

MOULD SLEEVE AND MOULDING METHOD

Field of the Invention

This invention relates to a mould sleeve and a moulding method and refers particularly, though not exclusively, to such a sleeve and method for producing ceramic tubes.

Background to the Invention

It has been proposed to use a movable sleeve to centralize the core during the production of plastics and metal tubes. However, it has never been proposed for ceramics tubes and tubes with multiple holes. Also, the prior proposal locked the core at one end. During forming, the core will therefore block a portion of the flow path of the material entering the mould thereby causing non-uniformity in the filling of the cavity by the material thus creating thermal stress within the formed tubes leading to distortion, especially for tubes with multiple holes. Also, with the prior proposal, during filling there is a pressure applied on the core that results in a bending stress within the core. As such, as the sleeve moves the stress within the core will be released and thus cause a deformation of the hole or the tubes formed.

As shown in Figure 1, room temperature single/double screw extrusion is a continuous commercial fabricating process to produce ceramic tubes and other relative large hollow sections. The starting raw materials are mixtures of ceramics powders and water-based binders. The mixtures are then formed into the required shapes by extrusion. The green parts are then oven or air dried prior to thermal debinding at 900 to 1000 degrees C. The debinded parts are then sintered at elevated temperature of 1400 to 1700 degrees C.

Room temperature plunger extrusion is only able to be used for batch ceramic tubes and other relative large parts. The process is the same as single/double screw extrusion with the exception of the shape forming process. In this process, the mixture is added to the extrusion chamber and then air is evacuated. After evacuation, the plunger pushes the materials out of the die to form the required shape.

These processes have been in the market for several years. However, the production yield is always low for high precision, relative large and complex components. As a result, complex and costly secondary operations are required. All these make the process an expensive fabrication process, although extrusion is considered one of the most inexpensive fabrication processes in terms of the green part forming.

There is no commercial high temperature ceramic extrusion process available using a mixture of powders and polymer binders.

The latest developed and commercially available high temperature ceramic extrusion uses a semi-solid high temperature ceramic extrusion process. In this process, the starting raw materials are mixtures of low melting point glass with ceramics powders and the extrusion is conducted at a temperature over 600 degrees C. The process is suitable for special ceramic-glass mixtures and the processing temperature is over 500 degrees C.

The commercial high temperature extrusion is available for aluminum and other metals and their alloys. The method is a batch process and the extrusion force is from a hydraulic plunger. The process is suitable metallic extrusion and the processing temperature is also over 500 degrees C.

Powder injection moulding utilizes the flow of the feedstock materials to form a complex shape by injection moulding. The green parts are then debinded and sintered through a particle diffusion process at high temperature. The process is suitable for producing small metallic, ceramic and carbide articles with a complex geometry in a large volume.

Summary of the Invention

In accordance with a first preferred aspect there is provided a method of moulding an article, the article having elongate openings therein, the method comprising:

- (a) placing a core in a cavity of a die set;
- (b) the core being supported at a first end by a core lock and at a second end by a movable sleeve mounted in and being movable relative to the cavity and the core;

- (c) injecting material into the cavity to commence to form the article;
- and
- (d) moving the movable sleeve along the cavity to support the core while forming the article.

According to a second preferred aspect there is provided apparatus for moulding an article with at least one elongate opening therein, the apparatus comprising:

- (a) a die set having a cavity;
- (b) a core for forming the at least one elongate hole and being for placement in the cavity and supportable at a first end by at least one of a core holder and at least one core lock, and at a second end by a movable sleeve mountable in and being able to move in a sliding manner relative to the cavity and the core;
- (c) the sleeve being able to so move under the influence of material entering the cavity.

The core may comprise a plurality of pins. The elongate openings may be through the article, or may be blind holes. The core may be placed in the cavity by means of a core holder. The at least one core lock may be at a moulding gate. The core lock may be a fixed or sliding lock. The core may be supported at a first end by the at least one core lock at the moulding gate and at the second end by the core holder. The support by the core holder may be by a guild plate. The core may be positioned by the movable sleeve. The core holder and the at least one core lock may be at opposite ends of the core. There may be one core lock for each pin.

Pressure of the material acting on a first end of the sleeve may force the sleeve along the cavity.

The sleeve may have a sleeve holder at a second end of the sleeve, the second end being remote from the first end; the sleeve holder being for drawing the sleeve along the cavity.

The sleeve may be of a cross-sectional shape, configuration and size that is substantially the same as the cross-sectional shape, configuration and size of the article. The sleeve may be a close but sliding fit within the cavity.

