



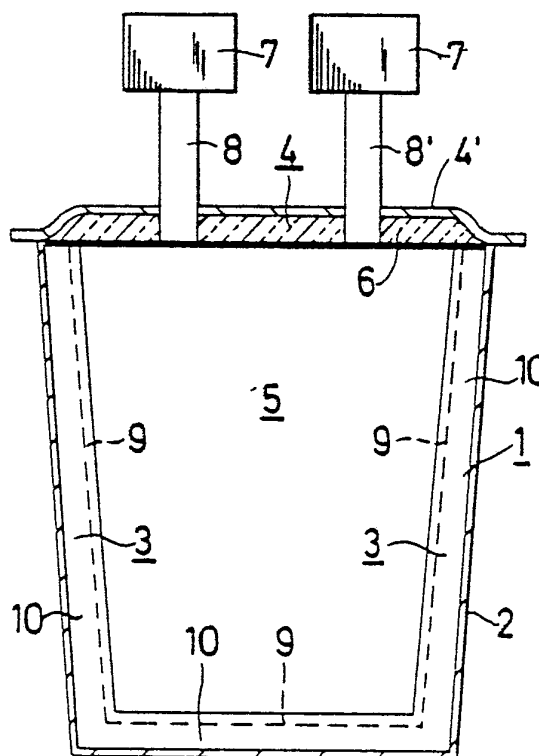
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/SE86/00586 (22) International Filing Date: 29 December 1986 (29.12.86) (31) Priority Application Number: 8506158-8 (32) Priority Date: 30 December 1985 (30.12.85) (33) Priority Country: SE (71)(72) Applicant and Inventor: EKEROT, Sven [SE/SE]; Skeppartagan 100, S-115 30 Stockholm (SE). (72) Inventor; and (75) Inventor/Applicant (for US only) : SVENNEBRINK, Jan [SE/SE]; Gränsvägen 7, S-175 46 Järfälla (SE). (74) Agent: ÖRTENBLAD, Bertil; Noréns Patentbyrå AB, Banérgatan 73, S-115 26 Stockholm (SE).</p>		<p>(81) Designated States: AT (European patent), BE (European patent), BR, CH (European patent), DE (European patent), FI, FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SU, US.</p> <p>Published <i>With international search report.</i> <i>In English translation (filed in Swedish).</i></p>

(54) Title: A METHOD FOR HEATING CERAMIC MATERIAL, PRIMARILY IN CONJUNCTION WITH THE USE OF SUCH MATERIAL IN METALLURGICAL PROCESSES, AND AN ARRANGEMENT FOR CARRYING OUT THE METHOD

(57) Abstract

A method for primarily pre-heating ceramic material primarily in metallurgical processes, the material, in the form of brick or the like, forming part of a lining (3) or the like and being intended to be brought into contact with molten metal, such as molten steel, or a like melt, either directly or indirectly. Heating is effected primarily to reduce the magnitude of the temperature changes that occur in the material as a result of the alternating presence and absence of molten metal, or of a like melt that has an effect on the material. The method is particularly characterized in that heating is effected with the aid of so-called microwaves, and in that the cavity required herefor is formed by an existing metallic casing (2), preferably a steel casing, together with requisite auxiliary casing devices (4), such as lid devices (4) around the material. At least one microwave generator (7) is connected to the cavity in a manner essentially known *per se*. The invention also relates to an arrangement for carrying out the method.



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A METHOD FOR HEATING CERAMIC MATERIAL, PRIMARILY IN
CONJUNCTION WITH THE USE OF SUCH MATERIAL IN METALLUR-
GICAL PROCESSES, AND AN ARRANGEMENT FOR CARRYING OUT
THE METHOD.

5 The present invention relates to a method for heating
ceramic material, primarily in conjunction
with the use of such material in metallurgical process-
es.

