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Applicant: **GIBSON ENGINEERING COMPANY LIMITED**
Weston Road Crewe
Cheshire CW1 1DB(GB)

(72)

Inventor: **Tingle, Arthur Gwynfryn**
21 Mount Drive
Nantwich Cheshire(GB)

(74)

Representative: **Lewis, Samuel Hewitt et al,**
FORRESTER & BOEHMERT Widenmayerstrasse 4/1
D-8000 München 22(DE)

(54)

Method of centrifugal casting.

(57)

A method of centrifugal casting comprises the steps of forming moulding material in a flask (41) around a pattern (35) made of decomposable material removing the decomposable material pattern (35) whereby the moulding material provides a mould (42), spinning the mould about an axis (A), introducing into the mould molten metal, continuing to spin the mould whilst permitting the metal to solidify to thus produce a casting, removing the casting from the moulding material.

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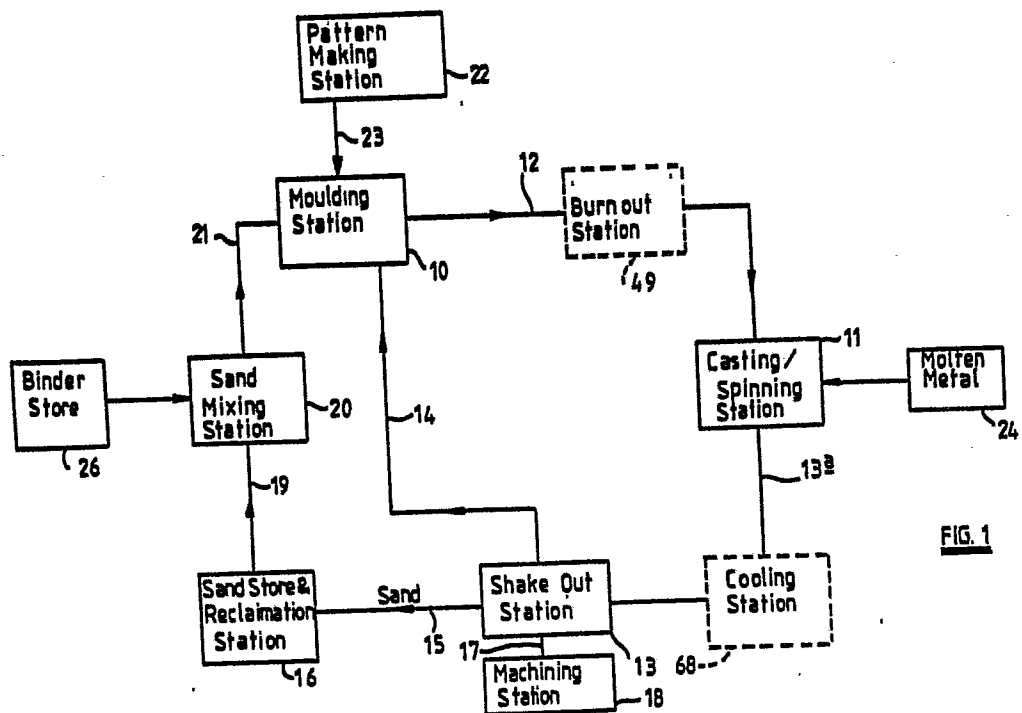


FIG. 1

Title: "Method of Centrifugal Casting"

This invention relates to a method of centrifugal casting and to various apparatus for use in the method.

Centrifugal casting is often employed in preference to static casting because it offers improved physical properties, such as denser metal structure, in the resultant casting.

In centrifugal casting, metal to be cast is introduced into a vertically or horizontally disposed spinning mould, and hence projected towards the walls of the mould. In this way, a concentric casting, i.e. having an opening along its entire length can be formed, the casting having a wall thickness substantially constant over the entire length of the casting, determined by the volume of metal introduced into the mould. However, where the mould is rotated about a vertical axis, the wall thickness can vary over the length of the mould. This can be controlled within limits by varying the speed of rotation, thus controlling the force imposed by the rotation and further improved by good mould design.

Alternatively, at least in a vertically disposed spinning mould, a solid casting can be produced by filling the mould completely with metal.

Castings thus produced have needed subsequently to be extensively machined, to form the casting to the exact required configuration.

In the simplest case, i.e. where the external surface of the casting is of generally cylindrical configuration, but provided with an appropriate draft, the mould may comprise a simple one-piece metal mould; after the casting has solidified the casting can easily be withdrawn from the mould.

