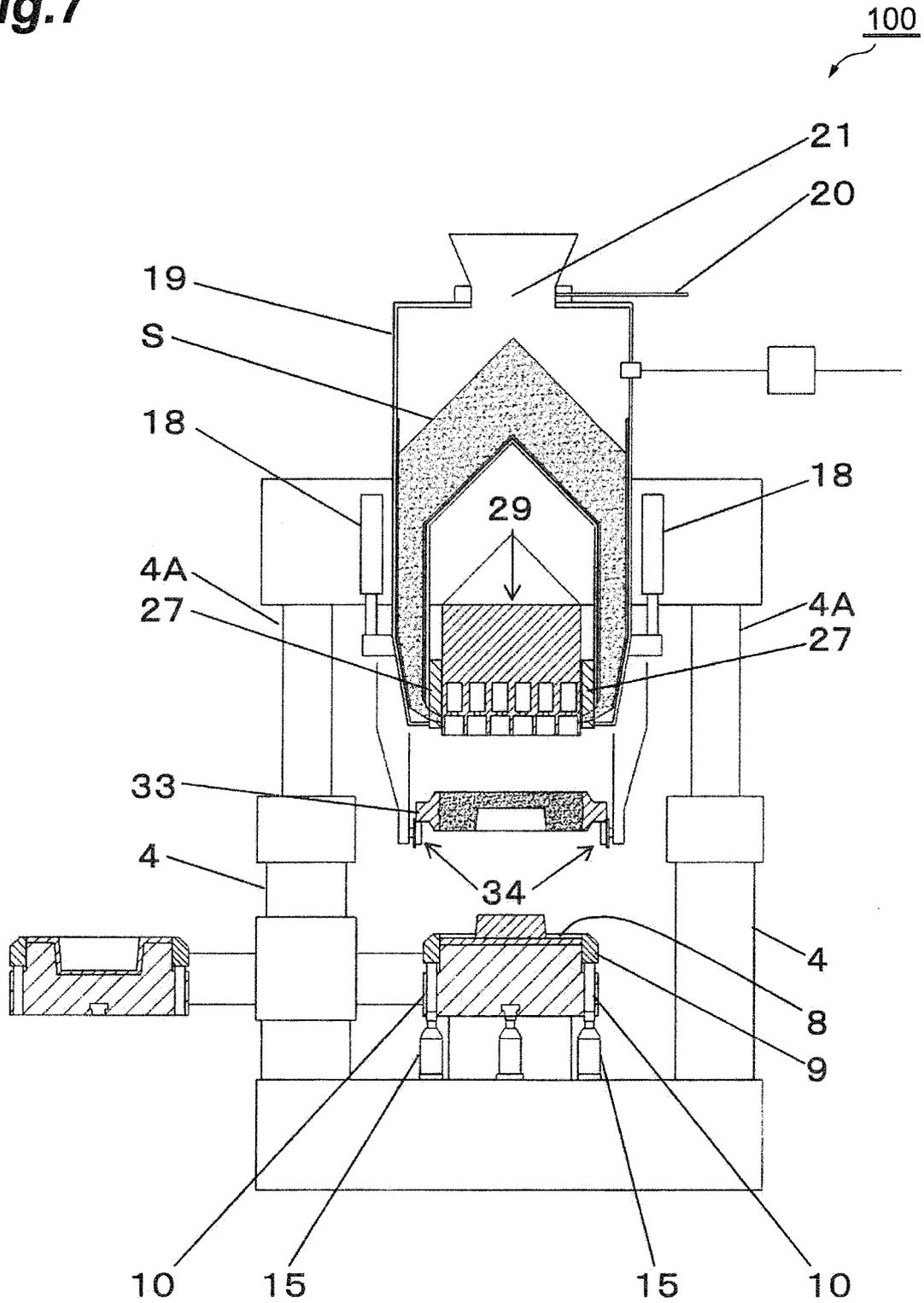
**Fig.5**



**Fig.6**

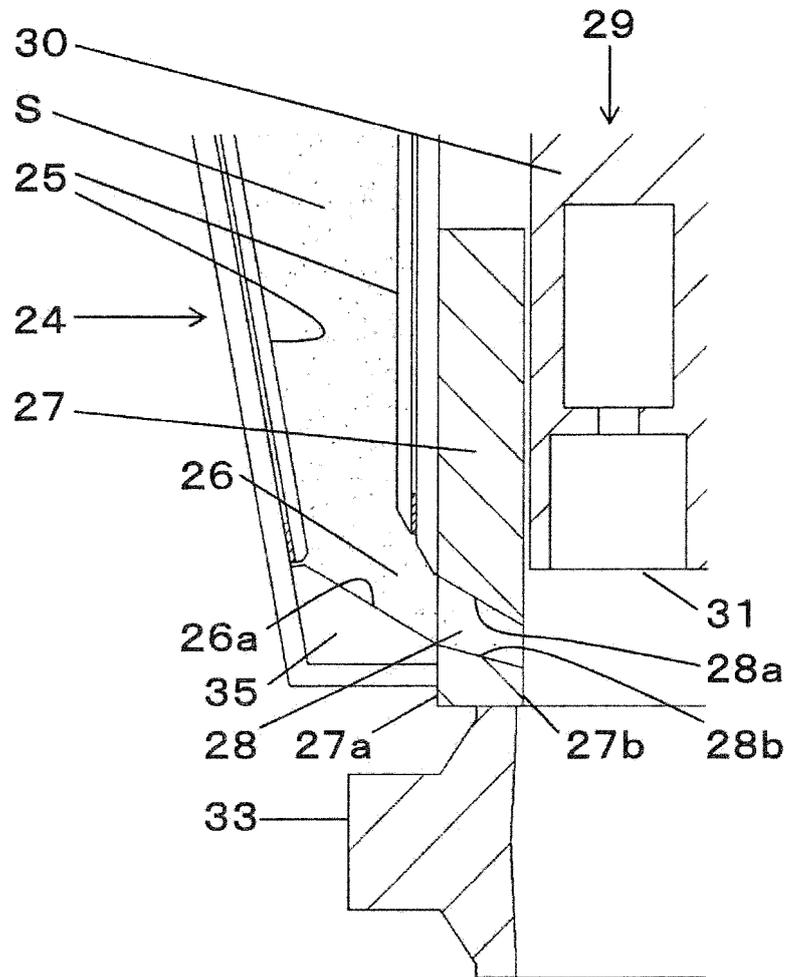


**Fig.7**

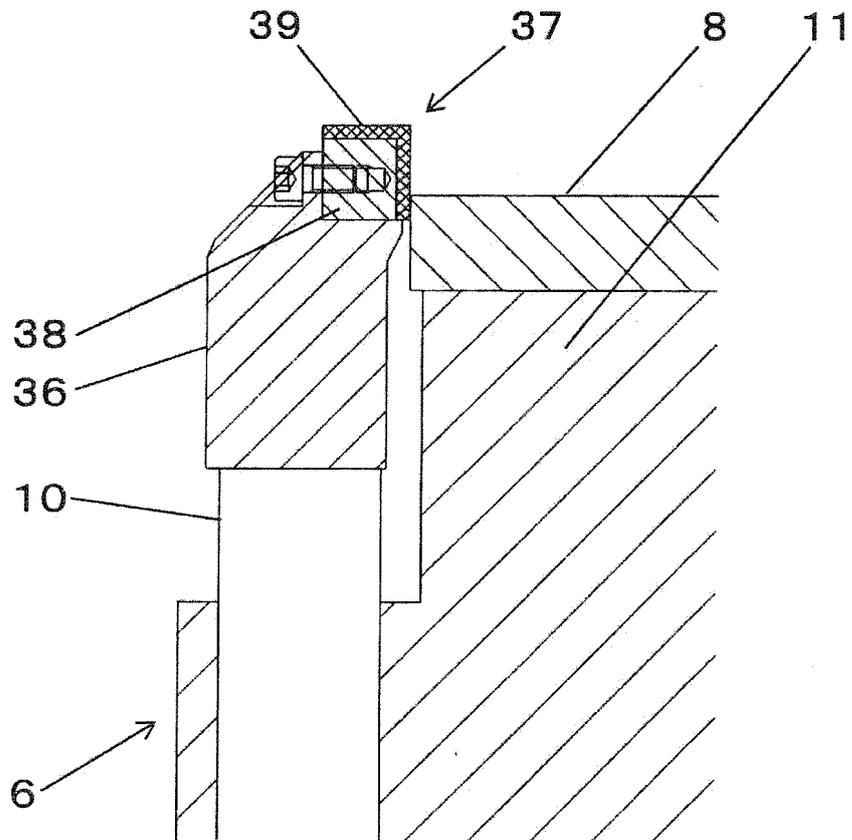




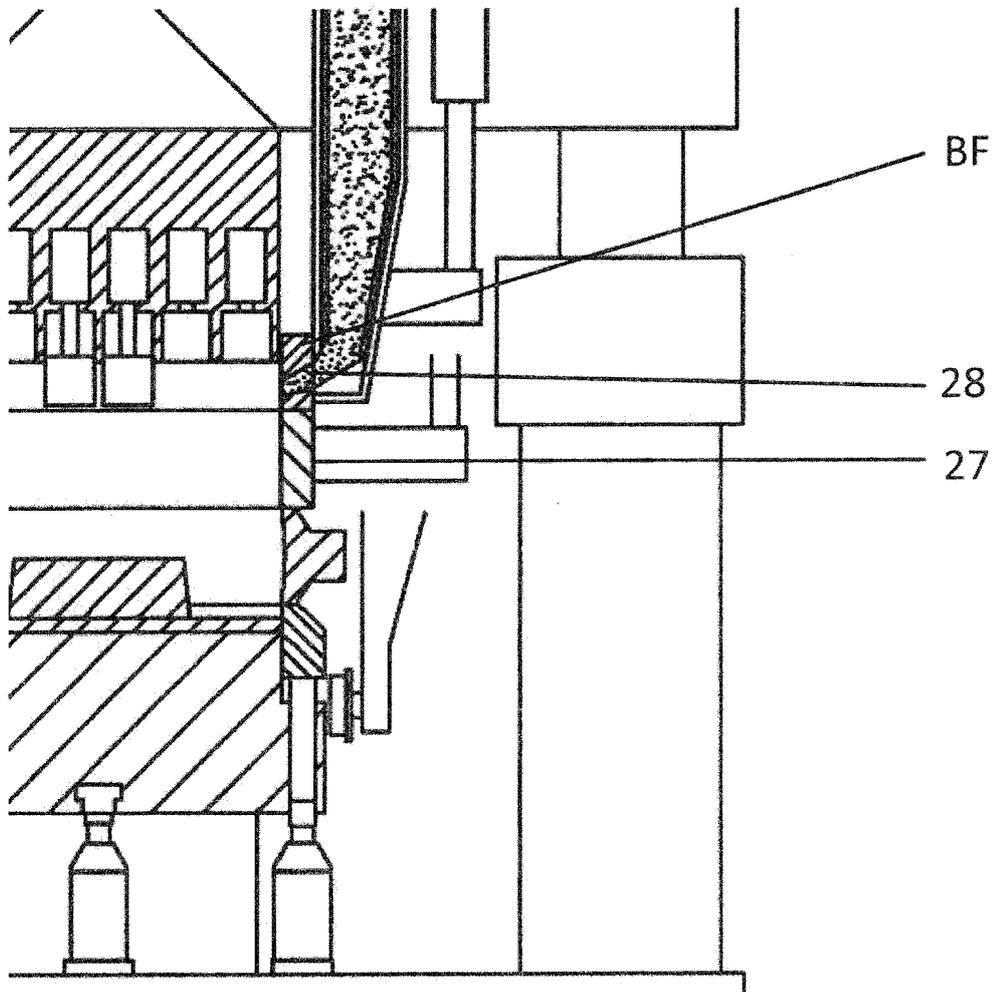
**Fig.9**



**Fig.10**



**Fig.11**



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/069026

## A. CLASSIFICATION OF SUBJECT MATTER

B22C15/28(2006.01)i, B22C11/00(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)

B22C15/28, B22C11/00

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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.
Y A	JP 2005-329469 A (Sinto Kogyo Ltd.), 02 December 2005 (02.12.2005), paragraphs [0008] to [0026]; drawings (Family: none)	1-7, 13-19 8-12
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 66877/1981(Laid-open No. 181459/1982) (Sinto Kogyo Ltd.), 17 November 1982 (17.11.1982), page 2, line 17 to page 6, line 2; fig. 1 (Family: none)	1-7, 13-19

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

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"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  
15 August 2016 (15.08.16)Date of mailing of the international search report  
30 August 2016 (30.08.16)Name and mailing address of the ISA/  
Japan Patent Office  
3-4-3, Kasumigaseki, Chiyoda-ku,  
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/069026

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 6-190506 A (Mitsubishi Heavy Industries, Ltd.), 12 July 1994 (12.07.1994), claims (Family: none)	6
A	JP 2012-55968 A (Sinto Kogyo Ltd.), 22 March 2012 (22.03.2012), paragraphs [0015] to [0041]; fig. 1 to 10 & WO 2011/049249 A2 & EP 2604362 A2 paragraphs [0015] to [0041]; fig. 1 to 10 & TW 201210716 A & CN 102834200 A	1-19

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**REFERENCES CITED IN THE DESCRIPTION**

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