10 The invention also relates to an arrangement for carrying
out the method.

Because of the high temperatures that occur in metal-
lurgical processes, particularly in steel manufacturing
processes, matters that concern the refractory brick and
linings employed play an important role in the efficien-
15 cy and economy of the process, both from an economical
and practical aspect. The choice of brick material used
is the result of a compromise made between, inter alia,
such parameters as high temperature erosion properties,
insulating properties, temperature shock stability, the
20 cost of raw materials, and manufacturing costs. The
brick is subjected to particularly high stresses when
coming suddenly into contact with molten steel. The
resultant rapid change in the temperature of the brick
surfaces results in the occurrence of superficial cracks
and so-called spalling. Naturally, these phenomena
25 negatively affect the long-term durability of the brick.

Although these problems can be alleviated by pre-heating
the bricks, the temperature achieved when using known
brick heating techniques, normally affected with the aid

of oil or gas burners or electrical heating devices, seldom exceed about 1000°C. All of these techniques employ some form of indirect heating method, which in itself results in a pronounced temperature gradient in the brick surfaces during the course of pre-heating the brick. Because the known techniques employ indirect heating methods, these techniques have a low degree of efficiency and have hitherto resulted in a cost of from 10 to 20 Swedish Crowns for each ton of steel produced.

In addition to the aforesaid drawback relating to temperature shock, the fact that present day pre-heating techniques when put into practice seldom result in temperatures above 1000°C introduces a further drawback, namely the drop in temperature to which the molten steel is subjected, this drop in temperature being the result of an increase in the temperature of, inter alia, the brick, the refractory lining. This drop in the temperature of the steel may reach to several tens of degrees of centigrade and must be compensated for by heating the molten steel bath to corresponding over-temperatures, which entails both time and energy costs and results in wear and tear on the furnace brickwork. This drop in temperature may also, in practice, cause difficulties in the form of freezing, so-called pocketing.

The need of heating the brick in steel manufacturing processes is particularly comprehensive, and includes all vessels and transport devices that are used between the steel furnace and the pouring station.

The present invention affords a solution to the above-

mentioned problems, in which the ceramic or refractory material, the brick, is heated directly.

The invention thus relates to a method for primarily pre-heating ceramic material in primarily metallurgical use, this material, in the form of bricks or corresponding elements, forming part of a lining or the like and being intended to be brought into contact with molten metal, such as molten steel or a corresponding melt, either directly or indirectly, said heating being primarily intended to reduce the magnitude of the temperature changes that take place in the material as a result of the alternating presence and absence of molten metal, or like molten material that has an affect on the ceramic material.

The method is particularly characterized in that heating of the ceramic material is effected with the aid of so-called microwaves, the microwave cavity required herefor being formed by an existing metallic shell or casing, preferably a steel casing, together with requisite auxiliary casing devices, such as lid devices around said material, at least one microwave generator being connected to said cavity in a substantially known manner.

The invention also relates to an arrangement for heating ceramic material, primarily ceramic material used in conjunction with metallurgical processes, said material having the form of bricks or the like which form part of a refractory lining or some corresponding structure and which are intended to come into contact with molten metal, such as molten steel or a corresponding melt, either directly or indirectly, said

heating of the ceramic material being effected primarily in order to reduce the magnitude of the temperature changes that occur in the material as a result of the alternating presence and absence of molten metal or a
5 corresponding melt that has an effect on the material.

The arrangement is particularly characterized by devices for heating the material with the aid of microwaves, wherein the cavity required herefor is formed with the aid of an existing metallic casing or shell, preferably
10 a steel casing, together with requisite auxiliary casing devices, such as lid devices, surrounding the material, and wherein at least one microwave generator is connected to the cavity.