If external formations such as ribs, rings etc., are required or a constant non-tapered wall thickness is required, the external wall of the casting can be machined to provide these. However, this machining is expensive to carry out and hence preferably avoided. Where the casting is concentric, such as a cylinder liner, internal machining is also nearly always required.

In a modified method, a split metal mould has been used so that the casting can be made with external formations, and the casting subsequently removed by splitting the mould longitudinally. Although this method is advantageous because the amount of machining required is reduced, the
5 moulds are expensive to produce. Furthermore, split and non-split metal
moulds quickly become distorted in use, due partly to the cast metal directly contacting the wall of the mould.

In a further modified method, known as the Noble method, a sand mould is provided in a sand flask, the sand being formed to shape so that the
10 resultant casting may have external formations, the casting being removable
in such case by virtue of fragmentation of the sand mould on shake-out. Thus again, the amount of machining required is reduced and furthermore a one-piece flask can be provided which is protected from direct contact with the cast metal by the insulation of the sand and which is cheaper to produce than
15 the split moulds.

This method presents a considerable improvement over the prior methods although forming of the sand to shape presents difficulty and the castings produced still require extensive machining.

The sand is formed, at present, by mixing the sand with a suitable
20 binder, and vibrating (centrifugally rotating or otherwise agitating the sand)
to compact the sand, and subsequently machining the sand to the desired shape.

The Noble method is described in more detail in "Modern Casting" in the issue December 1982, on Pages 20 to 22.

25 It is one object of the present invention to provide a new or improved method of centrifugal casting.

According to one aspect of the invention, we provide a method of centrifugal casting comprising the steps of forming moulding material in a flask around a pattern made of decomposable material (as herein defined)
30 removing the decomposable material pattern whereby the moulding material provides a mould, spinning the mould about an axis, introducing into the mould molten metal, continuing to spin the mould whilst permitting the metal to solidify to thus produce a casting, removing the casting from the moulding material.

35 By "decomposable material" we mean a material which, when in a solid state, is sufficiently strong to enable the moulding material to be formed therearound, and which can be substantially completely vaporised, liquidised

or otherwise decomposed to a state such that the material can leave the mould, for example by subjecting the material to burning and/or heat and/or a chemical reaction. Preferably the decomposable material pattern is removed from the mould in a gaseous state either by burning prior to the metal being cast into the mould, or by the action of heat gained from the cast metal, as the metal is cast into the mould.

One example of a suitable decomposable material is foamed plastic such as foamed polystyrene which is very light but strong for its volume, or even an unfoamed plastic such as polystyrene. The pattern can be solid, or hollow to further reduce the volume of the decomposable material, and thus the amount of burning/heat, required to remove the material.

By using the method in accordance with the invention, castings can be produced to fine tolerances by ensuring that the polystyrene or other decomposable material patterns are all produced to a close tolerance, thereby minimising the amount of machining subsequently required.

It has been found that cast surfaces are less prone to rust than machined surfaces, and thus because machining is reduced to a minimum, in the method in accordance with the invention, the quality of the resultant castings is considerably improved.

Further, because the moulding material does not need to be machined to be formed to shape, the moulds into which the molten metal is cast are all of more constant configuration relative to each other, and thus any machining which does subsequently need to be carried out, as the resultant casting can more easily be arranged to be carried out automatically.

The mould is preferably spun at between 250 and 2000 r.p.m., although the preferred spinning speed will depend upon the size and volume of the casting to be produced.

The axis of rotation of the mould is usually horizontal or vertical, but if required could be arranged to be at other angles inclined to the horizontal or vertical respectively.

The moulding material may be sand, such as silicon sand, chromite sand or zircon sand, mixed with a suitable binder, which sand can be reclaimed and re-used, after the casting is removed, although other types of moulding material may be used.

The flask in which the moulding material is placed around the pattern may comprise a tube closed at either end by suitable closure means. During moulding, the pattern is preferably received on a support fixed relative to a

moulding table, which may be arranged to be vibrated, centrifugally rotated or otherwise agitated to ensure compaction of the moulding material during moulding.

5 The support may extend vertically and the closure means at one end of the flask may lie between the pattern and the moulding table.

 Before spinning, the flask may be removed from the moulding table and the pattern removed from the support. The flask may be received in a flask holder, during spinning and drive may be transmitted through a transmission means such as a belt drive from a power means such as an electric motor, to the flask holder to rotate the flask holder and hence flask and mould, about said axis.

10 This arrangement, where a separate flask and flask holder are used, is advantageous because moulding can be carried out at a location remote from that at which spinning takes place, thereby assisting in automation of the method.

