



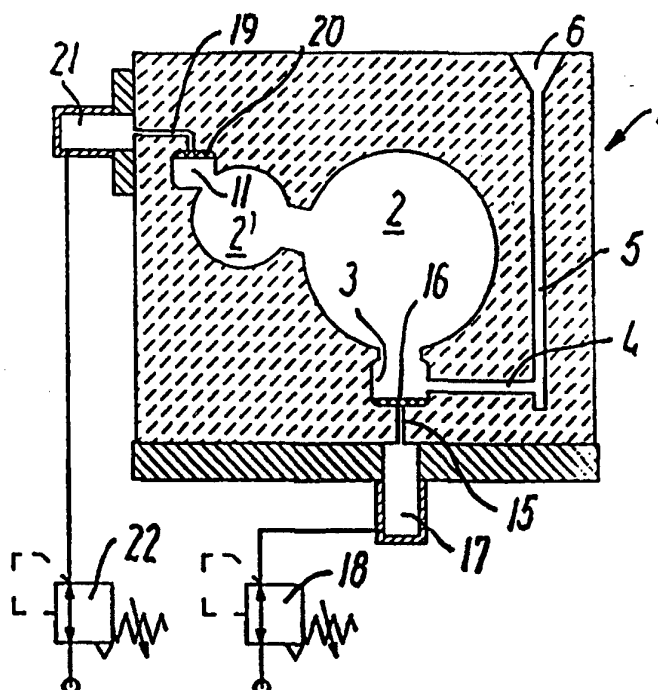
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(71) Applicant (for all designated States except US): DANSK INDUSTRI SYNDIKAT A/S [DK/DK]; Herlev Hovedgade 17, DK-2730 Herlev (DK).		Published With international search report. With amended claims.	
(72) Inventors; and (75) Inventors/Applicants (for US only): HANSEN, Preben, N. [DK/DK]; Sejrovej 41, DK-3140 Alsgårde (DK). PEDERSEN, Steen [DK/DK]; Abildvænget 1, DK-2750 Ballerup (DK). RASMUSSEN, Niels, W. [DK/DK]; Nørre Sideallé 6, st., DK-2200 København N (DK). MOGENSEN, Vagn [DK/DK]; Sassvej 6, DK-2820 Gentofte (DK). JESPERSEN, Emil [DK/DK]; Rytevænget 2, DK-2600 Glostrup (DK).			
(74) Agent: BUDDE, SCHOU & CO. A/S; Sundkrogsgade 10, DK-2100 København Ø (DK).			

(54) Title: METHOD AND EQUIPMENT FOR FEEDING SHRINKAGE VOIDS IN METAL CASTINGS

(57) Abstract

In a mould (1) with vertical parting surface, each mould cavity (2, 2') is connected through a wide throat with its own after-feeding reservoir (3, 11). When the mould (1) has been poured, a gas pressure is applied through a duct (15, 19) to a metal surface in the after-feeding reservoir (3, 11). This gas pressure is not allowed to exceed the metallostatic pressure in the mould at the surface, at which the pressure is applied, until the metal in the ingate (4) has solidified or the ingate has been blocked in some other way. At the location where the duct (15, 19) opens into the after-feeding reservoir, it is covered by an element (16, 20) that is impermeable for the metal having been poured but permeable for the pressurized gas. When the metal in the ingate (4) has solidified or the ingate has been blocked in some other way, the gas pressure may be increased.



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METHOD AND EQUIPMENT FOR FEEDING SHRINKAGE VOIDS
IN METAL CASTINGS

5

TECHNICAL FIELD

The present invention relates to a method of the kind set forth in the preamble of claim 1.

10

BACKGROUND ART

It is commonly known that metals, both in the liquid and solid state, when cooled undergo a decrease in volume, a so-called thermal contraction. In moulds, in which there is a non-uniform distribution of heat quantity in the mould cavity after the pouring, and in which for this reason not all the parts of the casting solidify at the same time, this causes the regions of the casting remaining longest in the liquid state to give off liquid metal to compensate for the contraction in the regions of the casting having solidified earlier, this leading to flaws in the casting commonly called "shrinkages", either appearing as depressions in the surface of the casting or as hollows (cavities or micro-shrinkages) within the casting. In order to avoid these faults, the skilled person can take a series of steps, of which the most common is the use of after-feeding reservoirs, i.e. cavities in the mould being filled with metal during the pouring operation and having such dimensions that the metal in them remains liquid longer than the last-solidifying regions of the casting, being connected to these regions through ducts with a relatively large cross-sectional area so as to enable them to after-feed these regions with liquid metal during their solidification.

Such after-feeding reservoirs are mainly known in two types, viz. as feeders or risers, i.e. substantially cylindrical cavities extending from the duct connecting them to the casting to the upper surface of the mould, and

as internal or enclosed cavities in the mould, so-called "suction buds", placed in the immediate vicinity of the region of the casting to be fed. Relative to the latter form, the former form exhibits the advantage that the higher metallostatic pressure at the after-feeding location, i.e. the pressure of the overlying metal column, to a high degree supports the after-feeding by pressing the feeding metal through the connecting duct into the casting, while in the latter form, the pressure diminishes during the after-feeding process. On the other hand, the latter form exhibits the advantage of normally giving a higher metal yield in the casting process, i.e. a lesser quantity of metal to be separated from the castings for subsequent re-melting (recycling), this also reducing the energy consumed for melting.

Compared to moulds with a horizontal parting surface, the top surface of moulds with a vertical parting surface has a relatively small surface area, and for this reason, the latter type of moulds allows only to a low degree the use of feeders or risers for after-feeding purposes, and thus, for this purpose it is generally necessary to use the above-mentioned "suction buds" with the associated disadvantage mentioned above, i.e. the lesser metallostatic pressure for pressing the after-feeding metal in through the duct to the casting. This disadvantage is additionally noticeable when after-feeding light-metal castings, i.e. castings of aluminium and its alloys or magnesium and its alloys, due to the relatively low specific weight of these metals.