The invention will now be described in more detail with
15 reference to exemplifying embodiments thereof and with reference to the accompanying drawings, in which

Figure 1 is a vertical sectional view taken on the line A-A in Figure 2, and illustrates schematically a first embodiment of a lining heating arrangement according to the invention shown in conjunction
20 with a ladle, some of the structural elements not being shown in section;

Figure 2 is a top plan view of the arrangement illustrated in Figure 1;

25 Figure 3 is a vertical, longitudinal, sectional view which illustrates schematically a second embodiment of a lining heating arrangement according to the invention used in conjunction with a pouring box, in which some details have not been shown in

section;

Figure 4 is a sectional view taken on the line B-B in Figure 3;

5 Figure 5 is a sectional view of one embodiment of a molten metal delivery pipe or conduit, the lining of which is heated in accordance with the invention;

Figure 6 is a sectional view taken on the line C-C in Figure 5;

10 Figure 7 illustrates schematically and in vertical section an arrangement for heating a nozzle located in the bottom of a ladle; and

Figure 8 illustrates schematically an arrangement for heating a nozzle in accordance with the invention.

15 Figures 1 and 2 illustrate a normal pre-heating application, namely the pre-heating of a container vessel in the form of a schematically illustrated ladle 1 used in steel manufacturing processes. The ladle includes an external steel shell 2 which embraces an internal layer 3 of
20 ceramic material, or materials, forming the ladle lining.

The reference 4 indicates shell or casing devices, lid devices, which together with the shell 2 define the necessary cavity for heating by microwaves at least a
25 part of the lining, a metallic lid, preferably a steel lid 4, covering the opening 5 of the ladle, said hollow being of appreciable size and facing upwards

when the vessel, the ladle, is mounted in the conventionally intended manner, as illustrated in Figure 1. The lid 4 comprises an outer casing 4', preferably made of steel, which is lined internally with a heat insulating layer 6. This layer exhibits but very small loss factors and will not therefore be heated to any appreciable extent by microwaves.

According to preferred embodiments, at least one microwave generator 7 is located in the vicinity of said lid devices 4, preferably adjacent to the lid 4, and is connected by means of waveguides 8 to the cavity formed. The embodiment illustrated in Figures 1 and 2 incorporates two generators 7.

In many cases the ceramic material, which is intended to be heated by microwaves and which therefore exhibits significant loss factors, preferably forms those parts 9 of the lining that are intended to come into contact with, e.g., a molten steel bath. These bath contacting parts 9 are shown in Figure 1. As indicated in Figure 1, insulating parts are preferably incorporated between the bath contacting parts 9 of the lining and the ladle shell 2.

The embodiment illustrated in Figures 3 and 4 comprises an elongated, relatively shallow container vessel 11, such as a so-called pouring box 11, the outlet of which is not shown in Figures 3 and 4. Similar to the ladle 1, the vessel 11 comprises a metallic outer shell 2 which embraces a ceramic lining 3. The outwardly facing opening 11' of the vessel 11 is covered by elongated lid devices 4, in a manner corresponding to the ladle 1, wherewith a suitable number of microwave

generators are provided, in the illustrated embodiment of Figures 3 and 4 three such generators 7, these generators being connected to the defined cavity by waveguides 8.

5 In the embodiment illustrated in Figures 5 and 6 the ceramic material to be heated, pre-heated, is enclosed by the lining of a liquid-metal delivery conduit 12 intended e.g., for conducting molten steel, this embodiment incorporating
10 microwave applicators 13 which are distributed along the conduit so as to supply microwaves thereto. The reference 14 indicates waveguides which establish a connection between generators (not shown) and the applicators 13. The conduit 12 suitably has extending therethrough an essentially tubular
15 ceramic part 15 which presents a through-bore 16 for the passage of molten material therethrough, and which preferably adjoins an outer metallic casing 17, preferably made of steel. Each applicator is suitably arranged concentrically with the part 15 and comprises,
20 e.g., a cylindrical widening of the casing 17.