According to a third preferred aspect there is provided a sleeve for use in the moulding of an article with at least one elongate opening therein, the sleeve being for placement in a cavity of a die set and being able to move in a sliding manner relative to the cavity and a core in the cavity; the sleeve being able to move under the influence of material entering the cavity and acting on a first end of the sleeve; the sleeve having a sleeve holder at a second end of the sleeve, the second end being remote from the first end; the sleeve holder being for drawing the sleeve along the cavity; the sleeve being of a cross-sectional shape, configuration and size that is substantially the same as the cross-sectional shape, configuration and size of the article. The sleeve may be for receiving therein, locating relative to the cavity, and supporting, the core.

According to a fourth preferred aspect there is provided a product produced by the above method.

Brief Description of the Drawings

In order that the present invention may be fully understood and readily put into practical effect, there shall now be described by way of non-limitative example only preferred embodiments of the present invention, the description being with reference to the accompanying illustrative drawings.

In the drawings:

Figure 1 is an illustration of a known, prior art process;

Figure 2 is a schematic side illustration of a preferred embodiment;

Figure 3 is a schematic illustration of the process steps with the preferred embodiment;

Figure 4 is a schematic illustration of a front view corresponding to Figure 2;

Figure 5 is a view corresponding to Figure 4 but of an alternative embodiment;

Figure 6 is a schematic illustration of the embodiment of Figures 2, 4 and 5 during the moulding process;

Figure 7 is a series of perspective views showing the process after the moulding process;

Figure 8 is a collage of perspective views of products able to be produced by the process.

Detailed Description of the Preferred Embodiments

To refer to Figures 2 to 6, there is shown a die set 10 that form a cavity 12 in which an article is to be formed. In this embodiment, the article is to be flat surface tubes for use in fuel cells. To form the tubes, core 14 is held in the cavity by core holder 16, and sleeve 20. A core guide plate 17 may be used, if required or desired. The core 14 may have a plurality of pins 15. One or more core lockers 80 may be used, if required or desired. The core lockers 80 may be fixed or sliding lockers. If sliding lockers, they may be pin lockers. There is preferably one locker 80 for each pin 15. The material enters cavity through sprue/runner/gate 18.

Located in cavity 12 is a movable sleeve 20 which is initially near the gate. The core 14 passes into and is supported by the sleeve 20.

As shown in Figure 3, as the material 22 enters cavity 12 through sprue/runner/gate 18 it presses on the top 28 of moveable sleeve 20. As more material 22 enters cavity 12, the material forces sleeve 20 along the cavity 12. As sleeve 20 moves, it continues to support cores 14. The core lockers 81, 82 and 83 hold the core 14 in position at the first or upper end. The sleeve 20 receives therein the core 14 to hold the core 14 in position relative to the cavity, and to support the core 14, until the sleeve 20 reaches the end of its movement, thereby forming the article 24 with tubes 30 formed by the core 14. The tubes 30 are elongate tubes and may be through article 24, or may be blind hole tubes. When the sleeve 20 moves sufficiently down the cavity 12, the core 14 is no longer in, located by or supported by, the sleeve 20.

In Figures 4 to 6, the sleeve 20 has a sleeve holder 26 that is able to be acted upon by a force provider or actuator (not shown) to draw sleeve 20 along cavity 12 as the material 22 advances along cavity 12. In this way the pressure in cavity 12, and hence on core 14, may be more controlled, and even reduced. Furthermore, it allows for more control of the core 14 to enable a more even wall thickness for article 24; and more even spacing, and regularity in the shape of tubes 30 formed in article 24. The sleeve 20 will be the same as, or will have a cross-sectional shape and configuration, of the article 24. Therefore, article 24 as shown in Figure 6 is also a representation of sleeve 20. The sleeve 20 will be a close but slidable fit in cavity 12. By close it means that the sleeve 20 will contact the wall 32 of cavity 12 with sufficient force to prevent material 22 from passing between sleeve 20 and

the wall 32 of cavity 12, but with sufficient freedom of movement to be able to slide as described above.

Figure 5 illustrates a different embodiment where the core 14 is held by the core holder 16 at one end – the opposite end to that of Figure 4 - and by the sleeve 20 at the other end. The sleeve 20 is initially near the gate 18. During forming, the sleeve 20 will move and the lockers 80 and holder 16 keep the core 14 at the desired position. As such there is no obstacle in the gate 18 to the entry of the material 22. Therefore, the material 22 can fill the cavity 12 more uniformly to form the article 24. Also, there is no bending pressure applied to the core 14.

As shown in Figure 7, once article 24 is moulded, the core 14 and core holder 16 are removed from cavity 12. The movable plate (10, 12, 14, 16, 34 and 36) opens and ejects the product. The pins 14 and pins holder 16 are then put back to the desired position positioned by a locker at the gate and sleeve. The mould is ready for next cycle.

