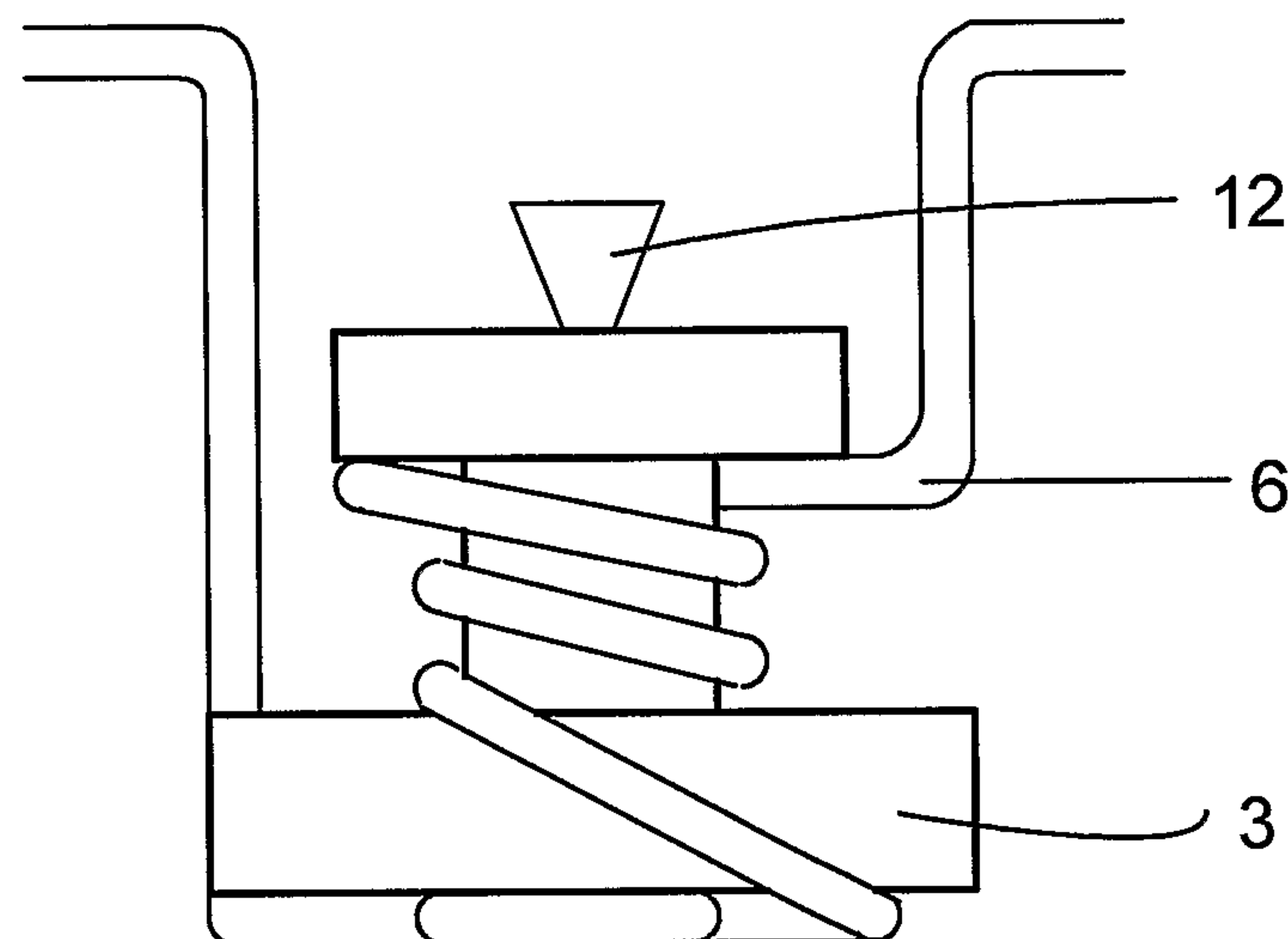




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MOULES EN METAL ET PROCEDE DE FABRICATION DU MOULE
(54) Title: SINGLE-PART EXPENDABLE CASTING MOULD WITH A CONTROLLED TEMPERATURE FOR CAST
METAL PARTS AND ASSOCIATED PRODUCTION METHOD



(57) **Abrégé/Abstract:**

In the case of a single-part expendable casting mould for cast metal parts (4) that is made of a set moulding material, which encloses a mould cavity and has embedded in it at least one metallic cooling channel (6), which carries a cooling medium, portions of the outer side of the metallic cooling channel (6) towards the mould cavity are not covered by the moulding material and/or are only slightly covered.