Figure 7 illustrates an arrangement which is intended particularly for heating a so-called nozzle 18 which includes a ceramic material that exhibits significant loss factors and which is intended to be heated with
25 the aid of microwaves. Auxiliary casing devices comprising a substantially cylindrical waveguide 19 for microwaves are arranged to be inserted into a container vessel 20, such as a ladle, and to be connected at one end part 21 thereof to the nozzle 18, this end part 21
30 of the waveguide 19 contributing towards forming a cavity 22. With regard to temperature influence, the

waveguide 19 may be cooled in some suitable manner, e.g. water cooled, and may be covered externally with an insulating material. The reference 7 indicates a microwave generator which is connected to the upper
5 part 23 of the waveguide 19. The reference 24 indicates a metallic lid. The nozzle 18 is conveniently embraced by a bush 25 made of a material which will not be heated to any appreciable extent by microwaves. Located beneath the nozzle is a guard 26, preferably
10 a metallic guard, which protects against the leakage of microwaves.

Figure 8 illustrates a further arrangement for heating a nozzle 27 incorporating material which is heated by microwaves. In this embodiment a substantially
15 cylindrical cavity, similar to the applicators of the Figure 5 and 6, is formed by means of a metal casing 28 which forms an applicator 28 and which is supplied with microwaves through a waveguide 29. In accordance with a preferred embodiment, the applicator 28 is constructed to oscillate in a coaxial mode when molten
20 metal runs through the nozzle, and to oscillate in another mode in the absence of molten metal in the through-bore 27' of the nozzle. The cavity, for example, may be of circular cross section substantially
25 at right angles to the longitudinal extension of the through-bore 27' and having a length corresponding to one half wavelength. The cylindrical mode used may be TM 010 the resonance frequency of which is not dependent on length, while the diameter is determined by the
30 resonance frequency. Thus, in this embodiment the diameter and length of the two oscillating modes are each determined per se. More complicated conditions, in which length and diameter

are dependent upon one another, can also be applied. The waveguide 29 and the applicator 28 are coupled together, so that both oscillating modes can be excited. This described arrangement provides both pre-heating and
5 back-up heating facilities while molten material passes through the nozzle, thereby enabling blockages etc. to be avoided.

With regard to the composition of the material to be heated by means of microwaves, it can be said that this
10 material preferably comprises a mixture of various ceramic components so adapted that the material obtains a pre-determined so-called loss factor with regard to microwaves.

In many cases the aforesaid material preferably comprises components which exhibit significant loss factors,
15 such as zirconium dioxide, ZrO_2 .

The method according to the invention and the function of the arrangement according to the invention will be understood in all essentials from the foregoing. By
20 incorporating in ceramic materials intended primarily for metallurgical use a material which exhibits significant loss factors in regard to microwaves, i.e. will be heated by microwaves, it is possible, by creating a microwave cavity around said material and applying
25 microwaves thereto, to heat ceramic material directly to extremely high temperatures if so desired. The possibilities of controlling temperature, temperature gradient, etc., are extremely good since such parameters as times, the components from which the ceramic material
30 is fabricated, etc., can be selected.

As will be understood from the foregoing, the invention affords particularly significant advantages over the known prior art. These advantages include, inter alia, high pre-heating temperatures and uniform temperatures.

In the foregoing the invention has been described with reference to a number of exemplifying embodiments. It will be understood that other embodiments are conceivable and that minor modifications can be made to the illustrated embodiments without departing from the concept of the invention.

For example there can be used as the material to be heated by means of microwaves a suitable stamped monolithic lining, which is suitably located on insulating brick exhibiting low loss factors.

In the foregoing, ladles, pouring boxes, conduits and nozzles have been recited as examples of vessels or the like or vessel parts suitable for pre-heating/heating by means of microwaves. The method in question, however, can be used to heat several types of vessel and vessel parts. Examples hereof include so-called torpedoes (transport cylinders), stopper rods and die bushes.

With regard to the aforesaid waveguides, such as the waveguides 8, they are normally and preferably of substantially rectangular cross-section, although other cross-sectional shapes are conceivable.

It will also be understood that hollows or cavities

which correspond to nozzles or the like through which molten metal is intended to run, and which are intended for injecting, for example, gas and/or particles, can be heated in accordance with the invention for use in
5 those cases where heating requirements prevail.

Furthermore, ceramic filters may need to be pre-heated in certain instances.