15 The method according to the invention may be utilised in an automated foundry comprising a moulding station, at which moulding material is formed in a flask, a casting/spinning station at which the mould is spun about said axis and molten metal introduced into the mould, means to convey the mould from the moulding station to the casting/spinning station, a shakeout station at which the casting is removed from the moulding material, and means to convey the mould from the casting/spinning station to the shakeout station.

20 Preferably, the flask is conveyed to the casting/spinning station at which the flask is received in a flask holder to which drive is transmitted through a transmission such as a belt drive from a power means such as an electric motor, to rotate the flask holder and hence flask about said axis.

25 After spinning, the flask, complete with mould and cast metal, may be conveyed to the shakeout station from where it may be conveyed by further conveying means once the casting has been removed from the moulding material, back to the moulding station.

30 The moulding material may be conveyed from the shakeout station to a reclamation station from whence it can be reclaimed and re-cycled for further use.

35 Where a pattern of decomposable material is used, this may be made by moulding at a pattern moulding station and conveyed to the moulding station by further conveying means, although where the patterns used are not made in the foundry, the patterns may be conveyed from a store to the moulding station.

If desired, the casting may be conveyed from the shakeout station to a machining station where a predetermined machining operation may be carried out on the casting.

According to a second aspect of the invention, we provide apparatus for use in a method of centrifugal casting according to the first aspect of the invention, said apparatus comprising a pattern made of decomposable material (as herein defined), a flask in which moulding material may be formed to a desired mould form about the pattern, a flask holder adapted to receive the flask, power means, a transmission to transmit power from the power means to the flask holder to cause the flask holder and hence flask and mould to rotate about an axis, means to introduce into the spinning mould, molten metal, means to remove the casting when the metal has solidified from the moulding material.

According to a third aspect of the invention, we provide apparatus for use in a method of centrifugal casting according to the first aspect of the invention, said apparatus comprising a structure adapted to be agitated, a support fixed relative to the structure on which a pattern of decomposable material (as herein defined) is in use received, a flask engaged with the structure and surrounding the support, and in use thereby providing a cavity between the pattern and the flask which is filled with moulding material.

The pattern may have an opening formed therein to receive the support or may be pierced by the support.

In one embodiment, where an end of the flask engages the structure and the support extends through the flask generally perpendicularly to the structure, the pattern may engage the structure either directly or through a closure means which closes the end of the flask.

In another embodiment, where a wall of the flask engages the structure and the support extends generally parallel to the structure, the pattern may engage closure means which closes the end of the flask.

The flask may be arranged to be removed from the structure, complete with the pattern and moulding material, and placed in a flask holder for spinning. Thus, the flask for use in an apparatus according to the fourth aspect of the invention may itself comprise apparatus according to the third aspect of the invention.

The invention will now be described, with reference to the accompanying drawings, wherein:-

FIGURE 1 is a flow diagram of an automated foundry in which methods in accordance with first and second aspects of the invention are carried out;

FIGURE 2 is a vertical section through a mould on a moulding table at the moulding station of the foundry of Figure 1;

FIGURE 3 is a vertical section through the mould of Figure 2 at a casting/spinning station.

5 Referring first to Figure 1, an automated foundry comprises a moulding station 10 at which a mould of silicon sand is formed around a pattern as hereinafter described, a casting/spinning station 11 at which the mould is spun and molten metal is introduced into the mould.

10 The foundry has conveyor means 12 to convey the mould from the moulding station 10 to the casting/spinning station 11.

The foundry further comprises a shakeout station 13 where a casting is removed from the mould, and from which flasks which contained the moulds are returned to the moulding station 10 by further conveying means 14, sand shaken out from the mould being conveyed by conveyor means 15 to a sand store and reclamation station 16. The castings are conveyed from the shakeout station 13 by conveying means 17 to a machining station 18. The moulds (and cast metal) are conveyed from the casting/spinning station 11 to the shakeout station 13 by a further conveying means 13a.

20 The sand is conveyed from the sand store and reclamation station 16 by conveying means 19, to a sand mixing station 20 where the reclaimed sand is mixed with binder and conveyed to the moulding station 10 by conveying means 21.

25 The patterns for the moulding station 10 may be manufactured in the foundry at a pattern making station 22, in which case the patterns may be conveyed to the moulding station 10 by further conveying means 23. Alternatively, the patterns could be made remote from the foundry, in which case the patterns may be conveyed from a pattern store to the moulding station 10.

30 Metal for casting may be prepared and stored in a holding furnace 24 and ladled or laundered or otherwise conveyed to the casting/spinning station 11.

Binder for the sand mixing station 20 may be stored in a binder store 26 and piped or otherwise conveyed to the sand mixing station 20 as required.