Figure 8 illustrates products able to be moulded using this process. They include: ceramic tubes with through hole or blind hole, sintering tubes, other products with elongate openings therein or thereon, and so forth.

The core 14 may be a single core, a single core with a single pin, a single core with multiple pins, or multiple cores.

Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention.

THE CLAIMS

1. A method of moulding an article, the article having elongate openings therein, the method comprising:
 - (a) placing a core in a cavity of a die set;
 - (b) the core being supported at a first end by at least one of a core holder and at least one core lock, and at a second end by a movable sleeve mounted in and being movable relative to the cavity and the core;
 - (c) injecting material into the cavity to commence to form the article;and
 - (d) moving the movable sleeve along the cavity to support the core while forming the article.
2. A method as claimed in claim 1, wherein the core comprises a plurality of pins, there being a pin for each of the elongate openings.
3. A method as claimed in claim 1 or claim 2, wherein pressure of the material acting on first end of the sleeve forces the sleeve along the cavity.
4. A method as claimed in any one of claims 1 to 3, wherein the sleeve has a sleeve holder at a second end of the sleeve, the second end being remote from the first end; the sleeve holder being for drawing the sleeve along the cavity.
5. A method as claimed in any one of claims 1 to 4, wherein the sleeve is of a cross-sectional shape, configuration and size that is substantially the same as the cross-sectional shape, configuration and size of the article.
6. A method as claimed in any one of claims 1 to 5, wherein the elongate openings are selected from the group consisting of: through the article, and blind holes.
7. A method as claimed in any one of claims 1 to 6, wherein the core is placed in and held in the cavity by the core holder.
8. A method as claimed in claim 7, wherein the at least one core locker is at a gate.

9. A method as claimed in claim 7 or claim 8, wherein the at least one core locker is selected from the group consisting of: a fixed locker, and a sliding locker.
10. A method as claimed in any one of claims 1 to 9, wherein the core is in, located by, and supported by the sleeve.
11. Apparatus for moulding an article with at least one elongate opening therein, the apparatus comprising:
- (a) a die set having a cavity;
 - (b) a core for forming the at least one elongate hole and being for placement in the cavity and supportable at a first end by at least one of a core holder and at least one core lock, and at a second end by a movable sleeve mountable in and being able to move in a sliding manner relative to the cavity and the core;
 - (c) the sleeve being able to so move under the influence of material entering the cavity.
12. Apparatus as claimed in claim 11, wherein the core comprises a plurality of pins, there being a pin for each elongate opening.
13. Apparatus as claimed in claim 11 or claim 12, wherein pressure of the material acting on a first end of the sleeve is able to force the sleeve along the cavity.
14. Apparatus as claimed in any one of claims 11 to 13, wherein the sleeve has a sleeve holder at a second end of the sleeve, the second end being remote from the first end; the sleeve holder being for drawing the sleeve along the cavity.
15. Apparatus as claimed in any one of claims 11 to 14, wherein the sleeve is of a cross-sectional shape, configuration and size that is substantially the same as the cross-sectional shape, configuration and size of the article.
16. Apparatus as claimed in any one of claims 11 to 15, wherein the elongate openings are selected from the group consisting of: through the article, and blind holes.

17. Apparatus as claimed in any one of claims 11 to 16, wherein the core is placeable in and holdable in the cavity by the core holder.
18. Apparatus as claimed in claim 17, wherein the at least one core locker is at a gate.
19. Apparatus as claimed in claim 17 or claim 18, wherein the at least one core locker is selected from the group consisting of: a fixed locker, and a sliding locker.
20. Apparatus as claimed in any one of claims 11 to 19, wherein the core is in, located by, and supported by the sleeve.
21. A sleeve for use in moulding an article with at least one elongate opening therein, the sleeve being for placement in a cavity of a die set and being able to move in a sliding manner relative to the cavity and a core in the cavity; the sleeve being able to move under the influence of material entering the cavity and acting on a first end of the sleeve; the sleeve having a sleeve holder at a second end of the sleeve, the second end being remote from the first end; the sleeve holder being for drawing the sleeve along the cavity; the sleeve being of a cross-sectional shape, configuration and size that is substantially the same as the cross-sectional shape, configuration and size of the article.
22. A sleeve as claimed in claim 21, wherein sleeve is for receiving therein, locating relative to the cavity, and supporting, the core.
23. An article produced by the method of any one of claims 1 to 10.
24. A method as claimed in any one of claims 1 to 10, wherein the at least one core lock and the core holder are at opposite ends of the core.
25. A method as claimed in any one of claims 2 to 10, wherein there is one core lock for each pin.
26. Apparatus as claimed in any one of claims 11 to 20, wherein the at least one core lock and the core holder are at opposite ends of the core.