With regard to the composition of the ceramic materials to be heated with the aid of microwaves, measurements
10 have shown that the majority of ceramic materials with solely minor modifications to the composition thereof can be used when heating in accordance with the invention. Suitable materials have been found to be ceramic materials based on ZrO_2 or Al_2O_3 supplemented
15 with some other oxidic material or materials, such as MgO , SiO_2 , Fe_2O_3 , etc.

In the case of embodiments substantially according to Figure 7, the waveguide may have an antenna effect and contribute towards transmitting microwaves to the
20 nozzle or the like without contributing to form a pronounced cavity.

The invention shall not be considered to be restricted to the aforescribed embodiments, since modifications can be made within the scope of the following Claims.

CLAIMS

1. A method for primarily pre-heating ceramic material used primarily in metallurgical processes, said material in the form of brick or the like forming part of a lining or the like and being intended to come into contact with molten metal, such as steel, or a like melt, either directly or indirectly, said pre-heating being primarily intended to reduce the magnitude of temperature changes occurring in the material as a result of the alternating presence and absence of molten metal, or of a like melt, that has an effect on the material, characterized in that heating is effected by means of so-called microwaves, the cavity required herefor being formed by an existing casing or shell (2), preferably a steel casing, together with requisite auxiliary casing devices (4, 13, 19, 24, 26, 28), such as lid devices (4, 24) around said material, said cavity having at least one microwave generator (7) connected thereto in a substantially known manner.
2. A method according to Claim 1, characterized in that said material is admixed with mutually different ceramic components in order to impart to said material so-called loss factors with regard to microwaves suitable for the purpose intended.
3. A method according to Claim 1 or 2, characterized by including in said material zirconium dioxide, ZrO_2 , as a component that exhibits significant loss factors with regard to microwaves.
4. A method according to Claim 1, 2 or 3 characterized

in that said material forms contact parts (9) of the lining (3, 15) or the like that are intended to be brought into contact with said molten metal or like melt, these contact parts (9) being insulated by means
5 of insulating parts (10) located between the contact parts and said casing.

5. A method according to Claim 1, 2, 3 or 4, characterized in that said material comprises the lining (3) of a container vessel, such as a ladle (1), a pouring
10 box (11) or the like, which includes an opening or hollow (5, 11') of appreciable size, said opening or hollow facing upwards when the vessel is mounted in a normal intended manner and being covered with the aid of metallic lid devices (4), preferably a steel lid,
15 which co-acts with the metallic casing (2) of the vessel so as to form a shell which is impervious to microwaves.

6. A method according to Claim 5, characterized in that at least one microwave generator (7) is connected
20 to said lock devices (4, 24) by means of waveguides (8).

7. A method according to Claim 1, 2, 3 or 4, characterized in that said material comprises the lining (15) of a conduit (12) intended for conducting molten metal,
25 such as molten steel, wherewith microwaves are supplied by means of microwave applicators (13) arranged along the conduit (12).

8. A method according to Claim 1, 2, 3, 4, 5, 6 or 7, characterized in that a so-called nozzle (18, 27) or

corresponding hollow through which material, such as molten metal, gas or powder, is intended to pass, is caused to incorporate said material and is heated by means of separate devices forming a cavity connected with the nozzle or the like or exercising an antenna effect and herewith cooperating in the transfer of microwaves to the nozzle.

9. An arrangement for heating ceramic material primarily used in metallurgical processes, said material in the form of brick or the like forming part of a lining or the like and being intended to be brought into contact with molten metal, such as molten steel or a like melt, either directly or indirectly, said heating primarily being intended to reduce the magnitude of temperature changes occurring in the material as a result of the alternating presence and absence of molten metal, or of a like metal that has an effect on the material, characterized by means for effecting said heating with the aid of microwaves; in that the cavity required herefor is formed with the aid of an existing metallic casing (2), preferably a steel casing, together with requisite auxiliary casing devices (4, 13, 19, 26, 28), such as lid devices (4, 24), around said material; and in that at least one microwave generator (7) is connected to said cavity.