35 Thus the foundry may be arranged to be automated, the various apparatus described in more detail below, and other components necessary for a centrifugal casting method, being conveyed around the foundry by various conveying means.

The shakeout station 13, sand store and reclamation stations 16 and sand mixing station 20 may each be conventional as is well known in the art, although the moulding station 10 and casting/spinning station 11 are peculiar to the methods in accordance with the invention.

5 The centrifugal casting method in accordance with the invention utilises patterns made of foamed polystyrene or other decomposable material, around which the sand is moulded, the patterns subsequently being removed by burning at a burnout station, or alternatively by the action of heat as the metal is cast into the mould at the casting/spinning station 11.

10 Referring now particularly to Figure 2, at the moulding station 10 a structure comprising a moulding table 31 is mounted on springs 32 on a base 33. A vibratory unit 31a is provided whereby the table 31 can be agitated by vibrating the table 31 as is well known in the art. Alternatively, instead of a table 31, a structure arranged to be centrifugally spun or otherwise agitated
15 could be provided.

Projecting upwardly vertically from the table 31 is a support 34 over which a polystyrene pattern 35, or in the present case patterns (four are arranged concentrically on the support 34) are received. The patterns 35 each have a central bore 36 and are glued end-to-end.

20 The external surfaces 37 of the patterns 35 have various projecting formations 38 which would make moulding using a non-decomposable pattern and a one-piece mould impossible, as the patterns 35 could not be withdrawn from the mould prior to casting.

25 Lying between the lowermost pattern 35 and the table 31 is a closure means comprising a plate 39 which has a central opening 40 to receive the support 34. Of course the plate 39 would be placed over the support 34 in the position shown, prior to the patterns 35 being received on the support 34.

30 Surrounding the patterns 35 and engaging with the plate 39, a flask 41 is received. Thus a cavity 42 is left between the patterns 35 and the inner surface of the flask 41, into which cavity 42 moulding material, in the present case silicon sand mixed with binder, is introduced.

35 The table 31 is vibrated as the sand is introduced so that the sand is compacted as much as possible. When the cavity 42 is full, a top closure means comprising a plate 43 is received on top of the flask 41, the plate 43 having a recess 44 to receive the top end of the support 34, so that the underside 48 of the plate 43 can engage sand on the top surface 49 of the uppermost pattern 35.

The flask 41 containing the mould can then be removed from the table 31 along with the closure plates 39 and 43, the support 34 sliding out of the bores 36 of the patterns 35 and through the aperture 40 in the bottom closure plate 39. The flask 41 containing the mould may be conveyed by conveying means 12 to the casting/spinning station 11.

As mentioned above, if desired the patterns 35 may be removed by burning at a burnout station which is indicated in dotted lines at 49 in Figure 1, prior to casting, or removed during the casting operation.

Referring now to Figure 3, at the casting/spinning station 11, the flask 41 containing the mould with the polystyrene patterns (as shown in place in the upper part of the Figure) where the patterns 35 are to be removed during casting, is received in a flask holder 50. Alternatively the mould without the polystyrene patterns (as shown in the lower part of the Figure) where the patterns 35 were removed at a burn out station 49, is received in flask holder 50.

The flask holder 50 accommodates the upper closure plate 43 at the inner end, although the lower plate 39 is replaced by a closure plate 54 having a large tapered central aperture 55 through which the molten metal is poured from a pouring horn 56 as the mould is spun. Preferably the pouring horn 56 at the casting/spinning station is arranged on a parallel link (not shown) so that it may be easily inserted and withdrawn from the aperture 55 in the end closure plate 54.

The flask holder 50 is secured by mountings 51 to a drive unit 52 which includes an electric motor (not shown) or other power means, and a transmission such as a belt drive, to the flask holder 50 to rotate the flask holder about a horizontal axis A.

If desired, the flask holder 50 may be supported along its length by rollers, although alternatively where the flask holder 50 is only short, these would not necessarily be provided.

The closure plate 54 has openings 55 through which pins 56 threadedly engaged with the body of the flask holder 50, are received. The pins 56 have openings 57 to receive wedges 58 which are inserted to ensure that the closure plate 54 is tightly held in engagement with both the end 59 of flask 41, and an end flange 60 of the flask holder 50, so that the assembly is held rigid.

Further, the edge 61 of the closure plate 54 is engaged by teeth 64 of toggle clamps 65. The toggle clamps 65 are pivotally secured to the body of the flask holder 50 around the end thereof, and the toggle clamps 65 move

from the open position shown in the upper part of Figure 3, to the closed position shown at the lower part of Figure 3, before the flask holder 50 is rotated. Three or preferably four such toggle clamps 65 are provided.