27. Apparatus as claimed in any one of claims 2 to 20, wherein there is one core lock for each pin.

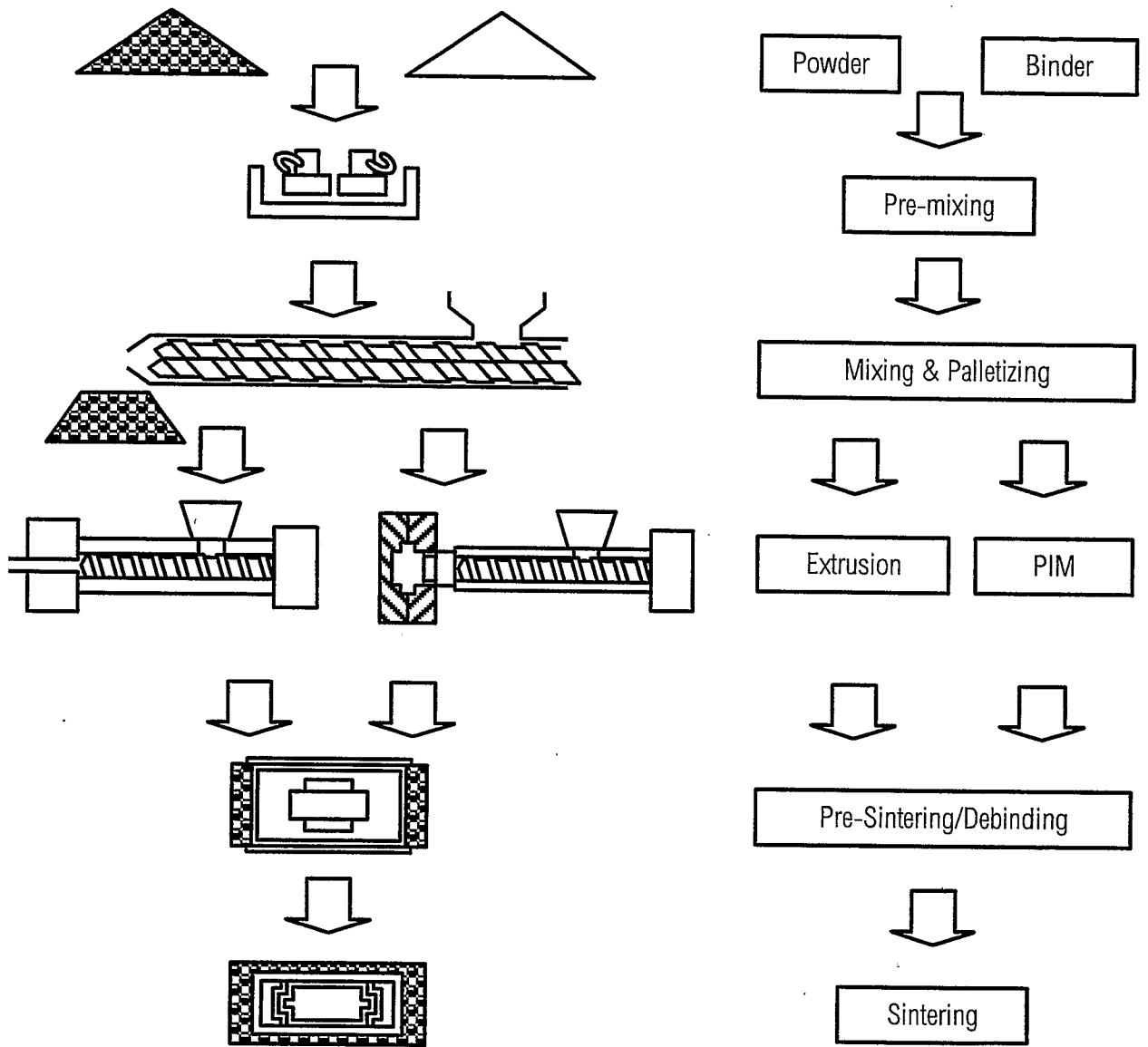


FIG. 1 (PRIOR ART)

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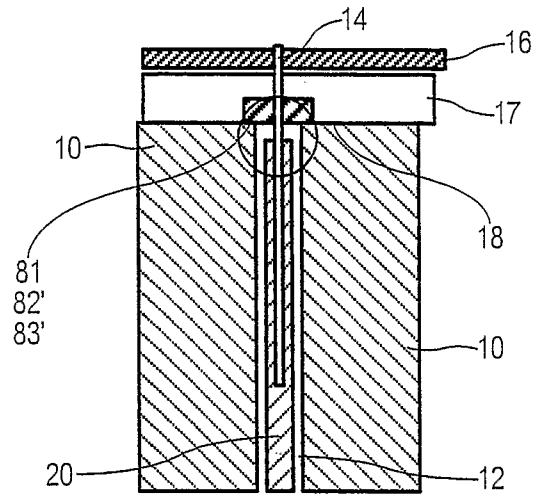