DISCLOSURE OF THE INVENTION

Casting of light-metal castings in moulds with vertical parting surfaces is of commercial interest especially in two cases, viz. by casting in permanent moulds, e.g. pressure die-casting, and by casting in moulds in a string-moulding plant, such as e.g. the "Disamatic" mould-making plant manufactured and marketed by the Applicants, and for this reasons, the object of the invention, especially with

a view to these two cases, is to provide a method of the kind set forth in the preamble of claim 1 with which it is possible to avoid the disadvantages referred to above, at the same time providing a possibility of increasing the metal yield, i.e. a reduction of the quantity of metal used for pouring the individual moulds.

According to the invention, the object stated is achieved by proceeding in the manner set forth in the characterizing clause of claim 1.

10 By in the manner indicated maintaining a pressure in the after-feeding reservoir during the solidification of the metal in the mould cavity, said pressure being approximately equal to the metallostatic pressure in the reservoir just after the pouring of the mould, a pressure is created
15 for pressing after-feeding metal in through the duct connecting the after-feeding reservoir to the mould cavity, this latter pressure corresponding to the pressure that could have been achieved by using a corresponding column of metal in a feeder or riser. Thus, when the mould is poured, a
20 quantity of liquid metal corresponding to this metal column is saved.

It goes without saying that the pressure being applied must not exceed the mean metallostatic pressure in the place where it is applied, until the metal in the ingate associated
25 with the after-feeding reservoir has solidified or this ingate has been blocked in some other manner, e.g. as described in the International Application WO 93/11892, it being obvious that otherwise, a higher applied pressure would force the metal back through the inlet without in any
30 manner contributing to after-feeding the casting. When the metal in the ingate has solidified or the ingate has been blocked, it is possible, should occasion arise, to increase the pressure being applied, thus increasing the certainty of an effective after-feeding.

35 It should be understood from the wording of claim 1 that in a mould, more than one after-feeding reservoir may

be associated with a single mould cavity, more than one mould cavity may be associated with a single after-feeding reservoir, or a single mould cavity may be associated with each after-feeding reservoir, likewise that the metal in all after-feeding reservoirs in a mould do not necessarily have to have a pressure applied.

Preferably, the measure set forth in claim 3 is used with a view to keeping the liquid metal as hot as possible, hence also as well-suited for after-feeding as possible. In this manner, it is also possible to achieve a further reduction in the quantity of recycled metal.

While especially in permanent moulds, the pressure on the metal in the after-feeding reservoir may be applied in a purely mechanical manner or pneumatically-mechanically or hydraulically-mechanically, a preferred embodiment of the method according to the invention is set forth in claim 4.

Claims 5-9 indicate various measures for the application of the gas pressure, especially claim 7 indicating a method for applying a gas pressure that is lower than the metallostatic pressure at that metal surface in the mould, where the gas pressure is being applied, while claim 8 indicates measures for ascertaining whether the metal in the ingate has solidified.

It will be obvious that the practical values of the magnitude of the gas pressure being applied will depend on the casting to be produced in each case and on the shape of the mould, but is generally preferred to keep the gas pressure, as indicated in claim 10, between approximately 0,05 and approximately 0,5 bar.

The pressurized gas being used may be atmospheric air, but it may also be an inert gas not reacting chemically with the metal being cast, e.g. nitrogen or CO₂, when casting magnesium or its alloys.

A generally applicable embodiment of the method according to the invention is set forth in claim 13.

Claim 14 relates to an embodiment of the method according to the invention, preferred for use with moulds in a string-moulding plant.

In order to prevent that the tube or duct, through which the gas pressure is applied to the after-feeding reservoir, is clogged by solidified metal from the reservoir, the latter may, as indicated in claim 15, be separated from the source of pressurized gas by a material that is impermeable for the liquid metal. As indicated in claim 16, this material may be capable of yielding when acted upon by the gas pressure, e.g. by constituting a layer of heat-resistant fibre material, so that during the after-feeding process, it will adapt itself to the contour of the metal surface in the after-feeding reservoir. As set forth in claim 17, this material may be permeable for the pressurized gas.

At the after-feeding reservoir an agent may be placed that is capable of developing gas to a sufficient extent for building-up the gas pressure, and this agent may be adapted to develop heat exothermally and contain heat-insulating components, such as set forth in the claims 18, 19, and 20.

For use in a string-moulding plant, the invention also relates to a mould with vertical parting surfaces for carrying out the method according to the invention. This mould is of the kind set forth in the preamble of claim 1, and it is according to the invention characterized by the features set forth in the characterizing clause of this claim 21. This mould may also exhibit the features set forth in claims 22, 23, and 24.

Finally, the present invention relates to a pouring and cooling zone of the kind set forth in the preamble of claim 25, said zone according to the invention exhibiting the features set forth in the characterizing clause of this claim 21. This pouring and cooling zone may be constructed as set forth in the claims 26 and 27.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed portion of the present description, the invention will be explained in more detail with reference to the drawing, in which

5 Figures 1 and 2 highly diagrammatically illustrate a first embodiment of the method according to the invention, in which pressure is applied in a mechanical manner to the metal in the after-feeding reservoir,

10 Figure 3 in the same manner as Figures 1 and 2 illustrates a second embodiment of the method according to the invention, in which the pressure on the metal in the after-feeding reservoir is applied by means of pressurized gas,

15 Figure 4 is a diagrammatic longitudinal sectional view through a part of a string-moulding plant with a moulding machine for making moulds, a string of such moulds produced by the machine, and a part of the pouring and cooling zone of the plant, and

20 Figure 5 is a cross-sectional view showing the pouring of a mould made up from two of the moulds shown in Figure 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a cross-sectional view of a casting mould generally designated 1. In this embodiment, the mould 1 may
25 be a permanent mould made of metal, and comprises a mould cavity 2, the latter through a short duct with a relatively large flow cross-section being connected to a feeding reservoir 3, the latter again being connected to an ingate 4 in an inlet system 4, 5, 6 also comprising a vertical downsprue
30 5, at the top of the mould 1 opening into a pouring cup 6. A displacement body 7 in the form of a plunger piston is movably placed in the mould 1 in such a manner, that it may be introduced into the feeding reservoir 3 vertically from above, said body 7 being capable of being subjected to a
35 downwardly directed force, symbolically shown as a weight, by means of a vertical rod 8 extending upwardly through the

upper part of the mould 1.