As the flask holder 50, and hence mould, is spun, molten metal introduced into the mould from the pouring horn 56 will be flung outwardly by the centrifugal force to fill the interior formations 66 which correspond to the exterior formations 38 of the patterns 35. A predetermined quantity of molten metal is introduced via horn 56 to give a required wall thickness in the resultant casting.

If the polystyrene patterns 35 are present, as illustrated in the upper part of Figure 3, the heat gained from the molten metal will cause the patterns 35 to vaporise.

The flask holder 50 is continued to be spun whilst the molten metal solidifies. The flask 41 and flask holder 50 will be protected from the heat given off from the metal as it solidifies, by the refractory properties of the zircon sand. To assist cooling, the exterior surface of the flask holder 50 is provided with a plurality of ribs 67 which provide heat sinks. When the metal has solidified, if desired the metal may be allowed to cool further before shakeout, and to this end the flask 41 may be removed from the flask holder 50 and conveyed to a cooling station indicated in dotted lines at 68 in Figure 1, between the casting/spinning station 11 and the shakeout station 13 so that the flask holder 50 can, in the meantime, be used for spinning further castings.

The flask 41 may be retained at the cooling station 68 until it has cooled to below a predetermined temperature.

It will be appreciated, that because of the use of polystyrene patterns, which can be made to close tolerances, in the centrifugal casting method described, the castings produced will be substantially constant relative to each other in configuration. Accordingly, any machining of the casting required at the machining station 18 can be carried out automatically.

Because of the detail which can be incorporated into the polystyrene patterns, the amount of machining of the resultant castings is minimised.

Referring again to Figure 3, in the lower half of the figure, instead of the patterns 35 being shown, the casting produced is shown at 70. The shape of the external wall 71 of the casting 70 of course conforms to the shape of the sand mould. The casting 70 has a wall thickness slightly greater than the required final wall thickness.

The required shape of the final, four, individual workpieces 72 to 75 is shown in chain dotted lines in the casting 70.

5 It can be seen that machining is required internally of the casting 70 over substantially the entire length thereof, as is usual, although only limited machining of the external surface 71 is required. In both cases, the amount of metal which will have to be removed is exaggerated for clarity. Of course it would also be necessary to cut the casting 70 to separate the four individual castings 72 to 75.

10 The method described is applicable to fully automated systems which have at the casting/spinning station 11 a plurality of flask holders 50, e.g. five, arranged on a carousel, i.e. arranged along radii of a rotating table, at generally regularly spaced angular intervals. Thus, while a first flask 41 and mould are being loaded into one flask holder 50, the second, i.e. next clockwise or anti-clockwise mould, depending upon the direction of rotation
15 of the carousel, mould can be spun. The third, next clockwise or anti-clockwise mould could at the same time have the metal introduced into the mould whilst the fourth, next clockwise or anti-clockwise mould (and cast metal) could be spun as the metal solidifies. The fifth, next clockwise or anti-clockwise mould could at the same time be removed from the flask
20 holder 50 and placed on a conveyor for conveying to the cooling station or shakeout station as required.

Thus, a fast efficient centrifugal casting method can be achieved. Of course, more or less than five flask holders could be provided around such a carousel if required.

25 The method described utilising a separate flask 40 in which moulding takes place provides considerable advantage over known systems, particularly where a carousel is used, because it is not necessary as in known arrangements, to mould the sand by machining at the carousel, but rather moulding without machining the sand can be achieved by virtue of the decomposable patterns, at a remote location, i.e. the moulding station 10,
30 and the flask 41 conveyed to the carousel. This obviously assists in automation.

Although the use of silicon sand mixed with binder to produce the sand
35 moulds has been described, alternatively, chromite sand or zircon sand mixed with a suitable binder or any other type of suitable moulding material could alternatively be used. Further, although the production of concentric castings, i.e. castings having an opening along the length thereof, has been

described, the method and apparatus according to the invention may be used to produce solid castings, although the mould will in this case usually need to be disposed vertically during spinning.