FIG. 2

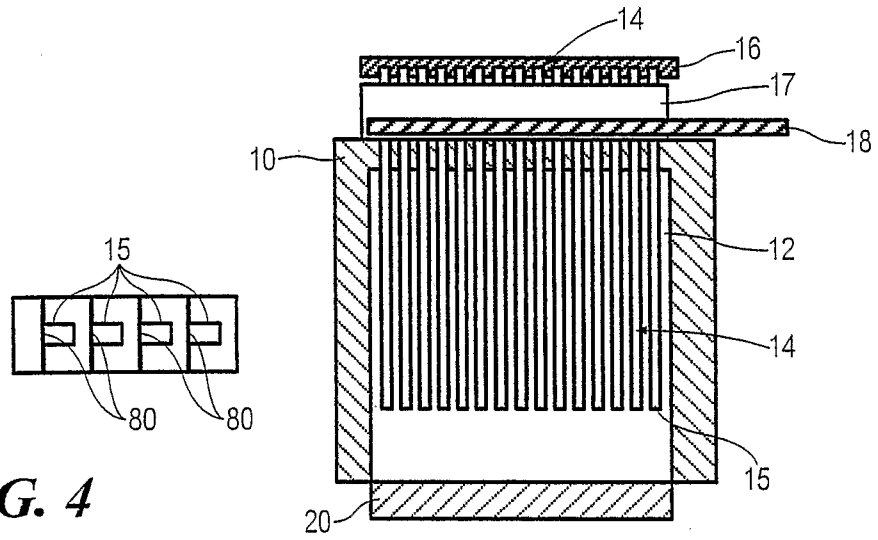


FIG. 4

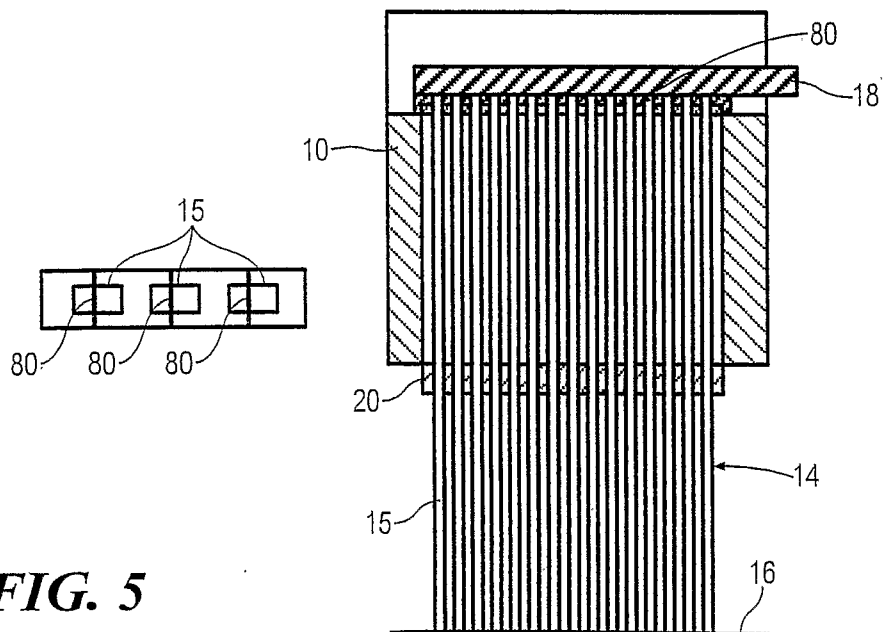


FIG. 5

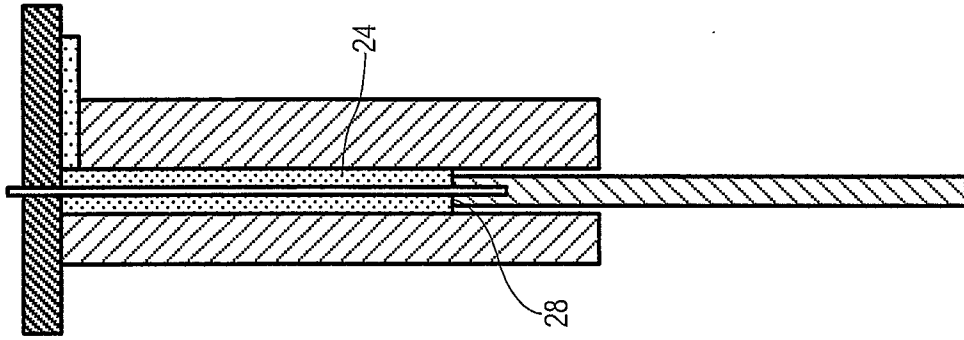


FIG. 3D