When the mould cavity 2 and the feeding reservoir 3 have been filled with liquid metal through the inlet system 4, 5, 6, a constant downwardly directed force is applied to the plunger piston 7 through the rod 8, said force having such a magnitude, that the pressure being exerted on the metal in the feeding reservoir 3 by the plunger piston 7 is at the most equal to the metallostatic pressure exerted on the lower end surface of the plunger piston 7 by the column of metal in the downsprue 5 and the pouring cup 6.

If the downwardly directed force on the rod 8 were greater, it would move the plunger piston 7 downwards into the feeding reservoir 3, thus displacing metal from the latter backwards through the inlet system 4, 5, 6.

During the cooling of the metal poured into the mould 1, the metal in the ingate 4 will be the first to solidify, after which the metal in the mould cavity 2 solidifies and forms the desired casting. The dimensions of the feeding reservoir 3 are chosen in such a manner that the metal in this reservoir and in the duct connecting it to the mould cavity 2 will be the last to solidify.

The latter condition is also supported by the fact that all the metal that is to fill the mould cavity 2 during the pouring-in operation has flowed through these parts of the mould 1, thus having heated the walls of these parts.

Thus, during the entire process of cooling and solidification of the metal in the mould cavity 2, liquid metal is present in the feeding reservoir 3 for following-up the thermal contraction of the metal in the mould cavity 2. During this process, the plunger piston 7 will act permanently on the metal in the feeding reservoir 3 with the same pressure as immediately after the pouring of the mould 1, and will therefore maintain a constant pressure in the feeding reservoir 3, since the plunger piston 7 moves downwardly in the reservoir 3 while displacing the metal being used for feeding the casting in the mould cavity 2.

The pressure in this manner being maintained in the feeding reservoir 3 during the feeding process corresponds approximately to the pressure from a column of liquid metal between the upper wall in the feeding reservoir 3 and the top of the mould 1. Thus, thanks to the present invention, the reservoir 3 functions in the same manner as a feeder or riser extending from the bottom of the reservoir to the top of the mould 1. In order to fill such a feeder or riser, a considerable quantity of metal would have been needed, and later on, this extra metal would have to be separated from the casting produced in the mould cavity 2 and recycled with the attendant disadvantages.

Thus, by proceeding according to the method of the invention, it is possible to achieve a higher degree of utilization of the metal, hence saving energy for melting metal.

When the metal in the ingate 4 has solidified, it is possible within the scope of the invention, by means of the rod 8 and the plunger piston 7 to apply a higher pressure to the metal in the feeding reservoir 3 than assumed above, hence achieving a still more certain and effective after-feeding, as it will be easier for such a higher pressure to force metal from the reservoir 3 to the mould cavity 2 through a duct, the flow cross-section of which could possibly be constricted due to metal having solidified on its walls. Further, the higher pressure will increase the tendency to overcome the after-feeding resistance in the partly-solidified metal.

In the mould 1 shown in Figure 2, the details 2-8 correspond substantially to the details similarly designated in the mould shown in Figure 1. In Figure 2, the plunger piston 7 is, however, horizontally movable into the feeding reservoir 3 under the influence of a force directed inwardly toward the mould 1 via a horizontal rod 8, said force being symbolically shown as a weight, acting on the rod 8 through a bell-crank lever 9 pivotably secured to a plate 10.

In this embodiment, the mould cavity 2 is enlarged with a further mould cavity 2', the latter being connected through a wide throat to a second feeding reservoir 11 for after-feeding the metal poured into the further mould cavity 2'. A plunger piston 12 is horizontally movable into the feeding reservoir 11 and adapted to be acted upon with a force directed inwardly towards the mould 1 via a horizontal rod 13 and a bell-crank lever 14 pivotably secured to the plate 10, by means of the weight shown symbolically.

Whereas during the pouring of the mould 1, the mould cavity 2' and the feeding reservoir 11 are also poured with metal through the throat connecting the mould cavities 2 and 2' with each other, the details 3-8 will otherwise function as explained above with reference to Figure 1.

When the mould 1 has been poured with metal, the plunger piston 12 is acted upon with such an inwardly directed force via the rod 13 and the bell-crank lever 14, that the metal in the reservoir 11 is acted upon with a pressure, that immediately after the pouring of the mould 1 is at the most equal to the metalostatic pressure, with which the metal in the reservoir 11 acts upon the end surface of the plunger piston 12.

Since the reservoir 11, unlike the reservoir 3, does not have liquid metal flowing through it during the pouring operation, for which reason its walls are not heated, and further, since it is being poured with metal having been cooled by passage through the remaining cavities and ducts in the mould, the reservoir 11 must be given correspondingly large dimensions with a view to enable it to after-feed the metal in the second mould cavity 2'.

During the cooling and solidification of the metal poured into the second mould cavity 2', the plunger piston 12 will in other respects function in the same manner as explained above with reference to the plunger piston 3 in the mould 1 shown in Figure 1.

This means that the feeding reservoir 11 will make

up for a feeder or riser that would extend from the upper wall of the reservoir 11 to the top of the mould 1.