CLAIMS:

1. A method of centrifugal casting characterised in the steps of forming moulding material in a flask (41) around a pattern (35) made of decomposable material removing the decomposable material pattern (35) whereby the moulding material provides a mould (42), spinning the mould about an axis (A), introducing into the mould molten metal, continuing to spin the mould whilst permitting the metal to solidify to thus produce a casting, removing the casting from the moulding material.
2. A method according to Claim 1 characterised in that the decomposable material pattern (35) is removed from the mould in a gaseous state prior to the metal being cast into the mould.
3. A method according to Claim 1 characterised in that the decomposable material pattern (35) is removed from the mould in a gaseous state by the action of heat gained from the cast metal, as the metal is cast into the mould.
4. A method according to any one of Claims 1 to 3 characterised in that the decomposable material is a foamed plastics material.
5. A method according to any one of the preceding claims characterised in that the moulding material is sand, mixed with a suitable binder.
6. A method according to any one of the preceding claims characterised in that the flask (41) is received in a flask holder (50), during spinning to which drive is transmitted through a transmission means from a power means (52) to rotate the flask holder (50) and hence flask (41) and mould, about said axis (A).
7. A method according to any one of the preceding claims which is utilised in an automated foundry comprising a moulding station (10), at which moulding material is formed in a flask (41), a casting/spinning station (11) at which the mould is spun about said axis (A) and molten metal introduced into the mould, means (12) to convey the mould from the moulding station (10) to the casting/spinning station (11), a shakeout station (13) at which the casting

is removed from the moulding material, and means (13a) to convey the mould from the casting/spinning station (11) to the shakeout station (13).

5 8. Apparatus for use in a method of centrifugal casting according to any one of Claims 1 to 7 comprising a pattern (35) made of decomposable material, a flask (41) in which moulding material is formed to a desired mould form around the pattern (35), a flask holder (50) adapted to receive the flask (41), power means (52), a transmission to transmit power from the power means (52) to the flask holder (50) to cause the flask holder (50) and hence flask (41) and mould to rotate about an axis (A), means (56) to introduce into the spinning mould, molten metal, means (13) to remove the casting when the metal has solidified from the moulding material.

10 9. Apparatus for use in a method of centrifugal casting according to any one of Claims 1 to 7 comprising a structure (31) adapted to be agitated, a support (34) fixed relative to the structure (31) on which a pattern (35) of decomposable material is, in use, received, a flask (41) engaged with the structure (31) and surrounding the support (34), and in use thereby providing a
15 cavity (42) between the pattern (35) and the flask (41) which is filled with moulding material.

10. Apparatus according to Claim 8 or Claim 9 characterised in that an end of the flask engages the structure (31) and the support (34) extends through the flask (41) generally perpendicularly to the structure (31) into an opening
20 (40) formed in the pattern (35), the pattern (35) engaging the structure (31) either directly or through a closure means which closes the end of the flask (41).

11. Apparatus according to Claim 9 characterised in that the flask (41) is arranged to be removed from the structure (31), complete with the pattern
25 (35) and moulding material, and placed in a flask holder (50) for spinning.