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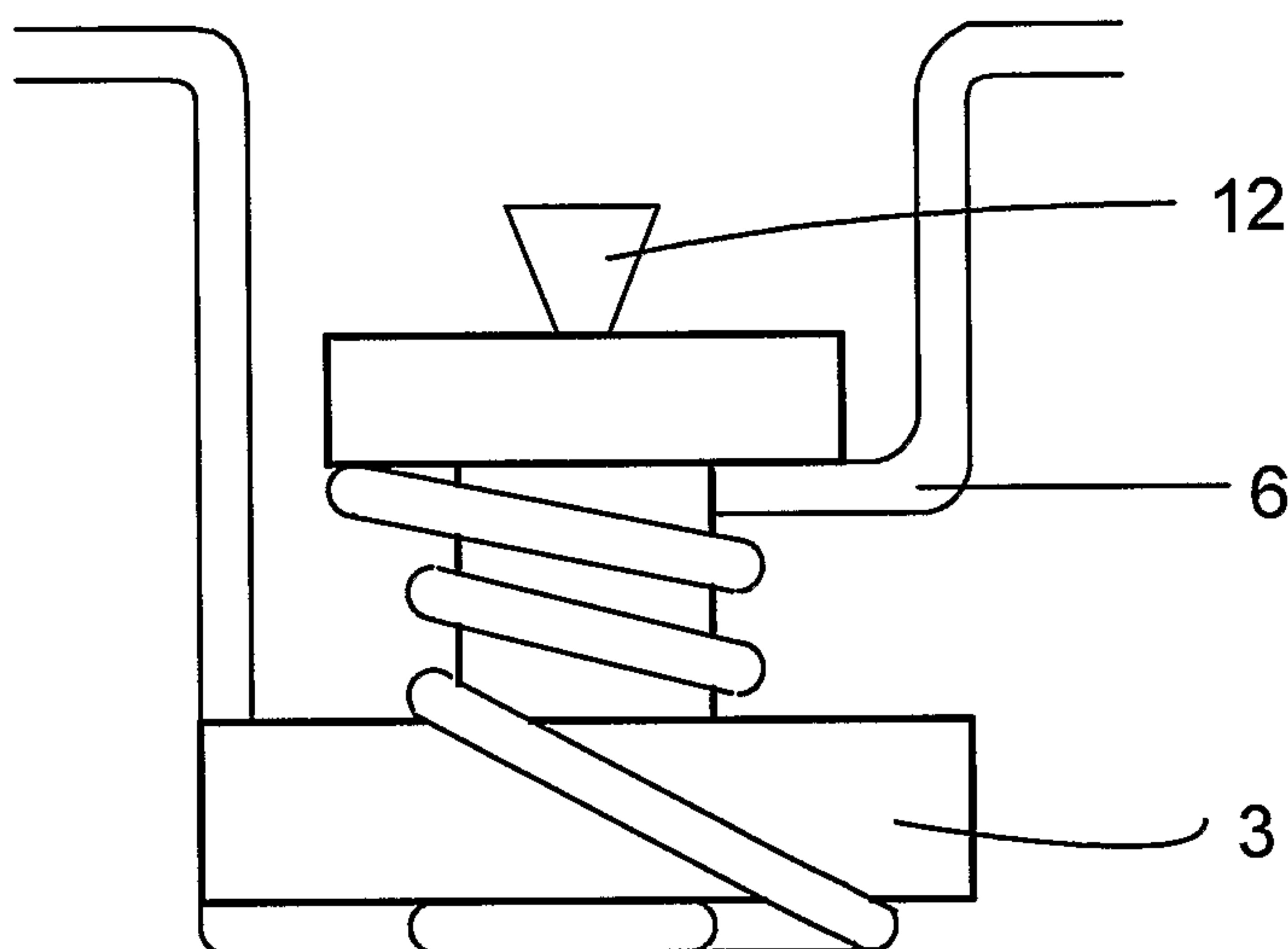
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[Fortsetzung auf der nächsten Seite]

(54) Title: SINGLE-PART EXPENDABLE CASTING MOULD WITH A CONTROLLED TEMPERATURE FOR CAST METAL
PARTS AND ASSOCIATED PRODUCTION METHOD(54) Bezeichnung: EINTEILIGE VERLORENE, TEMPERIERBARE GIESSFORM FÜR GUSSTEILE AUS METALL SOWIE
VERFAHREN ZU IHRER HERSTELLUNG(57) Abstract: In the case of a
single-part expendable casting mould
for cast metal parts (4) that is made of a
set moulding material, which encloses a
mould cavity and has embedded in it at
least one metallic cooling channel (6),
which carries a cooling medium, portions
of the outer side of the metallic cooling
channel (6) towards the mould cavity are
not covered by the moulding material
and/or are only slightly covered.(57) Zusammenfassung: Bei einer
einteiligen verlorenen Gießform für
Gussteile aus Metall (4) aus einem
verfestigten Formstoff, welcher
einen Formhohlraum umschließt
und mindestens einen im Formstoff
eingebetteten metallischen Kühlkanal
(6) aufweist, der ein Kühlmedium
führt, sind Abschnitte der Außenseite
des metallischen Kühlkanals (6) zum
Formhohlraum hin vom Formstoff

unbedeckt und/oder nur geringfügig bedeckt.

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Erklärungen gemäß Regel 4.17:

- *hinsichtlich der Identität des Erfinders (Regel 4.17 Ziffer i)*
- *hinsichtlich der Berechtigung des Anmelders, ein Patent zu beantragen und zu erhalten (Regel 4.17 Ziffer ii)*
- *hinsichtlich der Berechtigung des Anmelders, die Priorität einer früheren Anmeldung zu beanspruchen (Regel 4.17 Ziffer iii)*
- *Erfindererklärung (Regel 4.17 Ziffer iv)*

Veröffentlicht:

- *mit internationalem Recherchenbericht*

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Fassung:

2. Mai 2008

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SINGLE-PART EXPENDABLE CASTING MOULD WITH A CONTROLLED
TEMPERATURE FOR CAST METALPARTS AND ASSOCIATED PRODUCTION
METHOD

The invention relates to a one-piece lost mould for metal
5 castings and to a method for producing it. A preferred
application area for one-piece lost moulds for metal
castings is the quick and economical production of single
castings or castings in small numbers, which are usually
used as so-called prototypes. Such prototype castings
10 serve for checking the properties, for example the
strength, of complicated moulded workpieces that are to
be mass-produced, for example by pressure diecasting or
gravity diecasting processes, before fabrication of the
permanent metallic moulds for the mass production. To
15 allow the prototype castings to be realistically
assessed, they must correspond or approximate as closely
as possible in terms of their material properties to the
product that is later mass-produced.

20 Plaster, ceramic and sand moulds, which are produced
inter alia with lost patterns, are suitable in particular
for producing such prototype castings. Plaster and
ceramic moulds are usually produced by using wax patterns
that can be melted away, while sand moulds are produced
25 for example by using expanded polystyrene or plastic
patterns that can be removed by burning or gasifying. On
account of the poor thermal conduction of such moulds of
plaster, ceramic or moulding sand, the freezing times for
the molten metal are relatively long, at least in the
30 case of greater wall thicknesses. Depending on the metal
to be cast, the slow solidification and cooling often
results in a relatively coarse-grained structure, which
therefore cannot always adequately withstand loading.
Furthermore, if the solidification follows an
35 unfavourable direction in the individual regions of the

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mould, casting defects such as porosities or shrinkage cavities, for example, may also occur.