Even though the discussion above is based on the assumption that the moulds 1 are permanent metal moulds and that the plunger pistons 7 and 12 likewise are made of metal, the moulds 1 could in principle be sand moulds and the plunger pistons 7 and 12 e.g. be cylindrical core-sand elements, even though it must be admitted that in practice, this can only be realized with some difficulty.

On the other hand, it will be easy to understand that the force acting through the rods 8 and 13, in addition to the purely mechanical method shown symbolically, may be provided by means of pneumatic or hydraulic piston-cylinder units.

The embodiment of the method of the invention illustrated in Figure 3 is suitable for use in connection with both permanent moulds and sand moulds, and details, that are identical or correspond to details in Figures 1 and 3, carry the same reference numbers as in these two Figures.

Thus, in the mould 1 there is a mould cavity 2, through a first feeding reservoir 3 being connected to an inlet system 4, 5, 6, and a further mould cavity 2', connected to the mould cavity 2 and with a second feeding reservoir 11. From the bottom of the reservoir 3 a duct 15 leads to the outside of the mould 1, the transition between the reservoir 3 to the duct 15 comprising a separator 16 that is impermeable to metal but permeable to gas. At the outside of the mould 1, the duct 15 opens into a pressure chamber 17 in fluid-tight engagement with the outside surface of the mould, said pressure chamber 17 being connected to a conduit to a pressure-reducing valve 18, the latter again being connected to a source (not shown) of pressurized gas.

In a similar manner, the upper wall in the feeding reservoir 11 is connected through a duct 19 to the outside of the mould at one of the latter's side surfaces, the transition from the reservoir 11 to the duct 9 comprising a

separator 20 of the same kind as the separator 16. At the outside of the mould 1, the duct 19 opens into a pressure chamber 21 engaging the outside of the mould in a fluid-tight manner, said pressure chamber 21 via a conduit being
5 connected to a pressure-reducing valve 22, the latter again being connected to a source (not shown) of pressurized gas.

During the pouring of the mould 1 shown in Figure 3, the cavities 3, 2, 2' and 11 in this mould will be filled via the inlet system 4, 5, 6 in the same manner as described
10 above with reference to Figure 2. During this process, the separators 16 and 20 prevent metal from entering into and clogging the ducts 15 and 19.

After this, a gas pressure is applied to the lowermost surface of the metal in the feeding reservoir via the duct
15 15, the pressure chamber 17 and the pressure-reducing valve 18 and through the separator 16, said gas pressure not exceeding the metallostatic pressure in the mould 1 at this location. During this process, care must be taken that the gas pressure is not applied in such a manner that gas bubbles,
20 les, that could ascend into and expand in the mould cavity 2, thus producing a reject casting, appear above the separator 16.

In the same manner, a gas pressure is applied to the upper metal surface in the feeding reservoir 11 via the
25 duct 19, the pressure chamber 21, and the pressure-reducing valve 22 through the separator 20, this gas pressure not being allowed to exceed the metallostatic pressure in the mould at this surface.

The gas pressures acting upon the lower surface of
30 the metal in the feeding reservoir 3 and upon the upper surface of the metal in the feeding reservoir 11 will now function in the same manner as the plunger pistons 7 and 12 in the mould 1 shown in Figure 2 to maintain the metal pressure in these feeding reservoirs 3 and 11 at a constant value
35 during the cooling and solidification of the metal in the cavities 2 and 2', so that the metal in the reservoirs 3

and 11 will be able to feed these mould cavities with metal to compensate for the thermal contraction of the metal in the mould cavities.

Also with this embodiment of the method it is possible, after the solidification of the metal in the ingate 4, to increase the gas pressure on the metal surfaces in the reservoirs 3 and 11, taking care, however, that this does not cause gas bubbles to be introduced into the mould cavity 2 through the separator 16.

10 The separators 16 and 20 may consist of any suitable material having the appropriate ability to withstand heat, impermeability for metal but permeability for gas. Thus, they may be constituted by porous ceramic plates or sand cores with an organic or inorganic binder, or else plates
15 or mats of mineral fibres.

Instead of through the ducts 15 and 19, the pressure chambers 17 and 21 and the separators 16 and 20, the gas pressures in the two feeding reservoirs 3 and 11 could be applied through metal tubes extending through the mould,
20 especially a wet-sand mould, and opening into the reservoirs with their internal ends so constructed that they are permeable for gas but not for liquid metal, e.g. by being closed by a plug having these properties, the external end of each tube being connected to the pressure-reducing valve 18 or
25 21 respectively.

Figure 4 is a diagrammatic longitudinal sectional view through a string-moulding plant with a casting and cooling zone according to the invention. The plant comprises a moulding machine generally designated 25 and of the same
30 kind as the "Disamatic" moulding machine manufactured and marketed by the Applicants. The principles of construction and functioning of this moulding machine, which has been on the market for a number of decades and has found widespread use in foundries throughout the world, should be well known
35 by persons skilled in this art and is described in US Patent Publication No. 3,008,199, for which reason it will only be

described briefly in the present description.

Loose, clay-bonded mould sand with a moisture content suitable for mould-making is supplied from a supply reservoir 26 to a moulding chamber formed between on the one hand a squeeze plate 28 carrying a pattern 29 and secured to a hydraulic piston 27, and on the other hand an upwardly pivotable counter-pressure plate 30, in Figure 4 shown in its upwardly pivoted position, likewise having secured to it a pattern 31, here shown as a plane plate. When the squeeze plate 28 is advanced through the moulding chamber by means of the piston 27, the mould sand will be compacted between the squeeze plate 28 and the downwardly pivoted counter-pressure plate 30, or rather between the patterns 29 and 31 carried thereby, so that a mould consisting of green sand is formed. Then, the counter-pressure plate 30 is moved towards the right in Figure 4 so that the pattern 31 is loosened from the mould, and pivoted upwardly to the position shown in Figure 4. After this, the mould 32 is advanced by the piston 27 towards the right in Figure 4 so as to come into abutment against a previously produced mould 32, after which the piston 27 is withdrawn, freeing the pattern 29 from the mould 32. Thus, the row or string of moulds 32 is advanced stepwise towards the right in Figure 4 on a suitable support 33 in the direction of the arrow A, the shaped surface facing downstream on a mould 32 cooperating with the shaped surface facing upstream on the previously produced mould 32 in each case forming a casting cavity with associated cavities to be described below.