10. An arrangement according to Claim 9, characterized in that said material comprises a mixture of mutually different ceramic components so adapted as to impart to said material a pre-determined so-called loss factor with regard to microwaves.

11. An arrangement according to Claim 9 or 10, charac-

terized in that said material includes zirconium dioxide, ZrO_2 , as a component that exhibits significant loss factors with regard to microwaves.

5 12. An arrangement according to Claim 9, 10 or 11, characterized in that said material comprises a ceramic material based on ZrO_2 or Al_2O_3 supplemented with some other oxidic material or materials, such as MgO, SiO_2 and Fe_2O_3 .

10 13. An arrangement according to Claim 9, 10, 11 or 12, characterized in that said material is intended to form those contact parts (9) of the lining (3) or the like that are intended to come into contact with said molten metal or like melt, said contact parts (9) being insulated by means of insulating parts (10) located between the contact parts and said casing (2).

20 14. An arrangement according to Claim 9, 10, 11, 12 or 13, characterized in that said material comprises a preferably stamped, monolithic lining, which is preferably mounted on insulating brick or the like that exhibits low loss factors.

25 15. An arrangement according to Claim 9, 10, 11, 12, 13 or 14, characterized in that said material includes the lining of a container vessel, such as a ladle (1), a pouring box (11) or the like, which presents an opening or hollow (5, 11') of appreciable size, said opening or hollow facing upwards when the vessel is mounted in a normal intended manner and being covered by metallic lid devices (4), such as a steel lid arranged to co-act with the metallic casing (2) of the vessel in a manner to form a shell which is substantially impervi-

30

ous to microwaves.

16. An arrangement according to Claim 9, 10, 11, 12, 13 or 14, characterized in that said material is included in the lining (15) of a conduit (12) intended
5 for conducting molten metal, such as molten steel, and in that microwave applicators (13) are arranged along the conduit for supplying microwaves.

17. An arrangement according to Claim 9, 10, 11, 12, 13, 14 or 15, characterized in that when a so-called
10 nozzle (18, 27) or the like is present through which material, such as molten material, gas or powder is intended to pass, separate means are provided for forming a cavity in connection with the nozzle, or for exercising an antenna effect, therewith cooperating in
15 the transmission of microwaves to the nozzle or the like for heating the same.

18. An arrangement according to Claim 17, characterized in that a bottom nozzle (18) of a container vessel (20) includes said material, said requisite auxiliary
20 casing devices incorporating a substantially tubular waveguide (19) for microwaves intended for insertion into the container vessel (20) and having an end part (21) for connection to the nozzle internally of the vessel, said end part cooperating to form a cavity (22)
25 or to exercise said antenna effect.

19. An arrangement according to Claim 17, characterized in that said separate devices include a microwave applicator (28) arranged to oscillate in a coaxial mode when molten metal runs through the through-bore (27')
30 of the nozzle (27), and in another mode in the absence

of molten metal in the through-bore of said nozzle.

Fig. 1

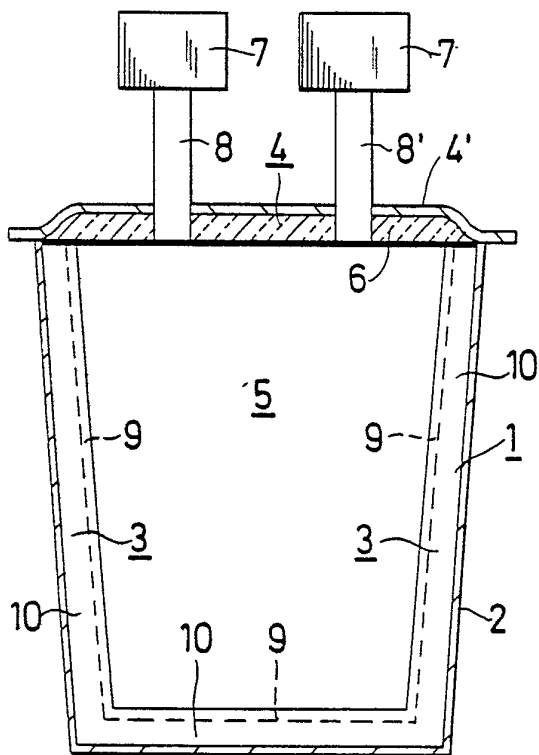


Fig. 2

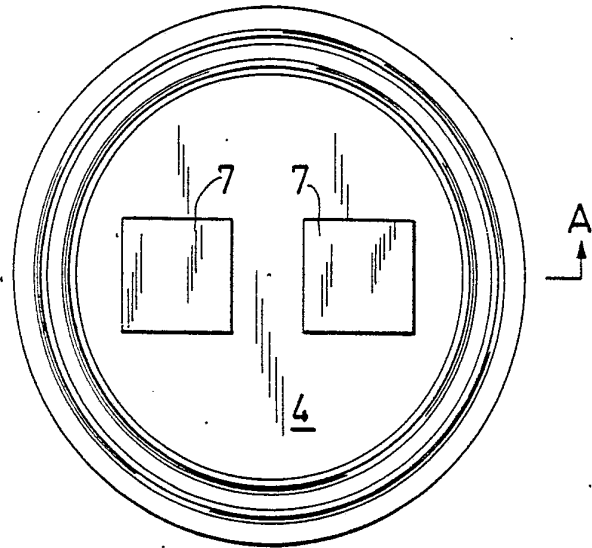


Fig. 3

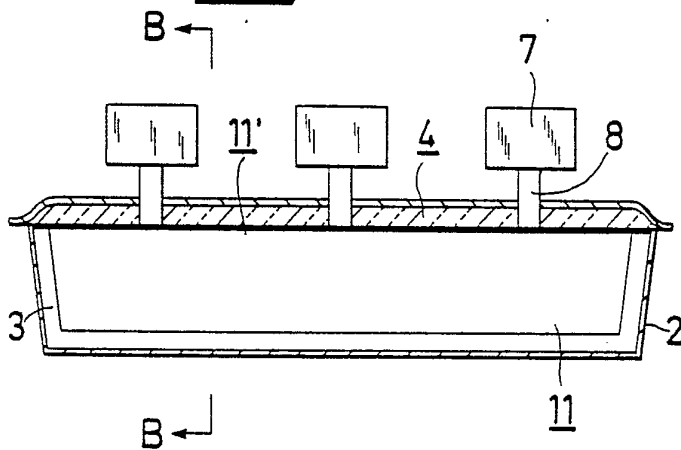


Fig. 4

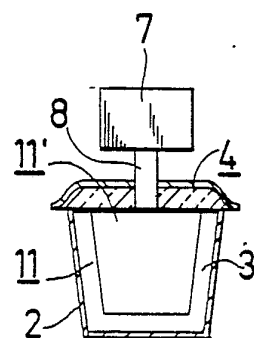


Fig. 5

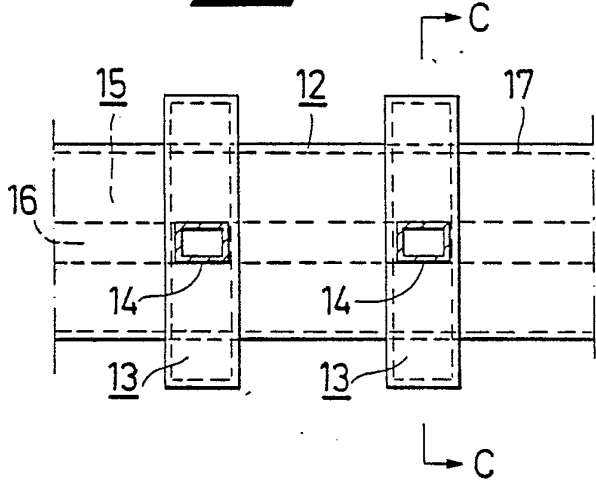


Fig. 6

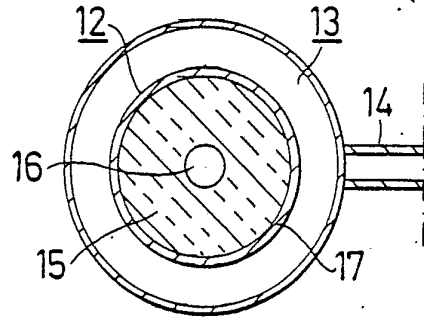


Fig. 7

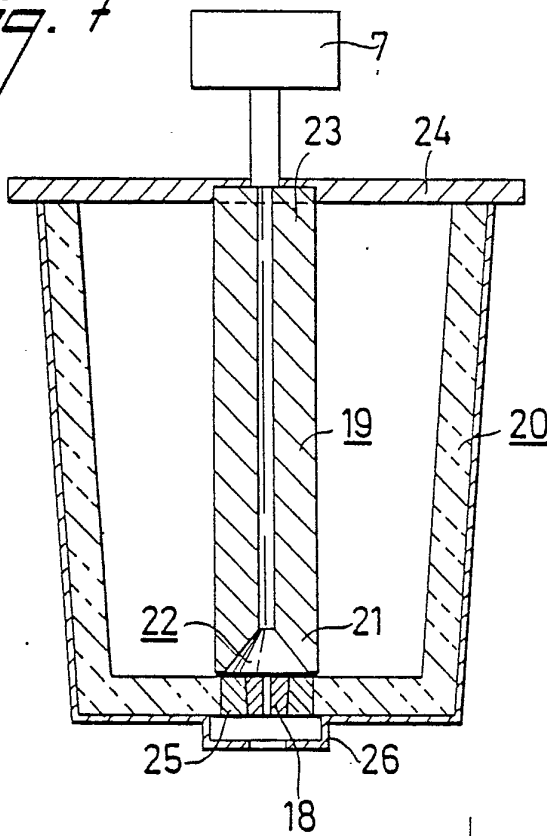
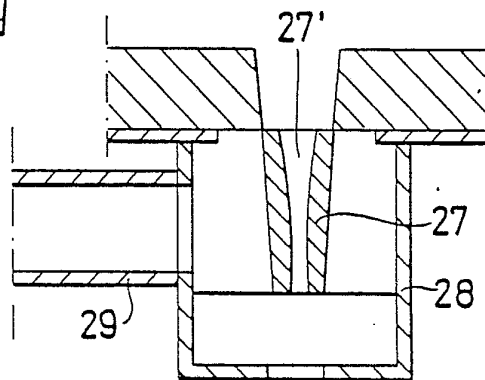


Fig. 8



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE86/00586

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC ⁴		
B 22 D 41/00, F 27 D 11/12, H 05 B 6/80		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC 4	B 22 D 41/00, /08; F 27 B 14/14; F 27 D 11/12; H 05 B 6/78, /80	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
SE, NO, DK, FI classes as above		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X Y	DE, C2, 3 015 300 (KOBE STEEL, LTD) 30 October 1980 the entire document	1,5,6,9,15 2-4, 7-8, 10-14, 16-17
Y	FR, A, 2 393 255 (COMMISSARIAT A L'ENERGIE ATOMIQUE et CARBONISATION ENTREPRISE ET CERAMIQUE) 29 December 1978 the entire document	2-4, 10-14
Y	GB, A, 2 122 859 (UNITED KINGDOM ATOMIC ENERGY AUTHORITY) 18 January 1984 fig 3	7,8, 16-17
A	US, A, 3 847 202 (VAUGHN ET AL) 12 November 1974	1
<p>⁹ Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"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</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"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.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
1987-03-16		1987-03-18
International Searching Authority		Signature of Authorized Officer
Swedish Patent Office		<i>Ulf Nyström</i> Ulf Nyström