5 A series of moulds and methods for producing prototype castings with one-piece plaster, ceramic or sand moulds that are produced by using lost patterns are known from the prior art.

10 US 4579166 describes use of the plaster casting technique for testing new machine components that could otherwise only be produced by pressure diecasting or gravity diecasting. The casting of such components by means of a plaster casting technique is indeed well-suited for the production of prototypes from aluminium, zinc, magnesium
15 and their alloys. However, the prototypes produced in this way correspond only in their outer form to the castings produced in a gravity die or pressure die, and the casting of such parts from magnesium or its alloys without a shielding gas and without cooling presents
20 difficulties. To overcome the disadvantages, the provision of a more or less porous plaster mould which only contains a small amount of unbound and bound water after calcining is recommended. During the casting, the mould is protected from reactions with the melt by
25 flooding the mould cavity with a shielding gas. This shielding gas contains sulphur or sulphur hexafluoride (SF_6) as an inhibiting agent. To control the cooling process, a thermocouple is placed in the mould near the casting and the temperature during the cooling of the
30 casting is monitored in order to detect uncontrolled reactions in the mould in good time and, for example, allow imminent explosions to be prevented. Active control of the cooling to achieve a finer structure is not possible with such a mould.

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European patent specification EP 571703 B1 describes the cooling of the molten metal by using a cooling fluid that gradually penetrates the wall of the mould and the boiling point of which is lower than the pouring
5 temperature of the melt. Starting from one end, the mould is steadily immersed in the cooling fluid. Immersion is intended to produce directional solidification. Directional solidification obtained in this way has advantages in terms of the segregation, precipitation and
10 shrinkage-cavity characteristics of cast components and hence allows casting defects to be avoided. However, selective influencing of the structure of the casting is not possible with this method either.

15 In the international patent application WO 9805450, along with the cooling of the mould by fluid, a nucleation plate is additionally used for the directional solidification of the melt. This takes place by the mould having a metallic base plate that is immersed in the
20 cooling bath for the directional solidification of the melt. The faster cooling on the metallic base plate has the effect of producing crystallization nuclei in the melt, causing the latter to solidify. With metal base plates, however, alloying of the melt must be expected.
25 For this reason, base plates through which a coolant flows have already been described. To protect the melt from impurities caused by material of the base plate going into solution, an intermediate plate of a material similar to that of the solidifying melt has additionally
30 been provided. Although this solution allows casting defects to be largely avoided, specific influencing of the structure of the casting is not possible in this way either.

35 Cooled plaster moulds are described in Japanese laid-open patent applications JP 63168250 A1 and JP 02187236 A1.

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During the production of the mould, an opening in the mould is closed by a plastic closure plate, which is burned away during the hardening of the plaster mould. Instead of the closure plate, a cooling plate is used
5 during the casting to achieve local cooling of the mould. In JP 02187236 A1, a cooler is likewise inserted into a plaster mould. A wax pattern comprising a product part and a runner part is placed in a mould frame consisting of iron. A pattern material which has the same form as
10 the cooler is placed on the part in which the cooling rate in the product part is to be speeded up. The plaster is filled into the space under the pattern material and the wax pattern and also into the frame. The unit as a whole is fired at approximately 700°C, the wax pattern
15 melting away.

After that, the plaster mould is turned and the cooler inserted. Finally, the liquid metal is cast. As a result, the cooling is speeded up at the thicker part of the
20 casting and shrinkage is prevented. It is disadvantageous that, when cooling plates or coolers are used, directional solidification is only possible from one side of the casting. For this reason, it is likewise not possible with the plaster moulds described above to
25 produce castings with a largely fine structure similar to pressure diecasting or gravity diecasting.

The use of a cooling line in a plaster mould to produce plastic articles is also known from European patent EP
30 0004844 B1. The cooling line is embedded in the plaster of the mould. As mentioned, the plaster mould serves for producing parts and prototypes from plastic, which is injected into the cavity of the mould. Here, the cooling line embedded in the plaster serves for faster cooling of
35 the polymer compound to speed up the production process. However, owing to the poor thermal conduction of the

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plaster, the cooling line that is completely embedded in the plaster cannot ensure the heat dissipation required for rapid cooling and directional solidification of a metal casting. In comparison with a pressure die or gravity die of metal, the thermal conductivity of such a plaster mould with the cooling line embedded in the plaster is still many times lower. Therefore, this mould is also not suitable for achieving the freezing times known from pressure diecasting or gravity diecasting and consequently comparably fine structures of the castings thereby created.

The present invention is therefore based on the object of developing a mould for metal castings for producing single castings or castings in small numbers in which, after the casting of the molten metal, the solidification to form a casting can be controlled with respect to the direction and speed of the solidification by using a coolant. It is also the object of the present invention to develop a simple and low-cost method for producing such a mould.

According to the invention, the object is achieved with regard to the mould by the features of Patent Claim 1 and with regard to the method for producing the mould by the features of Patent Claim 7. Advantageous refinements of the invention are provided by the subclaims.

The invention is to be explained in more detail below on the basis of an exemplary embodiment and with reference to Figures 1 to 5, in which specifically:

Figure 1 schematically shows a pattern or a grand master pattern for a casting to be produced,

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Figure 2 schematically shows a silicone mould for casting a lost pattern,

5 Figure 3 schematically shows a side view of a lost pattern produced as shown in Figure 2 and enclosed by a cooling channel,

10 Figure 4 schematically shows a sectional view of a mould produced by using the lost pattern as shown in Figure 3 enclosed by the cooling channel, and

15 Figure 5 schematically shows a casting produced with the mould as shown in Figure 4 after it has been removed from the mould.