These moulds are advanced stepwise past a pouring station B, in which the mould cavity is poured with metal by means of a suitable pouring device 34 as shown diagrammatically in cross-section in Figure 5, after which they are further advanced stepwise through a cooling zone C to a shakeout grille (not shown).

Each of the green-sand moulds formed in this manner comprises a mould cavity 35, the bottom of which is connected

through a short and wide duct to a feeding reservoir 36, the latter again being connected to an inlet system consisting of an ingate 37 and a downsprue 38, the latter at the top of the mould opening into a pouring cup 39. In the embodiment of the mould shown, the mould further comprises a feeder or riser 40 constituting a central connection between the upper part of the mould cavity 35 and the top of the mould.

According to the present invention, a duct 41 communicates the feeding reservoir 36 in the mould with the lower side of the latter, the duct 41 in each mould being obstructed by a separator 42 of the kind described with reference to the embodiment shown in Figure 3.

According to the present invention, a duct 43 extends from a location immediately downstream of the pouring station B and along at least a part of the cooling zone C in the support 33 below the string of moulds 32, said duct 43 being situated in the support 33 below the ducts 41 in the moulds 32. The duct 43 is supplied with compressed air with a pressure not exceeding the metallostatic pressure on the separator 42 in the fully poured mould, said pressure contributing to feeding the mould cavity 35 from the feeding reservoir 36 in the manner explained with reference to the feeding reservoir 3 shown in Figure 3.

Because in the moulds shown, the feeder or riser 40 serves for after-feeding an upper region of the mould cavity 35, this feeder or riser 40 may in an automatic moulding device 35 serve an additional purpose, since the presence of metal in the riser 40 indicating complete filling of the mould may be registered by a suitable optical or thermal sensor adapted to produce a signal for the pouring to be terminated.

In the above description, the invention has been explained on the basis of a few exemplary embodiments, but it will be understood that the invention may be modified in numerous ways within the scope of the claims set out below.

Thus, it will be understood immediately that the method according to the invention may be carried out with moulds having horizontal parting surfaces. Instead of supplying the pressurized gas from an external source, the gas could be
5 possibly be produced in the feeding reservoir by placing therein an agent capable of liberating or developing a gas, or of a set of reagents producing a gas by mutual chemical reaction. Likewise, the pouring of the moulds could be carried out otherwise than with the gravity pouring shown,
10 e.g. by pumping the metal from below into the mould and then blocking the inlet as described in the International Patent Application WO 93/11892.

Further, the agent mentioned may comprise additives, partly developing heat by exothermal reaction, partly having
15 suitable heat-insulating properties.

LIST OF PARTS

A	Direction / arrow
B	Pouring station
C	Cooling zone
1	Mould
2	Mould cavity
2'	Mould cavity
3	Feeding reservoir
4	Ingate
5	Downsprue
6	Pouring cup
7	Plunger piston / Displacement body
8	Rod
9	Bell-crank lever
10	Plate
11	Feeding reservoir
12	Plunger piston
13	Horizontal rod
14	Bell-crank lever
15	Duct
16	Separator
17	Pressure chamber
18	Pressure-reducing valve
19	Duct
20	Separator
21	Pressure chamber
22	Pressure-reducing valve
25	Moulding machine
26	Supply reservoir
27	Piston
28	Squeeze plate
29	Pattern
30	Counter-pressure plate
31	Pattern

- 32 Mould
- 33 Support
- 34 Pouring device
- 35 Mould cavity
- 36 Feeding reservoir
- 37 Ingate
- 38 Downsprue
- 39 Pouring cup
- 40 Feeder / riser
- 41 Duct
- 42 Separator
- 43 Duct

C L A I M S :

1. Method of after-feeding castings, especially light-metal castings, preferably in moulds (1) with vertical parting surfaces and pouring from below (ascending pouring) and
5 with at least one after-feeding reservoir (3, 11, 36) connected to at least one mould cavity (2, 2', 35) or each with one mould cavity, **characterized** in that after the pouring of the mould, the metal in at least one after-feeding reservoir (3, 11, 36) is subjected to a pressure, said pressure
10 ure being maintained and possibly increased until the metal in the mould cavity or cavities (2, 2', 35) has set, whereas the pressure applied in at least one after-feeding reservoir, at least after the metal in the associated inlet (4, 37) has solidified or the inlet is blocked in another manner,
15 is maintained higher than the metallostatic pressure in the mould (1) at the location of the application of pressure.

2. Method according to claim 1, **characterized** in that as a mould is used a once-only mould of a particulate material, preferably green sand.

20 3. Method according to claim 1, **characterized** in that each after-feeding reservoir or at least some of the after-feeding reservoirs (3, 36) is/are placed between an inlet (4, 37) or each its own inlet and the mould cavity (2, 35) or cavities.

25 4. Method according to claim 1 or 2, **characterized** in that the pressure is applied in the form of a gas pressure from a source of pressurized gas against a metal surface in the after-feeding reservoir (3, 11, 36).

30 5. Method according to claim 4, **characterized** in that the gas pressure is maintained at the most equal to the metallostatic pressure in the mould at the surface of the metal, to which the pressure is applied.

35 6. Method according to claim 4, **characterized** in that, until the metal in the inlet (4, 37) has solidified or the inlet is blocked in some other way, the gas pressure is maintained at the most equal to the metallostatic pressure

in the mould at the surface of the metal, to which the pressure is applied, and that the pressure is increased after the solidification of the metal in the inlet or the latter having been blocked.