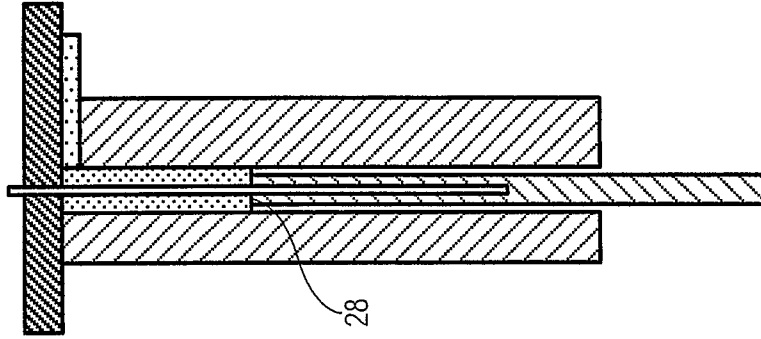


FIG. 3C

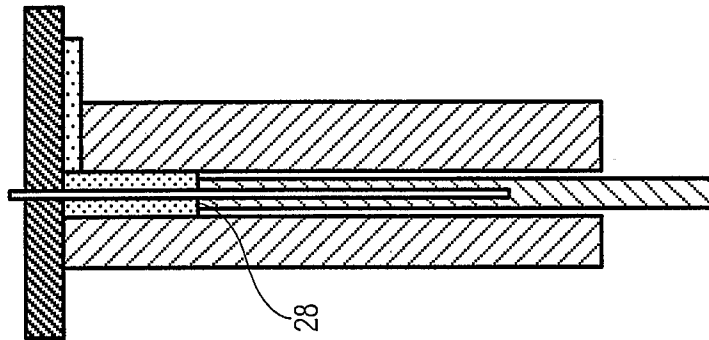


FIG. 3B

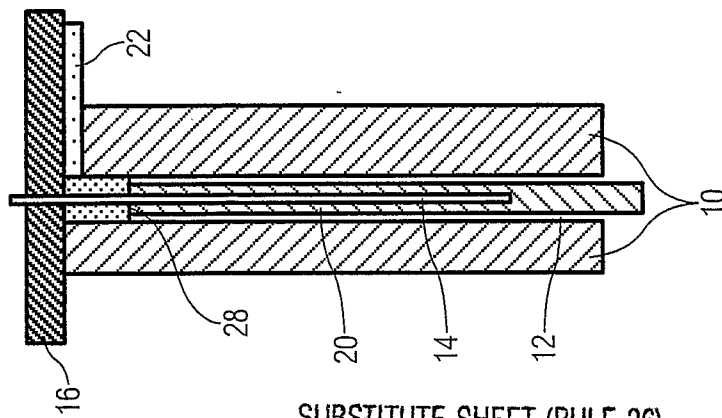


FIG. 3A

SUBSTITUTE SHEET (RULE 26)