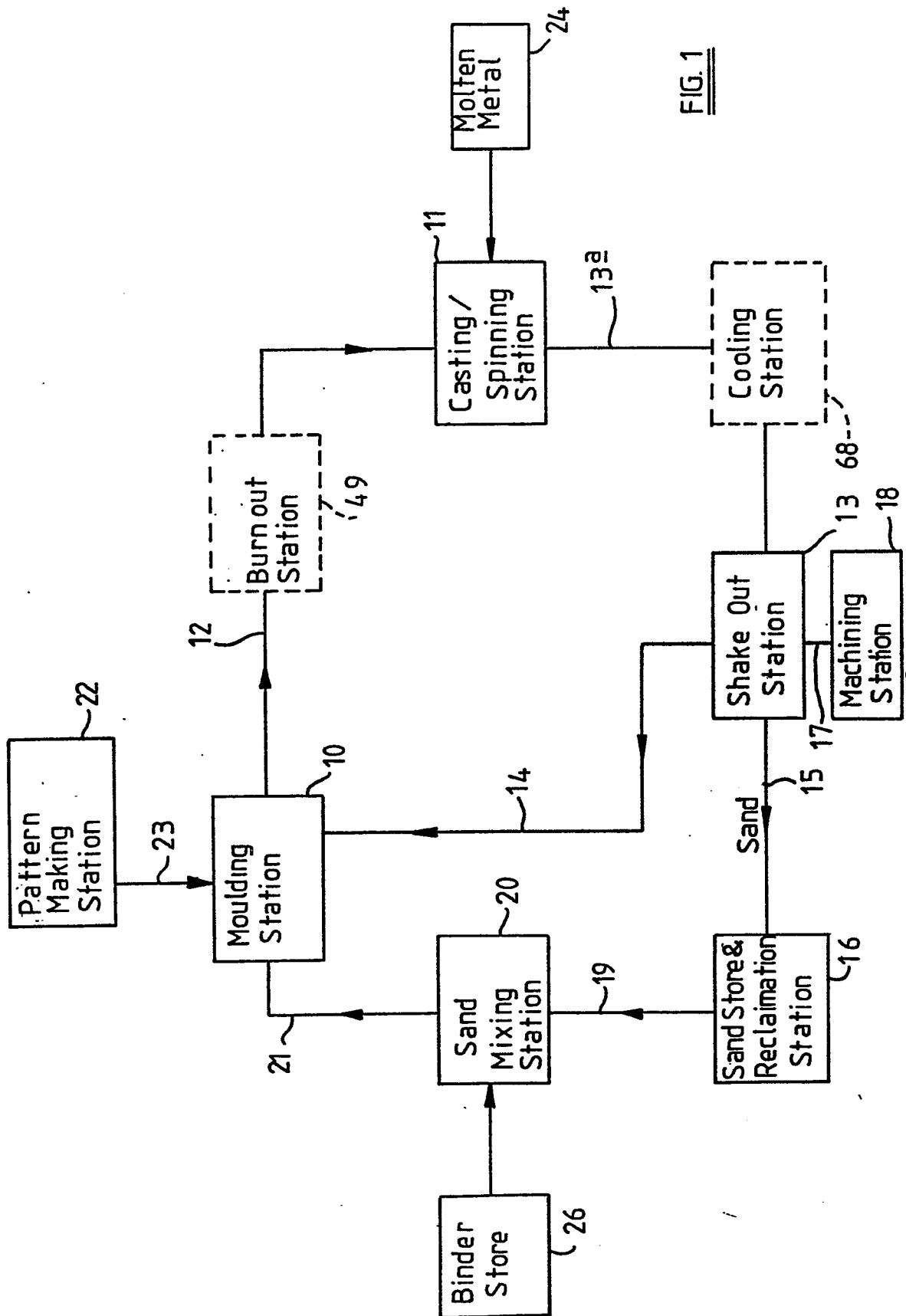
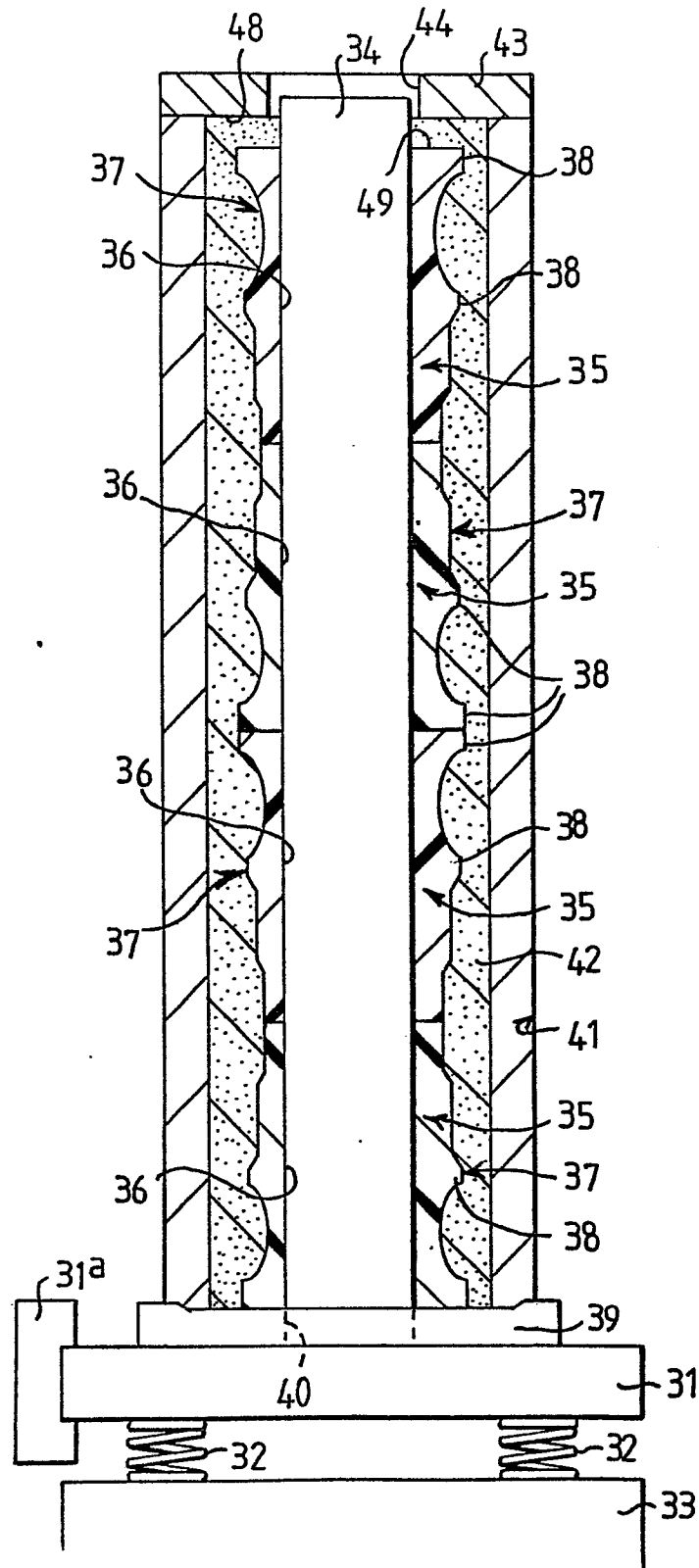


FIG. 1

FIG 2

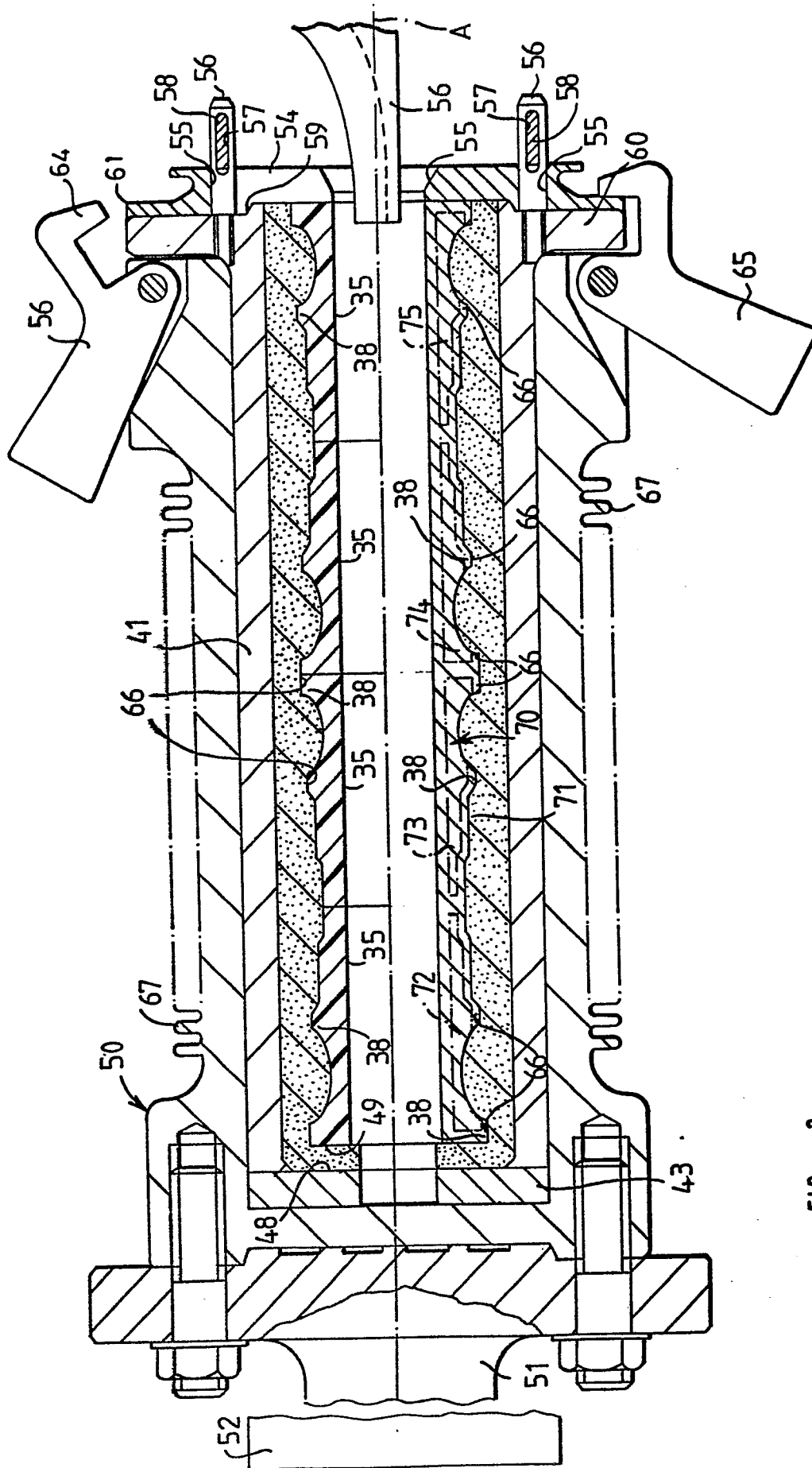


FIG 3