5 7. Method according to claim 5 or 6, characterized in

a) that the gas pressure is applied and made to rise uniformly immediately after the pouring of the mould, said pressure being measured continuously,

10 b) that the supply of pressurized gas is terminated immediately when the pressure rise as measured ceases, and

c) that the gas pressure is reduced to a pressure somewhat less than the pressure having been measured immediately before the cessation of the pressure rise.

15 8. Method according to claim 7, characterized in

a) that the procedural steps set forth in claim 7 are repeated at uniform intervals of time after the pouring of the mould, until the pressure rise as measured no longer ceases, and

20 b) that the supply of pressurized gas is continued until a predetermined gas pressure is measured, the latter pressure then being maintained.

9. Method according to claim 4, characterized in that the gas pressure is not applied until after the solidification of the metal in the inlet (4, 37) or the blocking of the inlet in another way, said pressure being maintained at a higher value than the metallostatic pressure in the mould at the surface of the metal, at which it is applied.

25 10. Method according to any one or any of the claims 4-9, characterized in that the gas pressure is maintained from approximately 0,05 bar to approximately 0,5 bar.

11. Method according to any one or any of the claims 4-10, characterized in that as the pressurized gas atmospheric air is used.

35 12. Method according to any one or any of the claims 4-10, characterized in that as the pressurized gas an inert

gas is used.

13. Method according to any one or any of the claims 4-12, characterized in

- 5 a) that the after-feeding reservoir (11) or reservoirs are placed laterally of the mould cavity (2') or cavities, and
b) that the gas pressure is applied to the upper metal surface in the after-feeding reservoir or each such reservoir.

14. Method according to any one or any of the claims 4-12, characterized in

- 10 a) that the after-feeding reservoir (3, 36) or reservoirs is/are placed below the mould cavity (2, 35) or cavities, and
b) that the gas pressure is applied to the lower metal surface in the after-feeding reservoir or each such reservoir.

15 15. Method according to any one or any of the claims 4-14, characterized in that each after-feeding reservoir (3, 11, 36) is separated from the source of pressurized gas by a material (16, 20, 42) that is impermeable for the liquid metal.

20 16. Method according to claim 15, characterized in that the separating material is capable of yielding when acted upon by the gas pressure.

17. Method according to claim 15 or 16, characterized in that the separating material is permeable for the pressurized gas.
25

18. Method according to claim 17, characterized by the use of an agent placed in the after-feeding reservoir and developing gas to an extent sufficient to build a sufficiently high gas pressure.

30 19. Method according to claim 18, characterized by the use of an agent developing heat exothermally.

20. Method according to claim 19, characterized by the use of an agent containing heat-insulating components.

21. Mould with vertical parting surface or surfaces
35 for carrying out the method according to any one or any of the claims 1-20, especially for pouring light-metal castings

from below, and consisting of two mutually abutting moulds (32) of green sand in a string-moulding plant, said mould comprising at least one mould cavity (35), an ingate (37) connected to the mould cavity (35), and an internal after-feeding reservoir (36) connected to the mould cavity (35) through a duct with a substantially larger cross-sectional area than that of the ingate (37), **characterized in that** the after-feeding reservoir (36) is placed underneath the mould cavity (35) and in a lower part of its side wall is connected to the ingate (37), and adapted to be connected to a source of pressurized gas through a duct (41) debouching at an external surface of the mould.

22. Mould according to claim 21, **characterized by an** element (42) of a material that is impermeable for the liquid metal being placed between the after-feeding reservoir (36) and the duct (41), through which the reservoir can be connected to the source of pressurized gas.

23. Mould according to claim 22, **characterized in** that said element (42) is capable of yielding when acted upon by gas pressure.

24. Mould according to claim 22 or 23, **characterized in that** said element (42) is permeable for gas.

25. Pouring and cooling zone in a string-moulding plant with moulds according to any one or any of the claims 21-24 and having a device (34) for sequentially pouring the individual moulds while they are being advanced stepwise past the pouring device and for cooling the moulds having been poured, **characterized by a duct (43) connected to at least one source of pressurized gas and extending in the longitudinal direction (A) of the mould string from a location immediately downstream of the pouring device (34), said duct (43) abutting against the moulds so as to communicate with the ducts (41) debouching in the external surface of the moulds.**

26. Pouring and cooling zone according to claim 25, **characterized in that the duct (43) extending in the long-**

itudinal direction (A) of the mould string is divided into at least two sections, of which the first section situated closest to the pouring device (34) is connected to a source of pressurized gas with a gas pressure not exceeding the
5 metallostatic pressure at the bottom of the after-feeding reservoir (36) in the moulds just having been poured, whilst the section or sections downstream of said first section is/are adapted to be connected to sources of pressurized gas with higher gas pressures.

10 27. Pouring and cooling zone according to claim 26, characterized in that said first section of the duct (43) extending in the longitudinal direction (A) of the mould string has such a length in said direction (A), that it is certain that the metal in the ingates (37) in the moulds has
15 solidified, when the moulds have passed through this section.

AMENDED CLAIMS

[received by the International Bureau on 1 June 1995 (01.06.95);
original claims 1-27 replaced by new claims 1-7 (2 pages)]

5 1. Mould with vertical parting surface or surfaces,
especially for pouring light-metal castings from below, and
consisting of two mutually abutting moulds (32) of green
sand in a string-moulding plant, said mould comprising at
least one mould cavity (35), an ingate (37) connected to
10 the mould cavity (35), and an internal after-feeding reser-
voir (36) connectable to a source of pressurized gas and
connected to the mould cavity (35) through a passage with a
substantially larger cross-sectional area than that of the
ingate (37), characterized in that the after-feeding reser-
15 voir (36) is placed underneath the mould cavity (35) and in
a lower part of its side wall is connected to the ingate
(37), and adapted at its bottom to be connected to the source
of pressurized gas through a passage (41) opening into an
external surface of the mould.

20

2. Mould according to claim 1, characterized by an
element (42) of a material that is impermeable for the liquid
metal being placed between the after-feeding reservoir (36)
and the passage (41), through which the reservoir can be con-
25 nected to the source of pressurized gas.

3. Mould according to claim 2, characterized in that
said element (42) is capable of yielding when acted upon by
gas pressure.

30

4. Mould according to claim 2 or 3, characterized
in that said element (42) is permeable for gas.

5. Pouring and cooling zone in a string-moulding
35 plant with moulds according to any one or any of the claims
1-4 and having a device (34) for sequentially pouring the
individual moulds while they are being advanced stepwise
past the pouring device and for cooling the moulds having

been poured, characterized by a channel (43) connected to at least one source of pressurized gas and extending in the longitudinal direction (A) of the mould string from a location immediately downstream of the pouring device (34),
5 said channel (43) abutting against the moulds so as to communicate with the passages (41) opening into the external surface of the moulds.

6. Pouring and cooling zone according to claim 5,
10 characterized in that the channel (43) extending in the longitudinal direction (A) of the mould string is divided into at least two sections, of which the first section situated closest to the pouring device (34) is connected to a source of pressurized gas with a gas pressure not exceeding the
15 metallostatic pressure at the bottom of the after-feeding reservoir (36) in the moulds just having been poured, whilst the section or sections downstream of said first section is/are adapted to be connected to sources of pressurized gas with higher gas pressures.

20

7. Pouring and cooling zone according to claim 6,
characterized in that said first section of the channel (43) extending in the longitudinal direction (A) of the mould string has such a length in said direction (A), that it is
25 certain that the metal in the ingates (37) and risers (40) of the moulds has solidified, when the moulds have passed through this section.

AMENDED SHEET (ARTICLE 19)

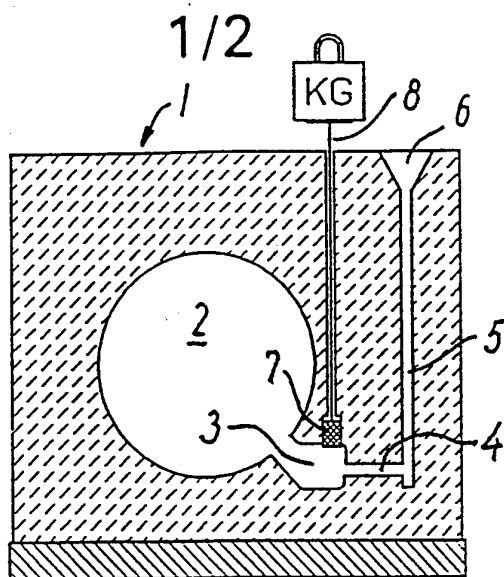


FIG. 1

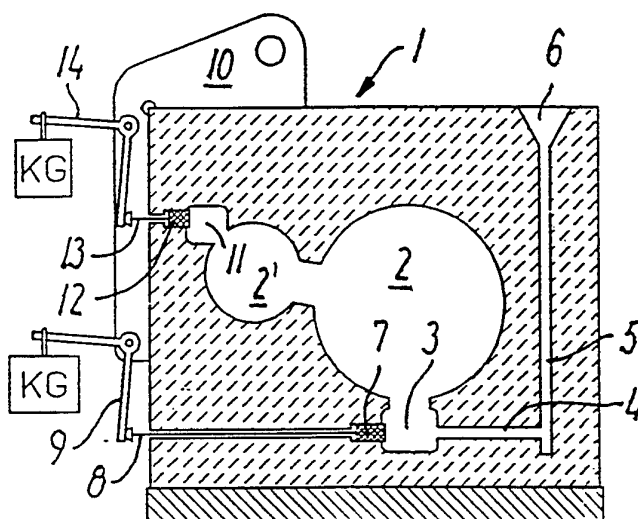


FIG. 2

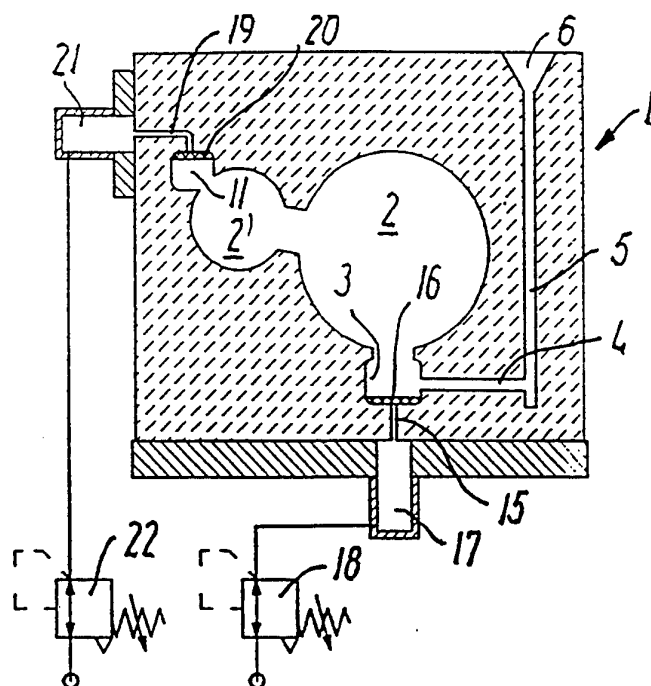
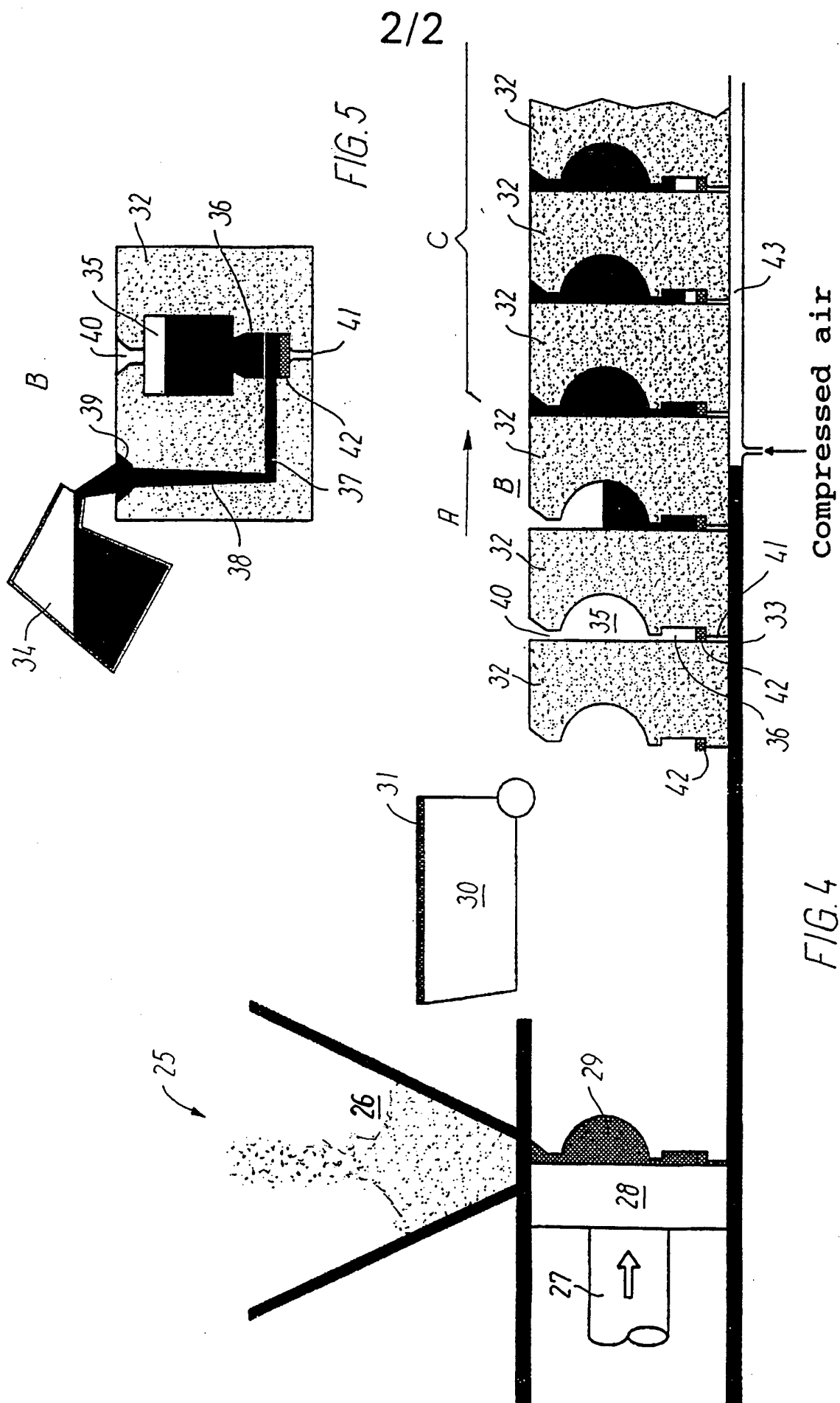


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 94/00221

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: B22C 9/08, B22D 18/08, B22D 27/09 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)		
IPC6: B22C, B22D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI, CLAIMS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 2568428 (I.A. BILLIAR), 18 Sept 1951 (18.09.51), figures 1-15, claims 1-3 --	1-6,9-13, 15-20
X	FR, A, 1312391 (M. STANISLAW T. JAZWINSKI), 5 November 1962 (05.11.62), figures 1-3, claim A, detail 53 --	1-6,9-13
X	US, A, 3566952 (WYMAN CURTIS LANE), 2 March 1971 (02.03.71), figures 1,4, claim 4 --	1-3
X	DE, A1, 2437435 (GEORG FISCHER AG), 27 March 1975 (27.03.75), figure 2 --	1,2
☒ 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
3 April 1995		13-04-1995
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer Mårten Hulthén Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 94/00221

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4436140 (MASUO EBISAWA ET AL), 13 March 1984 (13.03.84), figures 1,6 --	1-8
A	WO, A2, 9311892 (BAXI PARTNERSHIP LIMITED), 24 June 1993 (24.06.93), figures 1-2 --	21-27
A	WO, A1, 9322088 (BURDETT, SAVILE), 11 November 1993 (11.11.93), figure 1 --	14,21
A	NL, A, 7614080 (VICON N.V.) 20 June 1978 (20.06.78), figures 1 and 6 -- -----	25-27

INTERNATIONAL SEARCH REPORT

Information on patent family members

25/02/95

International application No.

PCT/DK 94/00221

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US-A-	2568428	18/09/51	NONE		
FR-A-	1312391	05/11/62	NONE		
US-A-	3566952	02/03/71	BE-A-	722828	24/04/69
			DE-A-	1805142	04/06/69
			FR-A-	1592577	19/05/70
			GB-A-	1248943	06/10/71
			US-A-	3513904	26/05/70
DE-A1-	2437435	27/03/75	CH-A-	558691	14/02/75
US-A-	4436140	13/03/84	DE-A,C-	3002692	28/08/80
			FR-A,B-	2447244	22/08/80
			GB-A,B-	2045659	05/11/80
			JP-C-	1214469	27/06/84
			JP-A-	55106665	15/08/80
			JP-B-	58043177	26/09/83
WO-A2-	9311892	24/06/93	AU-A-	3090692	19/07/93
			EP-A-	0615476	21/09/94
			NO-A,D-	942088	06/06/94
WO-A1-	9322088	11/11/93	NONE		