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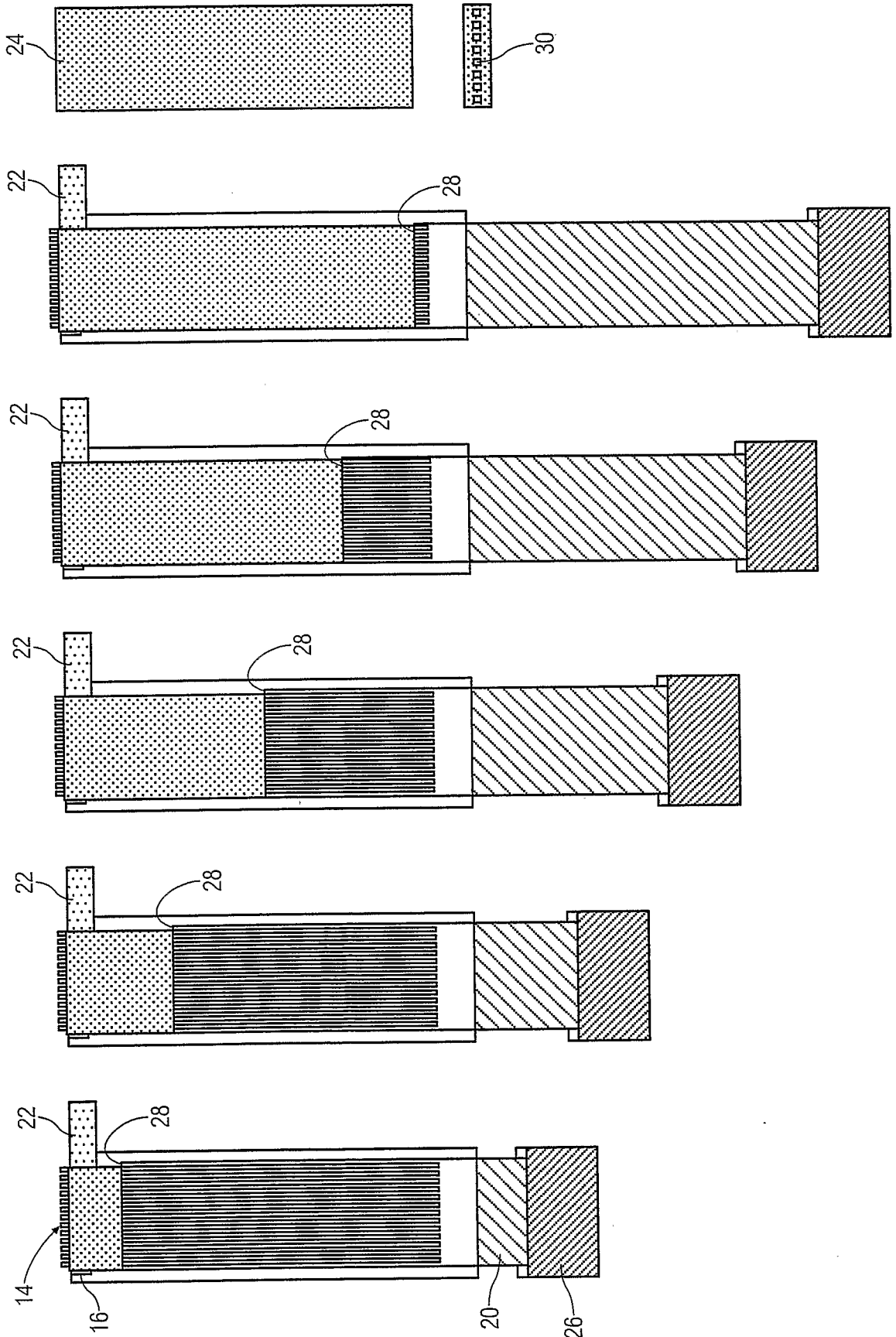


FIG. 6

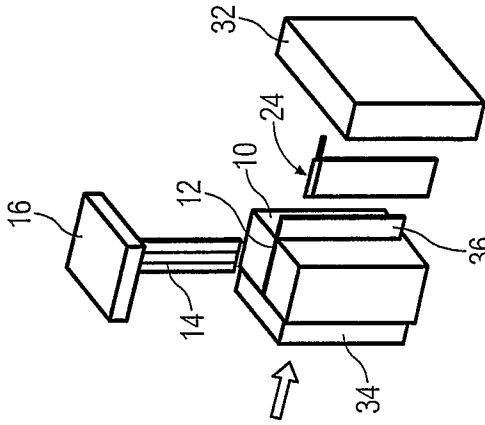


FIG. 7C

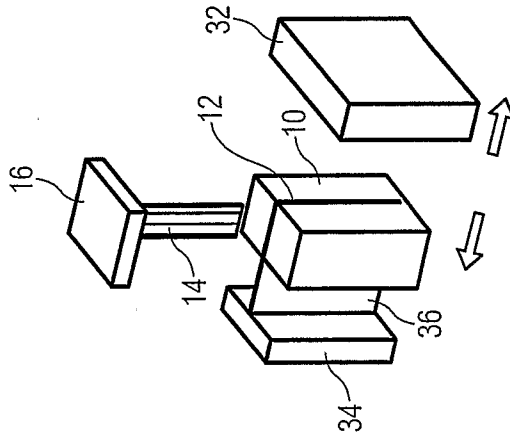


FIG. 7B

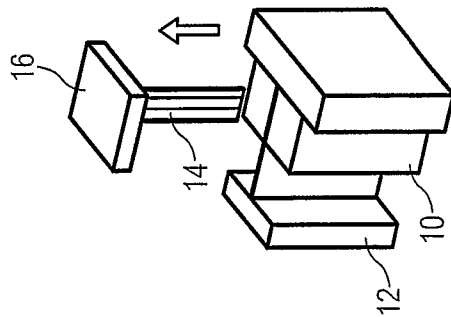


FIG. 7A

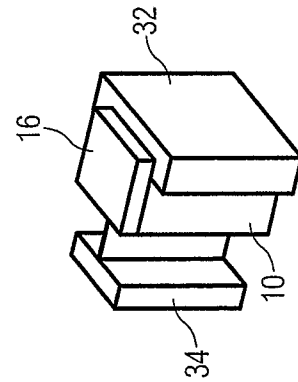


FIG. 7D

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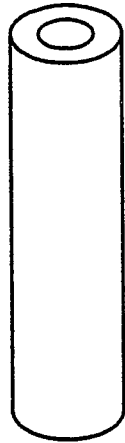