The pattern or grand master pattern 1 schematically represented in Figure 1 determines the exact shape of a casting 2 represented in Figure 5 that is to be produced with a mould according to the invention for metal castings 4. If a pattern 1 is not already available, something known as a grand master pattern 1 must first be produced. The production of such a grand master pattern 1 usually takes place by means of stereo lithography. However, other generative production methods may also be used for the layer-by-layer production of the grand master pattern 1. Further suitable methods are, for example, selective laser sintering, fused deposition modelling, laminated object modelling and 3D printing.

30 If a grand master pattern 1 has to be newly created and if only one casting 2 is to be produced, the said pattern should be produced immediately as a lost pattern of meltable wax, a low-melting pattern alloy or a burnable plastic or expanded plastic that is suitable for producing the mould according to the invention. If a pattern of the casting to be produced is available or the

grand master pattern 1 is not already a lost pattern, a lost pattern must first be produced from the available pattern or the grand master pattern 1 for the production of the mould according to the invention. This takes place
5 by the pattern or grand master pattern 1 being surrounded with liquid silicone in a moulding box, as can be seen in Figure 2. After setting of the silicone, the silicone mould 5 formed in this way is divided by cutting along a parting line 15, the pattern or grand master pattern 1 is
10 removed from the mould cavity that is formed and the silicone mould 5 is provided with a gating and feeding system (not specifically represented). After that, the silicone mould 5 is exactly reassembled in the moulding box and, for example, filled with liquid wax (likewise
15 not represented). After the setting of the wax, a lost pattern 3, for example of wax, can be removed from the silicone mould.

If prototype castings of high surface quality and
20 accuracy, i.e. those known as precision castings, are required, one-piece lost moulds of plaster or a ceramic compound come into consideration. In the case of castings with low surface quality requirements, a moulding base material that contains a binder (for example quartz sand)
25 may also be used as the moulding material for the one-piece lost mould for metal castings 2. Especially suitable in particular for the production of one-piece sand moulds are lost patterns of expanded polystyrene, which are produced by foaming in a foaming mould or by
30 machining, for example milling, an expanded polystyrene block.

As can be seen in Figure 3, the lost pattern 3 of wax, plastic (for example expanded polystyrene) or a low-
35 melting pattern alloy produced in some way or other for the purpose of producing the one-piece lost mould for

metal castings 4 according to the invention is at least partially enclosed with a flexible cooling channel 6. This is carried out in particular in the regions in which the molten metal is to solidify in a directional manner in the mould, in order to avoid casting defects, and in which the solidification is to take place relatively quickly, in order to achieve a fine-grained material structure that can adequately withstand loading. The selection of these critical regions can advantageously take place, for example, by simulation of the solidification processes (casting simulation). After the lost pattern 3 has been enclosed with the cooling channel 6, the lost pattern is embedded in a moulding material which can be made to set, while providing a gating and feeding system 12. If the lost pattern 3 is a wax pattern and if plaster is used as the moulding material, the wax pattern is melted away after the setting of the plaster mould. If a wax pattern is used and a ceramic compound is used as the moulding material, the wax pattern is likewise melted away after the setting of the moulding material and the ceramic mould is subsequently fired. If the lost pattern is an expanded polystyrene or plastic pattern and a moulding base material that contains a binder is used as the moulding material, the one-piece lost mould for metal castings 4 according to the invention, as represented in Figure 4, is ready for use already after the setting of the moulding base material. Removal of the lost pattern by burning or gasifying in this case only takes place by the molten metal itself when it is poured off.

For the metallic cooling channel 6, a metal material that is resistant to the molten metal is chosen. The metallic cooling channel 6 may be smooth-walled and have a round or oval cross section. In the case of lost patterns 3 of a geometrically simple form, the cooling channel 6 may be

made with smooth walls and be bent by means of bending tools around the lost pattern 3, while in contact with its surface.

- 5 A flexible metal tube, a flexible corrugated metal tube or a wound corrugated metal tube is preferably used for the metallic cooling channel 6.

Steel or high-grade steel has proven to be a successful
10 material for the metallic cooling channel 6. A flexible corrugated high-grade steel tube can be easily wound around the lost pattern 3, even with a small radius of curvature. Such corrugated high-grade steel tubes are produced in the form of a corrugated tube or wound as a
15 corrugated steel tube. If such a corrugated tube is used, undesired deformations of the tube cross section and stresses of the cooling channel 6 can be avoided when the lost pattern 3 is enclosed in an arcuate manner. The corrugation of the tube may comprise a wavy contour or a
20 rectangular contour. Such contours make it possible to form tight bends and create a relatively large cooling area. At the same time, they improve the heat exchange between the molten metal and the cooling medium carried in the cooling channel 6. The ends of the at least one
25 cooling channel 6 are provided with connection flanges 7, 8, which are each connected to a cooling medium supply 9 and a cooling medium discharge 10 that are not represented any further. Gaseous and liquid substances, such as for example air or cooling water, are used as
30 cooling media.

The amount of heat supplied to the one-piece lost mould for metal castings 4 by the molten metal cannot be given off directly into the ambience by convection and
35 radiation, as in the case of a gravity die or a pressure die. Rather, according to the invention, the heat is

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intensively extracted via the cooling medium by means of the cooling channel 6 that is embedded in the moulding material and uncovered, or only slightly covered, in the direction of the mould cavity, in order to cool the solidifying casting 2 as quickly as possible. Heat transfer fluids may also be used for the cooling, allowing the temperature of the one-piece lost mould for metal castings 4 to be controlled before the casting. If cooling is commenced at the latest when the melt is poured into the mould for metal castings 4, incipient melting of the melt at the cooling channel 6 can be avoided. Although the moulding materials that are used for the one-piece lost mould for metal castings 4 are poor heat conductors, the heat supplied by the molten metal can be dissipated via the cooling medium by way of the uncovered and/or only slightly covered outer sides of the metallic cooling channel 6 in the direction of the mould cavity as a result of the thermal gradient that exists in the cooling channel 6. Suitable arrangement of the at least one cooling channel 6 in the one-piece lost mould for metal castings 4 can also bring about directional solidification, and consequently counteract the formation of casting defects such as shrinkage cavities and porosities. The avoidance of incipient melting of the molten metal at the cooling channel 6 allows the casting 2 to be removed from the mould without any problem after cooling. The cooling channel 6 can easily be removed from the casting 2 together with the moulding material of the lost mould for metal castings 4.

30

As a result of the fast, directed cooling of the casting 2 that can be achieved by means of the mould for metal castings 4 according to the invention, casting defects in the casting 2 are largely avoided and a fine-grained structure of the casting 2 is achieved. Consequently, the castings 2 produced in the one-piece lost mould for metal

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castings 4 according to the invention have properties that are the same as or very similar to those which can be achieved when casting in gravity dies or pressure dies. The one-piece lost mould for metal castings 4 according to the invention is consequently particularly suitable for producing prototypes of castings when the latter's functional properties, for example their strength, are checked before producing the expensive gravity or pressure dies for mass production.

10

It is expressly pointed out that the above description of embodiments of the one-piece lost mould for metal castings 4 according to the invention and of the methods for producing it are merely of an explanatory nature and are not intended to have any restrictive effect on the scope of protection of the invention. The scope of protection of the invention is determined by the wording of the accompanying patent claims.

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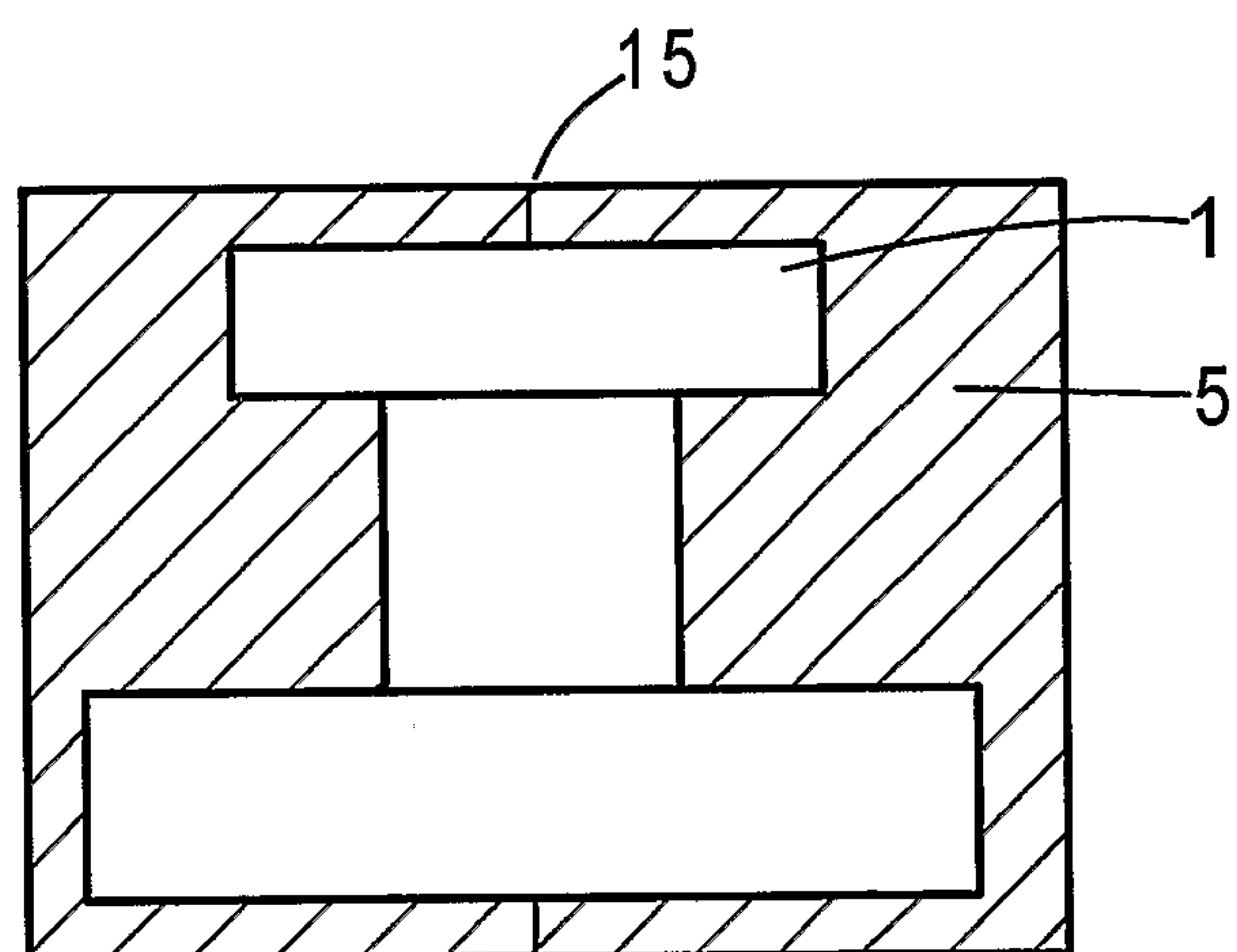
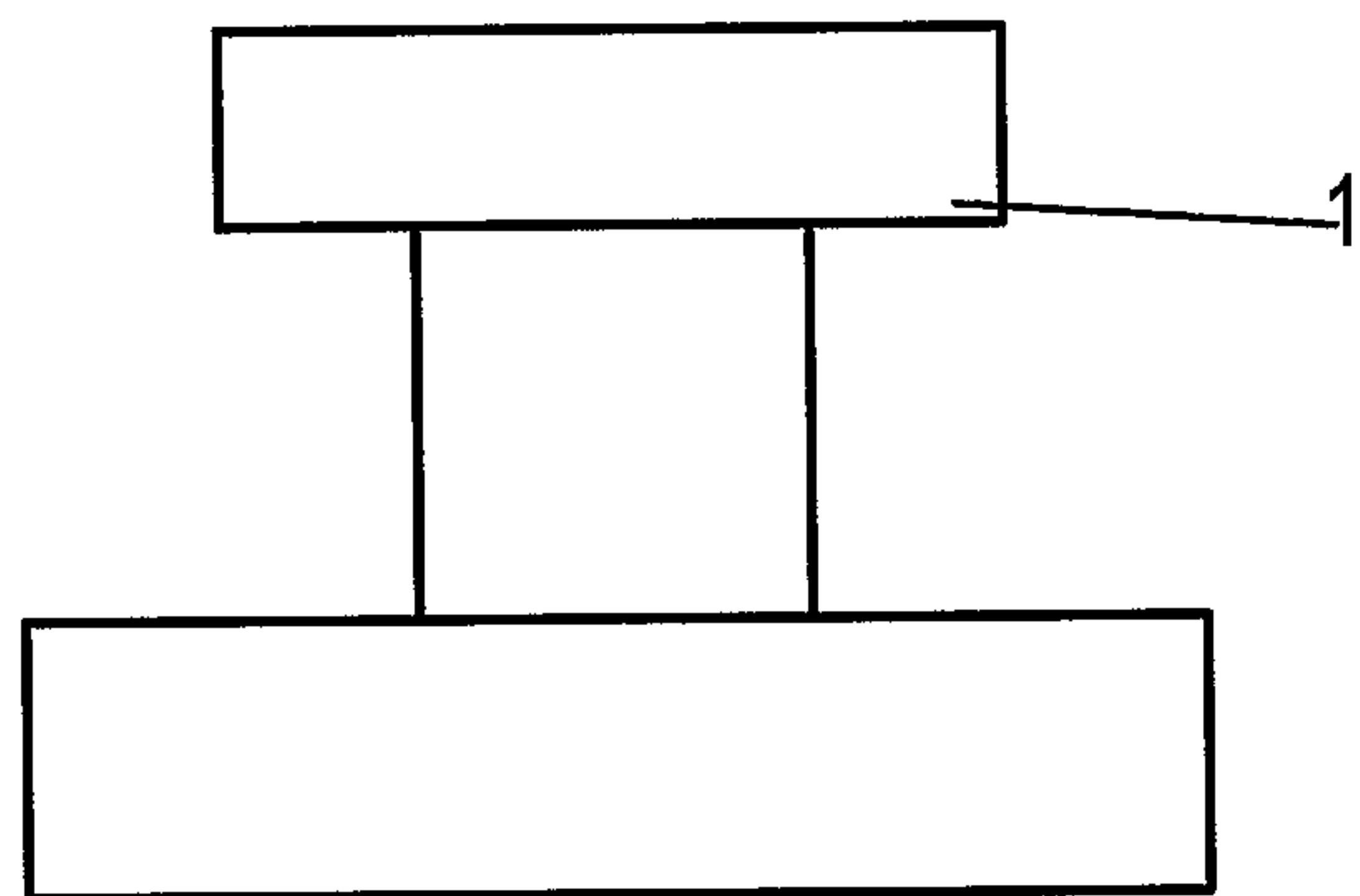
Patent claims

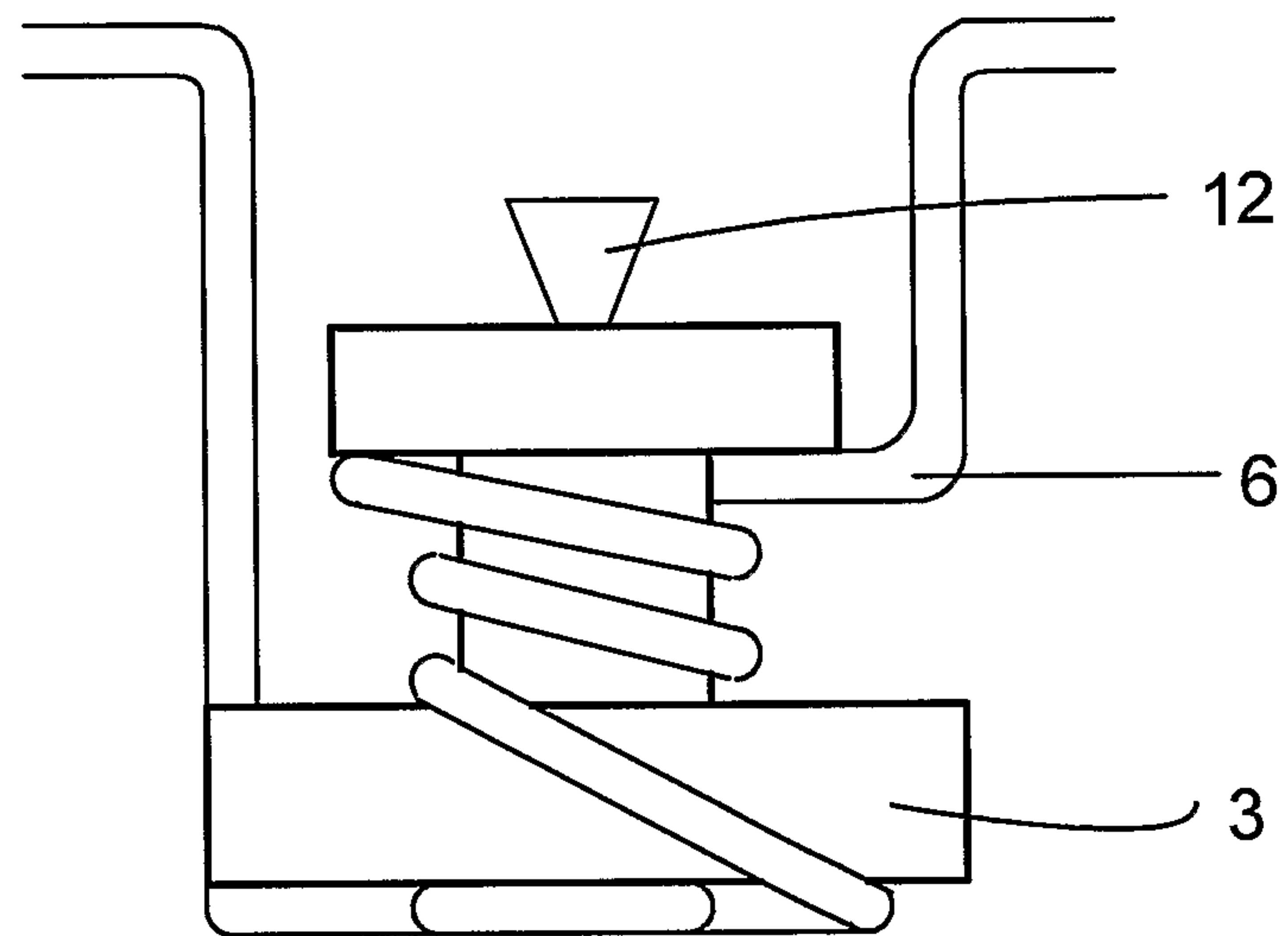
1. One-piece lost mould for metal castings (4) of a set
moulding material which encloses a mould cavity and
5 has at least one metallic cooling channel (6) that is
embedded in the moulding material and carries a
cooling medium, characterized in that portions of the
outer side of the at least one metallic cooling
channel (6) are uncovered and/or only slightly covered
10 by the moulding material in the direction of the mould
cavity.
2. Mould for metal castings (4) according to Claim 1,
characterized in that the at least one cooling channel
15 (6) is smooth-walled and has a round or oval cross
section.
3. Mould for metal castings (4) according to Claim 1,
characterized in that the at least one metallic
20 cooling channel (6) is a flexible metal tube, a
flexible corrugated metal tube or a wound corrugated
metal tube.
4. Mould for metal castings (4) according to at least one
25 of the preceding claims, characterized in that the at
least one metallic cooling channel (6) is formed from
steel or high-grade steel.
5. Mould for metal castings (4) according to at least one
30 of the preceding claims, characterized in that plaster
or a ceramic compound is used as the moulding
material.
6. Mould for metal castings (4) according to at least one
35 of Claims 1 to 4, characterized in that a moulding

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base material that contains a binder is used as the moulding material.

- 5 7. Method for producing a one-piece lost mould for metal castings (4) according to at least one of Claims 1 to 6, characterized by the steps of:
forming a lost pattern (3),
enclosing selected regions of the lost pattern (3) with at least one cooling channel (6),
10 embedding the lost pattern (3) that is enclosed by the at least one cooling channel (6) in a moulding material which can be made to set, while providing a gating and feeding system (12),
making the moulding material set, and
15 removing the lost pattern (3) by melting or burning or gasifying.
- 20 8. Method according to Claim 7, characterized in that the lost pattern (3) is a wax pattern, plaster is used as the moulding material and the wax pattern is melted away after the setting of the plaster mould.
- 25 9. Method according to Claim 7, characterized in that the lost pattern (3) is a wax pattern, a ceramic compound is used as the moulding material, the wax pattern is melted away after the setting of the moulding material and the ceramic mould is fired.
- 30 10. Method according to Claim 7, characterized in that the lost pattern (3) is an expanded polystyrene or plastic pattern, a moulding base material that contains a binder is used as the moulding material, and removal of the lost pattern by burning or gasifying only takes place by the molten metal itself when it is poured
35 off.



**FIG. 3**

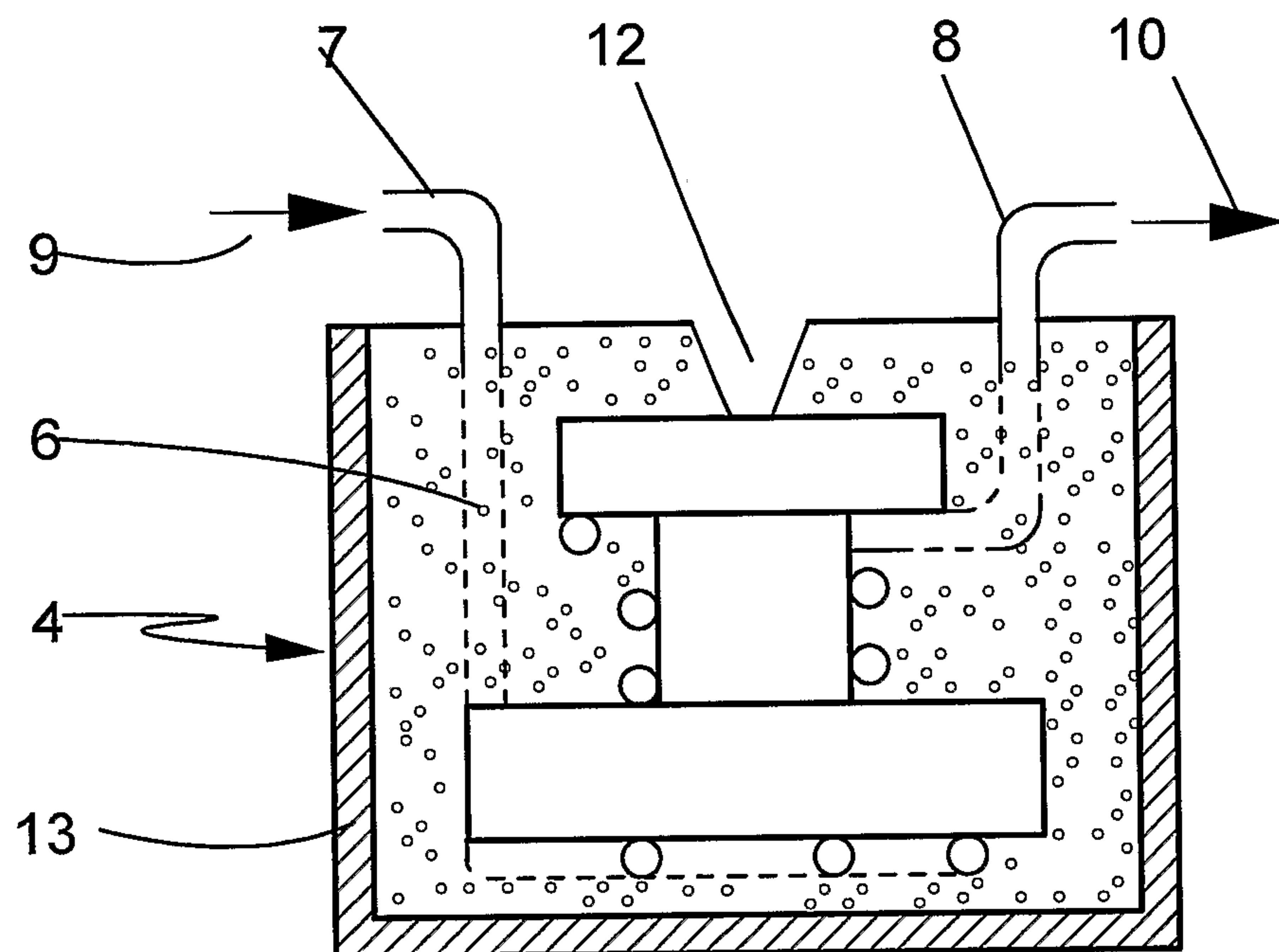


FIG. 4

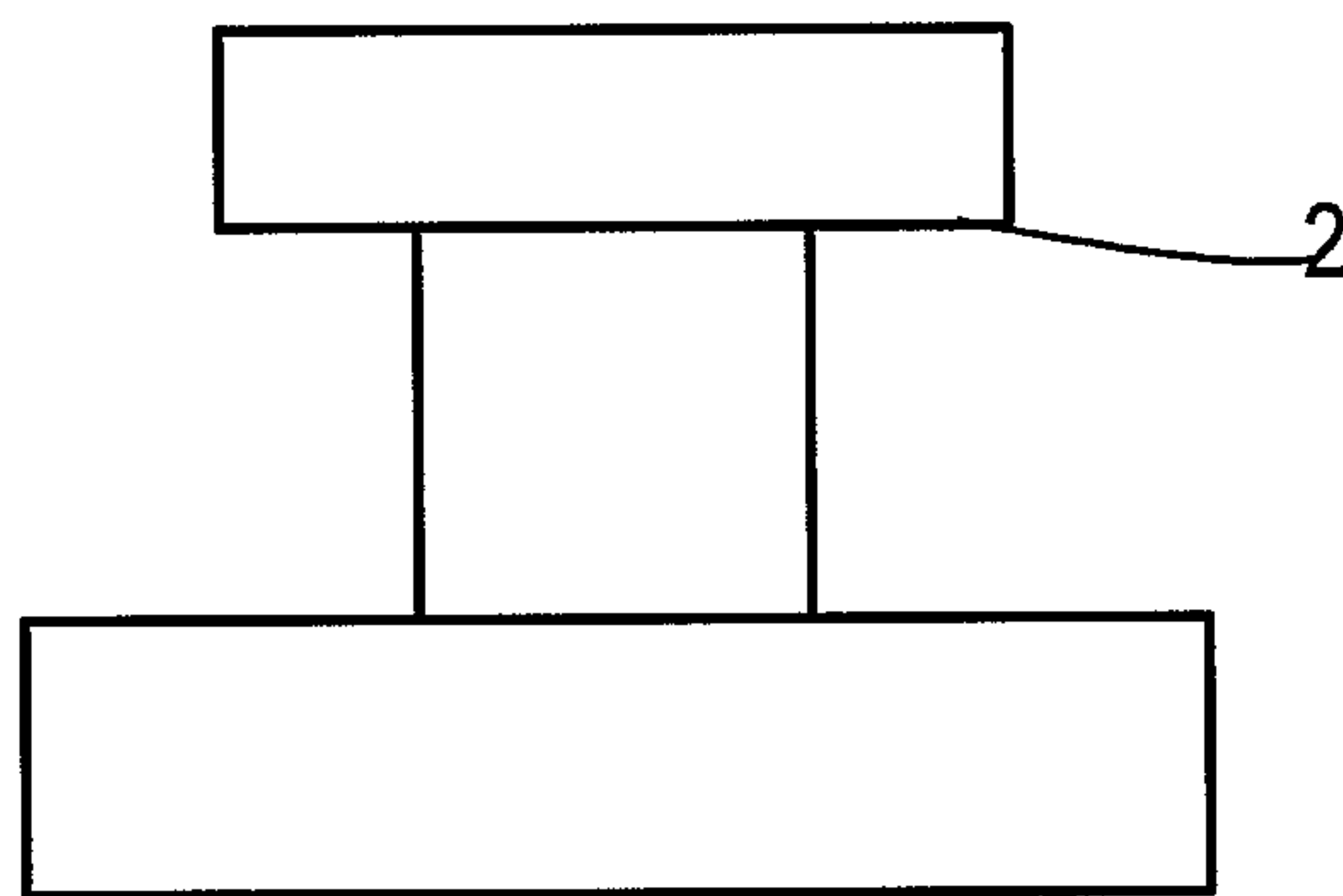


FIG. 5