FIG. 8A

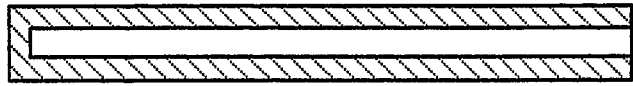


FIG. 8B

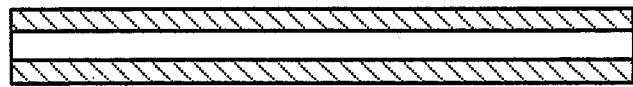


FIG. 8C

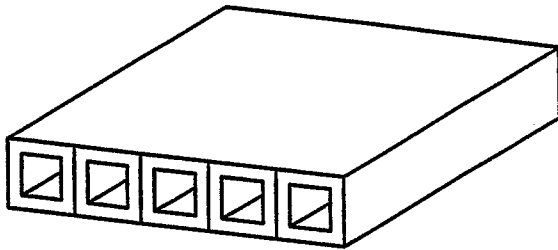


FIG. 8E

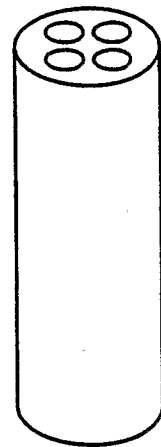


FIG. 8D

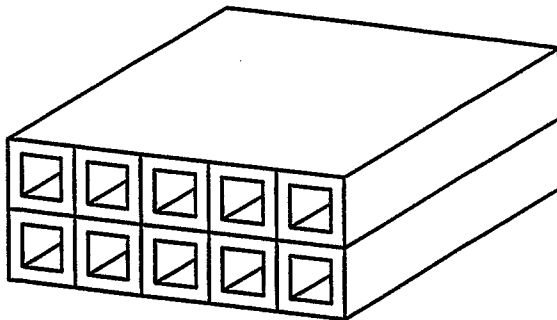


FIG. 8F

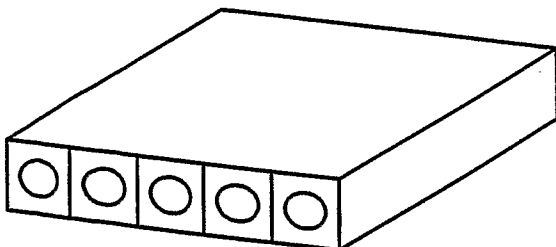


FIG. 8G

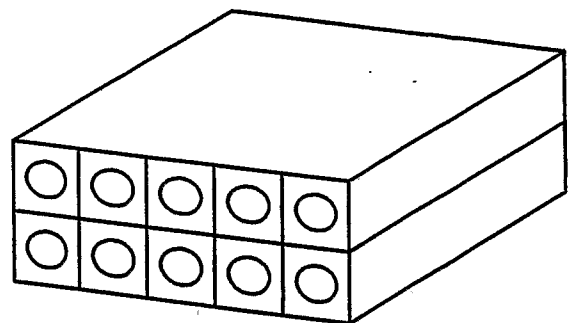


FIG. 8H

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2007/000128

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl.		
B28B 21/38 (2006.01) B29C 45/42 (2006.01)		
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)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPAT, USPTO, ESP@CE: sleeve, movable, insert		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2757099 A1 (SOCIETE DES CERAMIQUES TECHNIQUES SOCIETE ANONYME) 19 June 1998 Whole document in particular figures	1-27
X	Patent abstracts of Japan, JP 04-261802 A (TOTO LTD) 17 September 1992 Abstract and figure	1-27
X	WO 1990/ 000960 A (MEDISPO MEDIZINTECHNIK GMBH) 08 February 1990 Whole document	1-27
A	WO 1992/005024 A1 (JACOBS, Ian) 01 April 1992 Whole document	
<input type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex		
* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search 26 June 2007		Date of mailing of the international search report 19 JUL 2007
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929		Authorized officer SERINEL SAMUEL AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2382

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2007/000128

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member
FR 2757099	
JP 4261802	
WO 9000960	DE 3825488 DE 3825489
WO 9205024	

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX