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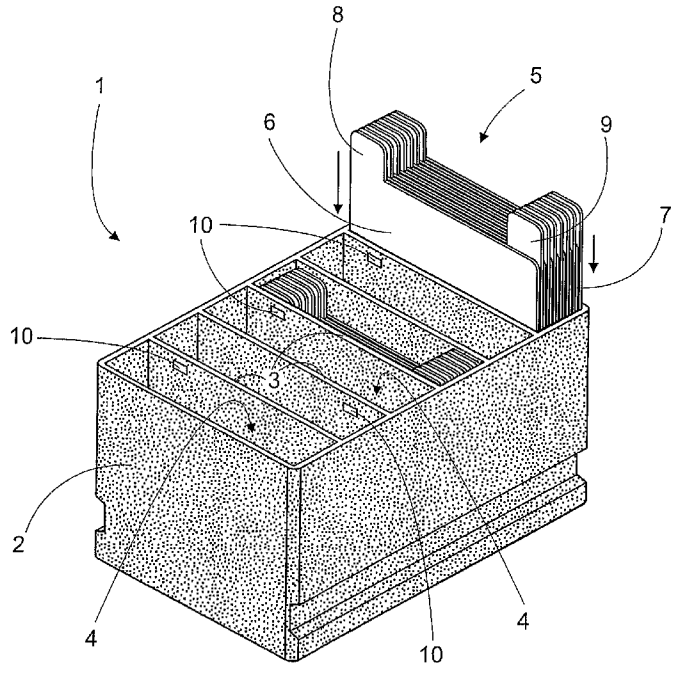
(54) Title: METHOD AND APPARATUS FOR MANUFACTURING A BATTERY ASSEMBLY



(57) Abstract: A method for interconnecting the plate lugs in the elements of a battery, the method comprising to invert the battery box including the plates therein and insert the plate lugs into corresponding element die sections and to introduce melting lead into the die section to connect the lugs and to pass through corresponding orifices in partitions of the battery to interconnect the lugs of adjacent elements. An apparatus and the obtained battery is also provided.

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METHOD AND APARATUS FOR MANUFACTURING A BATTERY ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention relates to a new method and apparatus for manufacturing a battery assembly and the battery assembly obtained by the method and apparatus, and preferably the invention refers to a method for making a safe and reliable interconnection of the battery plates with less manufacturing steps as compared to typical methods.

2. Description of the Prior Art.

Basically a battery is comprised of a battery box including a plurality of inner partitions for defining the elements or elements where the positive and negative plates are arranged. Each plate is provided with a plate lug upwardly extending in order to be interconnected to form the circuitry of the battery. There are several techniques to connect the lugs but there is one important aspect that must be taken into account by any of the procedures and this aspect is that the connection between the lugs must be

reliable, otherwise, if only one connection fails to provide a continuous electrical conductivity the battery does not work.

US No. 3,944,436 to Gaide, discloses a method comprising the steps of inserting the plate lugs in an elementary mould connecting together the plate lugs by rods formed by melting lead, and making the connection between the rods associated with plates of opposite polarities of two adjacent elements of the accumulator. The elementary mould comprises a channel common to two adjacent elements of the accumulator and is provided onto the plates in the battery box. Alternatively, the elementary mould comprises two channels with each of them having the plate lugs of same polarity fitted in them. As clearly shown in Fig. 4 of Gaide´s patent, the connections between the plates of one element and the plates of an adjacent element are formed by melting the lugs 46, 48 of both positive and negative plates, such melting being effected either by means of a blow-pipe or a heating rod, or by casting lead in the channels 42 and 43 of the moulds 40 or 40; or by means of turns through which a high-frequency current flows. This method requires of elementary moulds to be arranged onto the plates in a manner that each lug passes through a notch of the mould, making the process to be cumbersome and time consuming.

US Patent No. 5,505,744 to Eberle et al. discloses the steps of a method for making battery terminals on lugs 70 of battery plates 66, wherein the first step gathers a group of battery plates with lugs protruding from a non-metallic case. A second step consists of immersing the protruded lugs in a mould filled with a molten lead by rotating the lugs downward direction. The mould is shaped for strap cavities 114 and 112 where the lugs are immersing, and cavities for two terminals 116 and 118, as shown in Figs. 11-13. As clearly disclosed and illustrated the group of plates of this patent is all arranged in only one battery box without partitions as it is typical in a battery with several elements. Under these circumstances this patent does not approach the problem of interconnecting the plates in one element with the plates in an adjacent element involving, in this interconnection, the necessary battery partition.

US No. 6,059,848 to Shannon et al. discloses an improved battery design which utilizes the battery cover of the container as a mold to make the cast electrical circuits, including the external terminals. The battery cover includes a plurality of plate strap mold wells which receive molten lead, with the mold wells being separated by a partition wall and including an aperture formed in the partition wall to allow molten lead to flow between adjacent plate strap mold wells and connect thereof.

Terminal mold wells have terminal apertures through which molten lead flows to form an external terminal with the aid of an external terminal mold. A meltable sealant material is pre-applied to the plurality of mold wells to become fluid under the temperature of molten lead and to solidify when cooled to prevent leakages of electrolyte and gasses. The cover is simultaneously fixed to the battery box while die-casting the straps of the circuitry. While the problem of failure in the connection of plate lugs has been partially solved and the time of manufacturing process has been reduced, there exist the drawback that the quality control of the plate straps can not be carried out in a proper manner as long as, when the straps are cooled down and in solid status, it would be necessary to remove the cover and open the battery to control the plate straps and interconnections.

US No. 5,206,987 to Renard, discloses a method and apparatus for joining plate lugs via a low resistance electrical coupling wherein substantially oxide-free, arc-melted, superheated molten lead is cast into a cavity between the parts. As shown in Fig. 2 of Renard, each positive polarity plate in one cell element includes an upstanding lug 10 and each negative plate in the cell element in the next adjacent compartment includes an upstanding lug 12. The positive plate lugs 10 of one cell element are aligned with each other and with similarly

aligned negative plate lugs 12 in the next cell element on opposite sides of the opening 8 in the partition 6. The positive polarity lugs 10 are surrounded by a trough 14 and the negative polarity lugs 12 are surrounded by a trough 16. The troughs 14 and 16 remain with the battery and if they are made from thermoplastics they may be temporarily flanked by blocks of metal to support the sides of the troughs 14 and 16 against drooping under the heat from the melt. After solidification, the blocks are removed. Again, this method is cumbersome as long as it requires the use of additional pieces and tools such as the troughs 14, 16.

It would be therefore very convenient to have a new technique and/or method for obtaining a battery with the plates interconnected in a safe and reliable manner and with a less number of method steps also permitting to easily carry out the necessary quality control.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a new method for assembling electrical batteries wherein the interconnection of the positive and negative plates is easily and quickly carried out.

It is still another object of the present invention to provide a method for manufacturing a battery wherein the

interconnection of the battery plates is made in a safe and reliable manner.

It is a further object of the present invention to provide a method for interconnecting battery plates in a battery of the type having a battery box including a plurality of partitions defining separate elements receiving said battery plates, the partitions including orifices to communicate each adjacent pair of elements, the battery plates comprising positive battery plates and negative battery plates each battery plate having a plate lug with the plate lugs of the positive battery plates being aligned at one side of the battery box and the plate lugs of the negative battery plates being aligned at another side of the battery box, the method comprising the steps of:

a) inserting the battery plates into the elements of the battery box;

b) providing at least one mould for receiving said lugs, the mould having a number of element die sections separated by gaps and each gap is designed for receiving one of said partitions of the battery box and for accommodating one orifice of the partition to fluidly communicate two adjacent element die sections,

c) inverting the battery box and inserting the plate lugs into the element die sections of the mould and simultaneously inserting the battery box partitions into

the gaps of the mould whereby each orifice of the partitions are placed in fluid communications with two adjacent element die sections, and

d) introducing melting metal into the element die sections and through the orifices to form plate straps that mechanically and electrically connect the plate lugs.

It is a further object of the present invention to provide a method for interconnecting the plate lugs in the elements of a battery, the method comprising to invert the battery box including the plates therein and insert the plate lugs into corresponding element die sections and to introduce melting lead into the die section to connect the lugs and to pass through corresponding orifices in partitions of the battery to interconnect the lugs of adjacent elements. An apparatus and the obtained battery is also provided.

It is a further object of the present invention to provide an apparatus for making a battery comprising a battery box or container and a battery cover fixed to the box, the box including a plurality of partitions defining separate elements receiving said battery plates, the partitions including alternate orifices to communicate each adjacent pair of elements and the battery plates comprises positive battery plates and negative battery plates with each battery plate having a plate lug and with the plate lugs of the positive battery plates being aligned at one

side of the battery box and the plate lugs of the negative battery plates being aligned at another side of the battery box, the apparatus comprising at least one mould for die-casting a melting metal, the mould having a number of element die sections separated by gaps and each gap is designed for receiving one of said partitions of the battery box and for accommodating one orifice of the partition to fluidly communicate two adjacent element die sections, wherein the mould comprises a mould body having a lower portion with at least one inlet for the melting metal and an upper portion having said element die sections, with the inlets for the melting metal being connected to inner conduits in the mould body for conducing the melting metal into the element die sections.

It is a further object of the present invention to provide a battery comprising a battery box or container and a battery cover fixed to the box, the box including a plurality of partitions defining separate elements receiving said battery plates, the partitions including orifices to communicate each adjacent pair of elements and the battery plates comprises positive battery plates and negative battery plates with each battery plate having a plate lug and with the plate lugs of the positive battery plates being aligned at one side of the battery box and the plate lugs of the negative battery plates being aligned at another side of the battery box, wherein the plate lugs are

interconnected by plate straps obtained by die-casting a melting metal around the plate lugs, with the plate lugs of an element being interconnected with the plate lugs of an adjacent element through one of said orifices in the battery partition.

The above and other objects, features and advantages of this invention will be better understood when taken in connection with the accompanying drawings and description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example in the following drawings wherein:

Figure 1 shows a top perspective view of a battery box or container with some battery plates being inserted into the cells or elements and some elements being empty, with the battery cover not shown for clarity purposes, all according to a preferred embodiment of the present invention;

Figure 2 shows a top perspective view of the battery of Figure 1 with the plate straps, according to the invention, already formed into the battery container;

Figure 3 shows a cross section view along cutting line III-III of Figure 2;

Figure 4 shows a cross section view along cutting line IV-IV of Figure 2;

Figure 5 shows a top perspective view of a mold according to a preferred embodiment of the invention to manufacture the plate straps of Figures 2, 3;

Figure 6 is a perspective view of a battery of Figure 1, with all the plates arranged therein and the box inverted to be placed into a couple of molds of Figure 5, according to the invention;

Figure 7 shows a cross section of the mold taken along line VII-VII of Figure 5;

Figure 8 shows a cross section of the mold taken along line VIII-VIII of Figure 5;

Figure 9 shows a cross section of the mold taken along line IX-IX of Figure 5, and

Figure 10 shows a cross section of the mold taken along line X-X of Figure 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now referring in detail to the invention, the same refers to a battery 1 comprising a battery box or container 2 and a plurality of battery partitions 3 defining separate cells or elements 4. A pack of battery plates 5 is arranged within each element 4, with a pack 5 being shown, in Figure 1, partially inserted in an end element, with another pack being entirely placed into another element and with other elements empty just for clarity purposes.

Each pack 5 is comprised of a plurality of battery plates, namely positive plates 6 and negative plates 7, arranged in a manner that they are interleaved but with the positive plates isolated from the negative plates. Each battery plate 6, 7 has a corresponding plate lug 8, 9, with plate lugs 8 of the positive battery plates being aligned at one side of the battery box and plate lugs 9 of the negative battery plates being aligned at another opposite side of the battery box as better shown in Figure 4. Partitions 3 include orifices 10 in alternating side positions, that is, when a partition has an orifice at one side of box 2, the adjacent partitions have their respective orifices 10 at the opposite side, as illustrated in Figure 1. Each orifice communicates one element with the adjacent one. The battery assembly, as shown in Figure 2, to which reference will be made below in connection to the particular aspects of the invention, is to be closed by a battery cover, not shown, typically sealed by heat welding for example, onto box 2.

According to the invention, the lugs are firmly interconnected by straps 11 and the straps are interconnected in pairs through orifices 10 by means of interconnecting bridges 12. For illustrative purposes two adjacent straps interconnected by a bridge 12 are indicated by reference number 13 and two adjacent straps 11 not interconnected through partition 3 are indicated by

reference number 14 in Figure 2. Straps 11, 13 making a safe and reliable mechanical and electrical interconnection of the lugs are integral pieces of metal, obtained by die-casting, such as lead, through a corresponding orifice 10, as it is more clearly shown in Figure 3. The battery assembly also includes a negative terminal 15 and a positive terminal 16 forming integral part of plate straps 11. A cover, not shown, will be sealed onto box 2 as it is well known, with the cover having corresponding metal terminals to be connected to terminal 15 and 16.

The battery is manufactured, according to the invention, by a new method to which reference will be made below, in an apparatus, also according to one aspect of the invention, as illustrated in Figures 5 to 10. The apparatus comprises a die-casting station generally indicated by reference number 17 in Figure 6. Station 17 comprises at least one mould 18, preferably two moulds 18, more clearly shown in the perspective view of Figure 5 and the cross sections of Figures 7-10. A mould 18 is provided at each opposite side of the apparatus, and one mould is for receiving the positive plates of a cell and the other opposite mould is for receiving the negative plates of the same cell. In a mould the plates are arranged in a manner that the positive plates of an element are adjacent to the negative plates of an adjacent element or cell.

Mold 18 comprises a mould body having a lower portion 19 with at least one inlet 20 for introducing the melting metal and an upper portion 21 having the element die sections, one of them indicated by a bracket and numeral reference 22. Inlet 20 for the melting metal is connected to inner conduits 23 for conducting the melting metal into the element die sections.

Each element die section comprises a die sump 24 and a die channel 25 for receiving the plate lugs to be connected by the melting metal. Die channel 25 and die sump 24 are both separated by an overflow wall, preferably a ramp-like wall 26. Die sump 24 includes at least one inlet orifice 27. Orifices 27 are in fluid communication with conduits 23 for receiving the melting metal from the inner conduits 20 in the mould body. Thus, melting metal is received into die sump 24 in an amount that, when desired, it overflows the overflow wall 26 to be poured into die channel 25 when the plate lugs are placed into the die channel. The die sumps comprise two end die sumps each one including a terminal well 28. Since well 28 makes the end sump to need more melting metal flow, preferably two orifices 27, as shown in Figure 5, are provided in the end sumps designed with wells 28 for forming terminals 15, 16. Alternatively, end sumps may include only one orifice 27 as shown in Figure 8.

Element die sections 22 are separated by gaps 29 and each gap is designed for receiving one partition 3 as shown in Figure 7 in a manner that orifice 10 is accommodated in such a way that when the melting metal is poured into channel 25 it may flow through orifice 10 to interconnect adjacent element die sections 22 and elements 4 as shown in Figure 3.

While interconnection through orifices 10 may be made at any level of partition 3, at or above straps 11, 13, it is preferably that interconnections or bridges 12 are located above straps 11 in order to have a distance with the electrolyte in the battery in order to prevent any electrolyte from short circuiting the system by passing from one element to the adjacent one. For this purpose, some gaps include an interconnecting well 30 having a bottom deeper than the bottom of adjacent die channels 25. As shown, gaps including an interconnecting well 30 are alternated with gaps free of any interconnecting well. With two moulds in the apparatus, as shown in Figure 6, the gaps of one mould including an interconnecting well are offset respective the gaps of the other mould including the interconnecting wells.

As shown in Figure 7, each gap has a width designed to fittingly receive a battery partition 3 in a sealing manner to prevent the melting metal from leaking out of the element die sections. In addition, each gap has a depth

designed to receive a battery partition 3 in a manner that orifice 10 of the partition remains placed to fluidly connect adjacent element die sections, either at the same level of straps 11 or alternatively in a manner that the orifice of the partition remains placed in the interconnecting well 30 to fluidly connect adjacent element die sections. Body mould 18 may be made of any appropriate material, such as steel or any resin capable of resisting the temperatures employed in melting the metal, such as lead, at between 350°C - 450°C.

For having a control over the temperature all along the mold 18 and in some specific parts thereof, heating and cooling means may be provided. Heating means may comprise any typical resistance 31 or any other heat source such as vapour conduits and the like. These heating means, while illustrated only in the cross section of Figure 10, they may be arranged in any desired section according to the needs. In like manner, cooling means may comprise conduits 32 for circulating cooling water for example for cooling the lead into channel 25 to remove the battery once straps 11 are solidified.

According to a preferred aspect of the invention, the method for manufacturing the inventive battery comprises the steps of providing the battery box and inserting the battery plates into the elements of the battery box as it is shown in Figure 1. With all the plate

packs inserted into the box, the battery box is inverted as shown in Figure 6 and then it is lowered onto a couple of moulds 18 in die-casting station 17. In such a manner, the lugs 8 and 9 are arranged into respective die channels 25 of molds 18 and partitions 3 are inserted into gaps 29 as shown in Figure 7. Thus, orifices 10 remain into corresponding interconnecting wells 30 in a way that each element die section 22 is fluidly communicated in pairs through corresponding orifices 10.

With the plates and battery assembly arranged as disclosed above, a melting metal, preferably lead, is introduced through inlet 20, conduits 23 and orifices 27 in order to fill up sumps 24. Under control, the melting lead is over supplied in a manner that the lead overflows ramp wall 26 and pours into die channels 25. Thus, the melting metal flows around lugs 8, 9, into channel 25, enters into interconnecting wells 30 and flow through orifices 10, forming a continuous strap a shown in Figure 3, to mechanically and electrically connect the plate lugs.

Since, preferably, the positive battery plates are thicker than the negative battery plates, the melting metal introduced into the element die sections receiving the positive battery plates is at a first higher temperature of 420 °C and the melting metal introduced into the element die sections receiving the negative battery plates is at a

second lower temperature of 380°C. These selected temperatures may be controlled by the heating means 31.

While preferred embodiments of the present invention have been illustrated and described, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined in the appended claims.

WE CLAIM:

1. A method for interconnecting battery plates in a battery of the type having a battery box including a plurality of partitions defining separate elements receiving said battery plates, the partitions including orifices to communicate each adjacent pair of elements, the battery plates comprising positive battery plates and negative battery plates each battery plate having a plate lug with the plate lugs of the positive battery plates being aligned at one side of the battery box and the plate lugs of the negative battery plates being aligned at another side of the battery box, the method comprising the steps of:

a) inserting the battery plates into the elements of the battery box;

b) providing at least one mould for receiving said lugs, the mould having a number of element die sections separated by gaps and each gap is designed for receiving one of said partitions of the battery box and for accommodating one orifice of the partition to fluidly communicate two adjacent element die sections,

c) inverting the battery box and inserting the plate lugs into the element die sections of the mould and

simultaneously inserting the battery box partitions into the gaps of the mould whereby each orifice of the partitions are placed in fluid communications with two adjacent element die sections, and

d) introducing melting metal into the element die sections and through the orifices to form plate straps that mechanically and electrically connect the plate lugs.

2. The method of claim 1, wherein each gap defines an interconnecting well extending deeper than adjacent element die sections, with each gap being designed for receiving one of said partitions of the battery box and the step of inverting the battery box and inserting the plate lugs into the element die sections of the mould and simultaneously inserting the battery box partitions into the gaps of the mould includes to place each orifice of the battery partitions into a corresponding interconnecting well.

3. The method of claim 2, wherein the step of introducing melting metal into the element die sections includes pouring the melting metal also into the interconnecting wells to pass through the orifices of the battery partitions placed in the interconnecting wells.

4. The method of claim 1, wherein the melting metal is melting lead.

5. The method of claim 1, wherein the positive battery plates are thicker than the negative battery plates and wherein the melting metal introduced into the element die sections receiving the positive battery plates are at a first temperature and wherein the melting metal introduced into the element die sections receiving the negative battery plates are at a second temperature.

6. The method of claim 5, wherein the first temperature is higher than the second temperature.

7. The method of claim 6, wherein the first temperature is 420°C and the second temperature is 380°C.

8. An apparatus for making a battery according to the method of claim 1, the apparatus comprising said at least one mould for die-casting the melting metal in the element die sections separated by gaps to form the plate straps, wherein the mould comprises:

a mould body having a lower portion with at least one inlet for the melting metal and an upper portion having said element die sections, with the inlets for the melting metal being connected to inner conduits in the mould body

for conducing the melting metal into the element die sections.

9. The apparatus of claim 8, wherein each element die section comprises a die sump and a die channel for receiving the plate lugs to be connected by the melting metal, the die channel and the die sump being separated by an overflow wall.

10. The apparatus of claim 9, wherein the die sump includes at least one inlet orifice for receiving the melting metal from the inner conduits in the mould body, whereby the melting metal is received into the die sump and it overflows the overflow wall to be poured into the die channel when the plate lugs are placed into the die channel.

11. The apparatus of claim 10, wherein the die sumps comprise two end die sumps and each end die sump includes a terminal well.

12. The apparatus of claim 10, wherein some of the gaps includes an interconnecting well having a bottom deeper than the bottom of adjacent die channels.

13. The apparatus of claim 12, wherein gaps including an interconnecting well are alternated with gaps free of any interconnecting well.

14. The apparatus of claim 13, wherein two moulds are provided, one at each opposite side of the apparatus, and each mould is for receiving the positive plates and the negative plates respectively.

15. The apparatus of claim 14, wherein the gaps of one mould including an interconnecting well are offset respective the gaps of the other mould including the interconnecting wells.

16. The apparatus of claim 8, wherein each gap has a width designed to fittingly receive a battery partition in a sealing manner to prevent the melting metal from leaking out of the element die sections.

17. The apparatus of claim 8, wherein each gap has a depth designed to receive a battery partition in a manner that the orifice of the partition remains placed to fluidly connect adjacent element die sections.

18. The apparatus of claim 12, wherein each gap has a depth designed to receive a battery partition in a manner

that the orifice of the partition remains placed in the interconnecting well to fluidly connect adjacent element die sections.

19. A battery manufactured according to the method of claim 1, wherein the plate lugs are interconnected by plate straps obtained by die-casting a melting metal around the plate lugs, with the plate lugs of an element being interconnected with the plate lugs of an adjacent element through one orifice in the battery partition.

20. The battery of claim 19, further including a negative terminal and a positive terminal forming part of the plate straps.

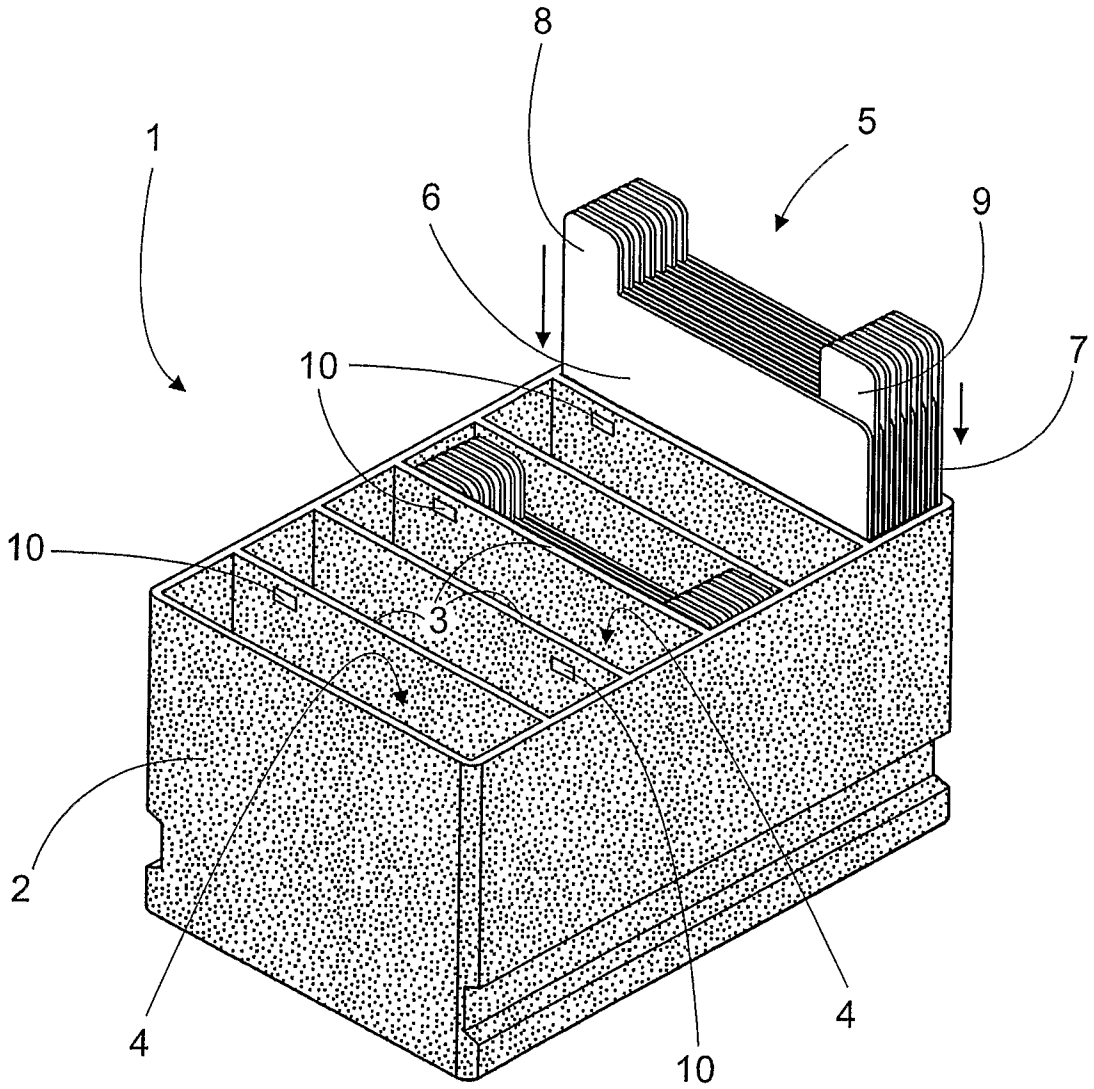

Fig. 1

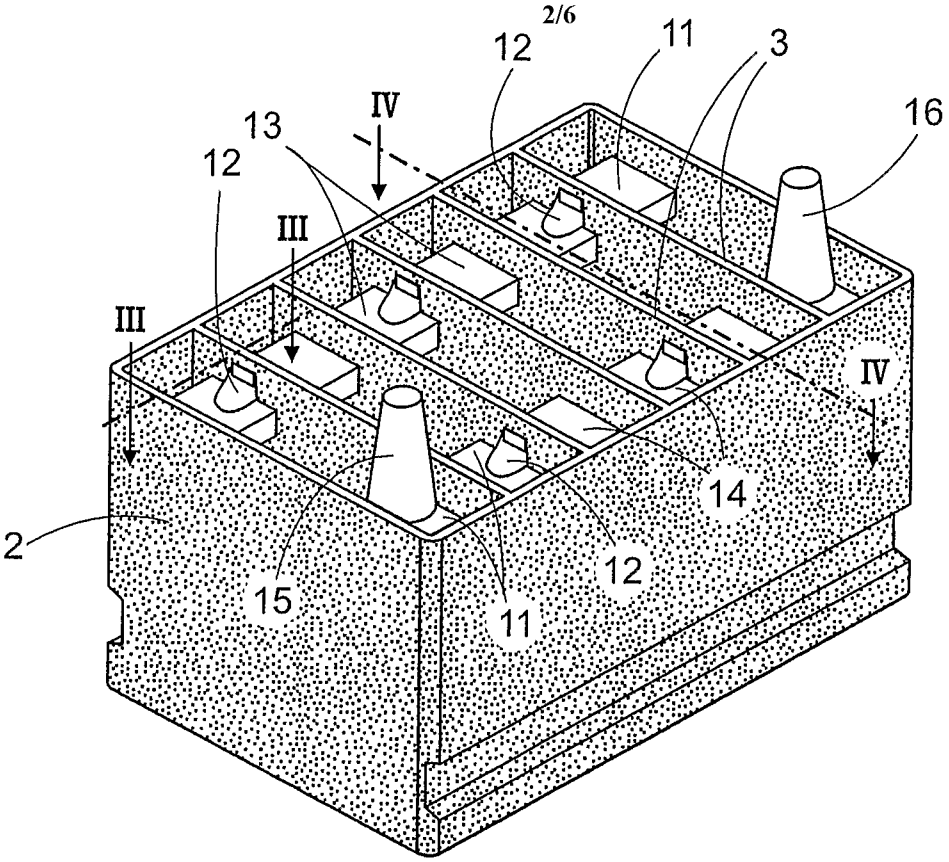

Fig. 2

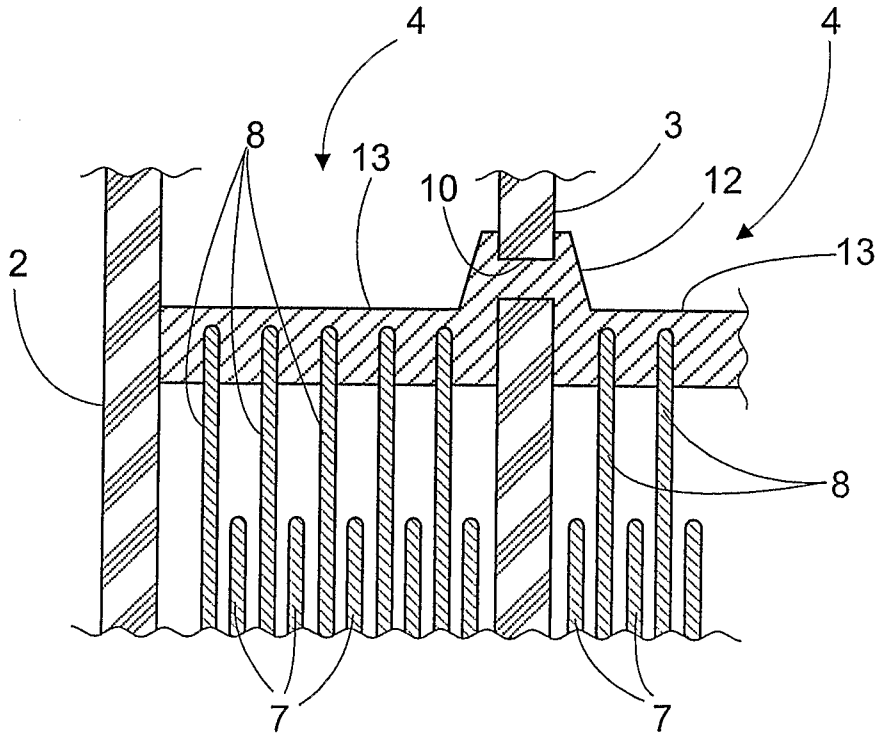

Fig. 3

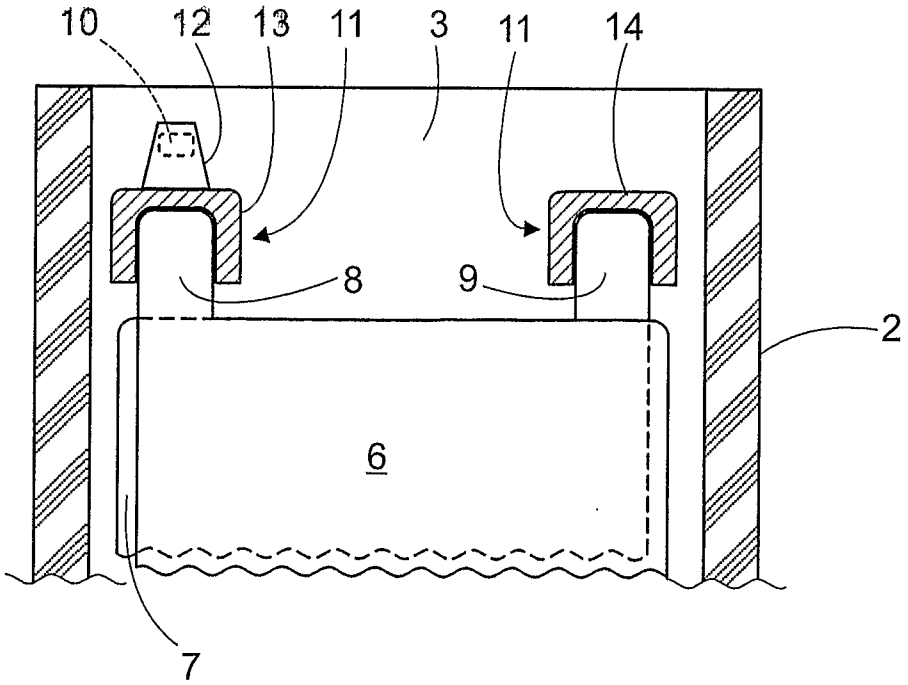
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Fig. 4

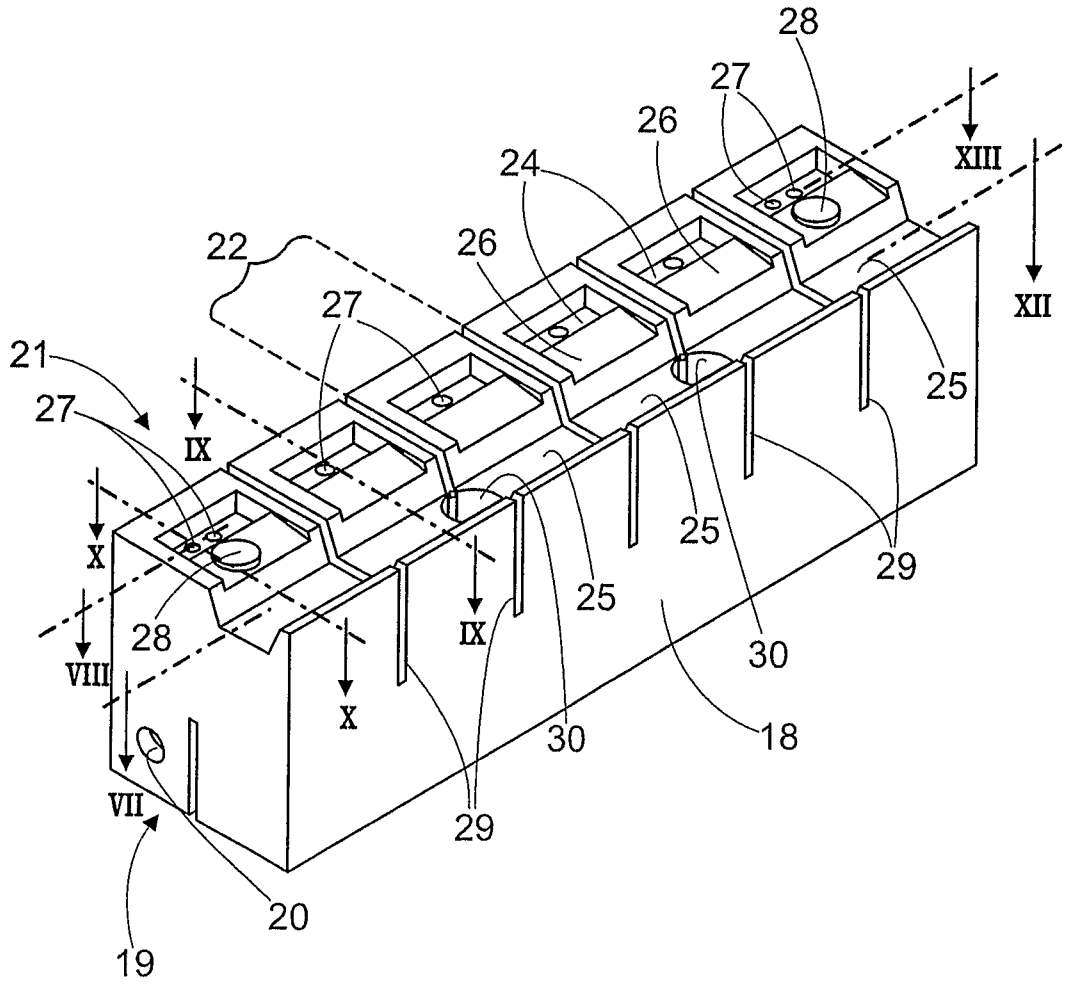
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Fig. 5

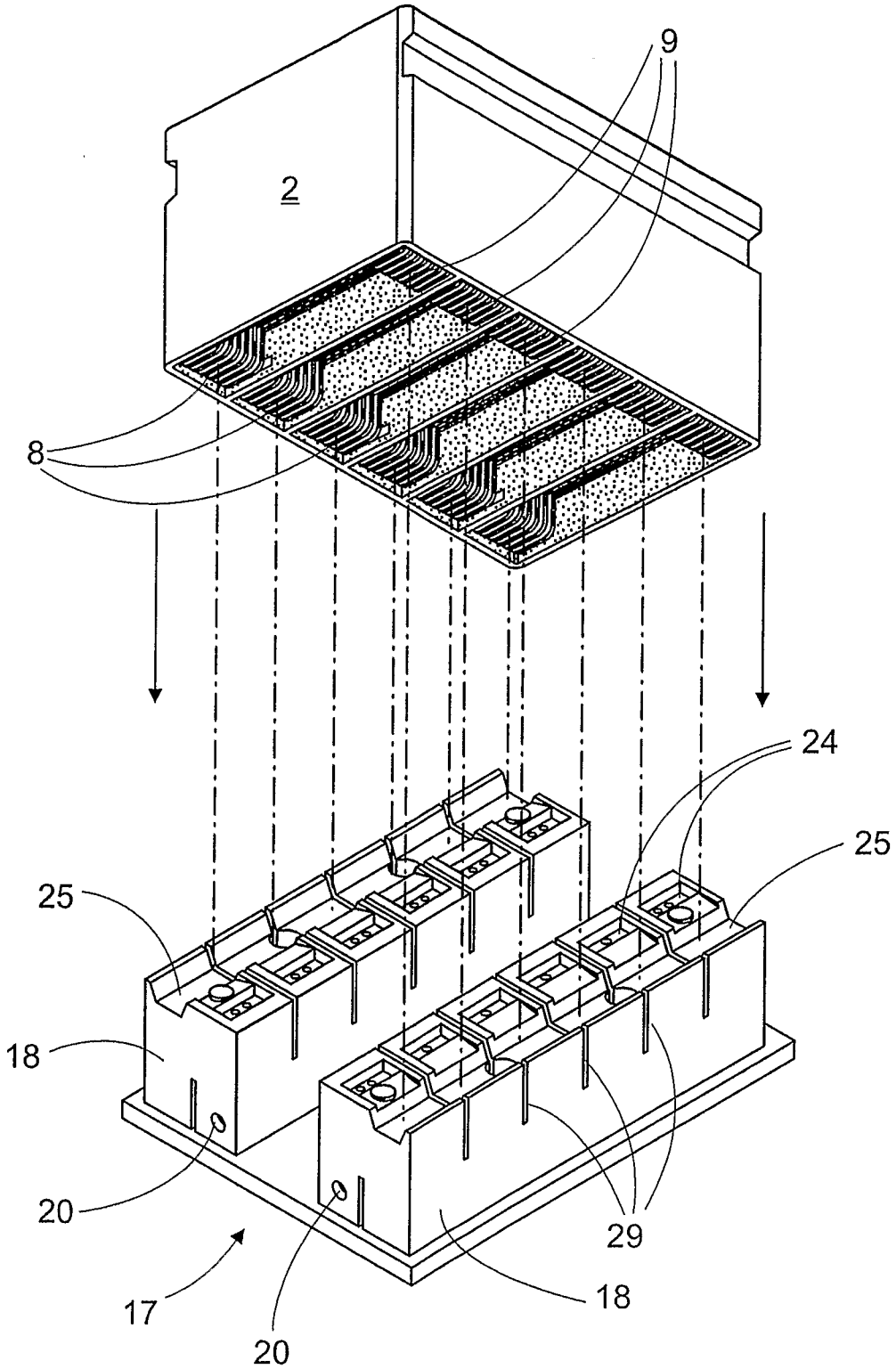

Fig. 6

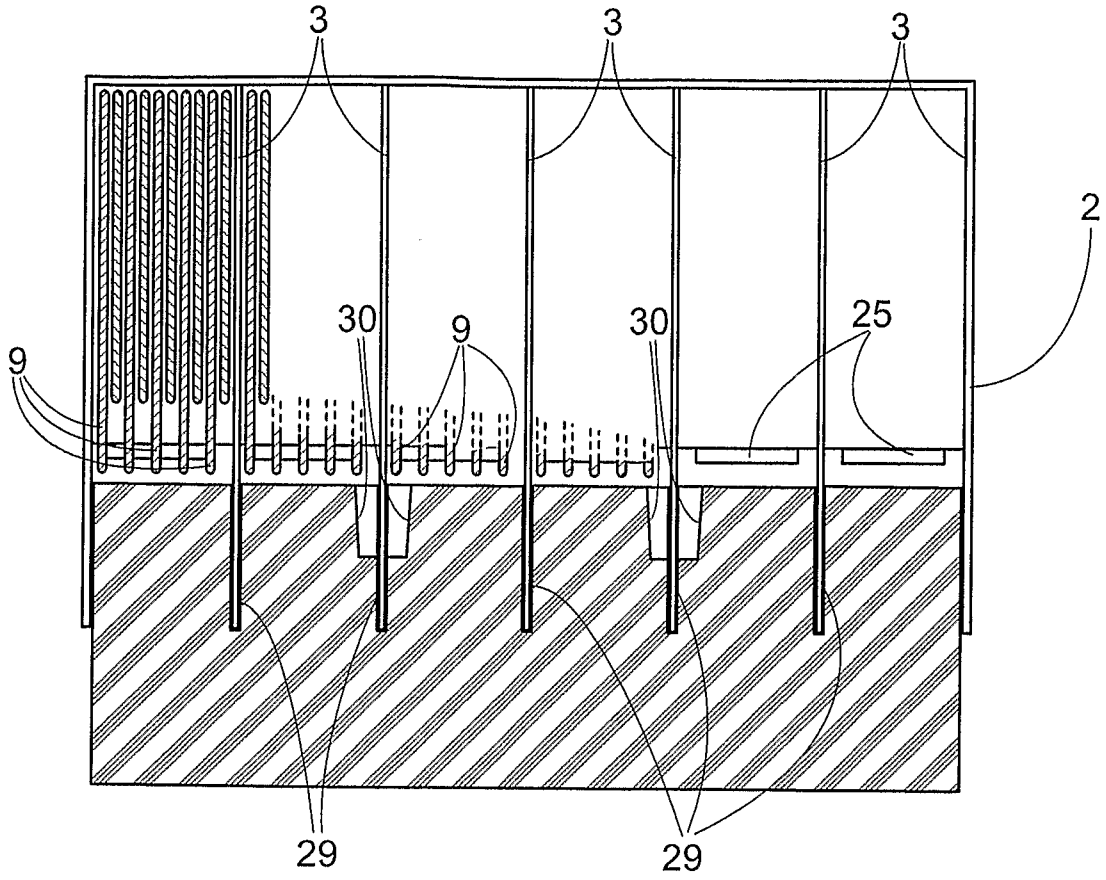

Fig. 7

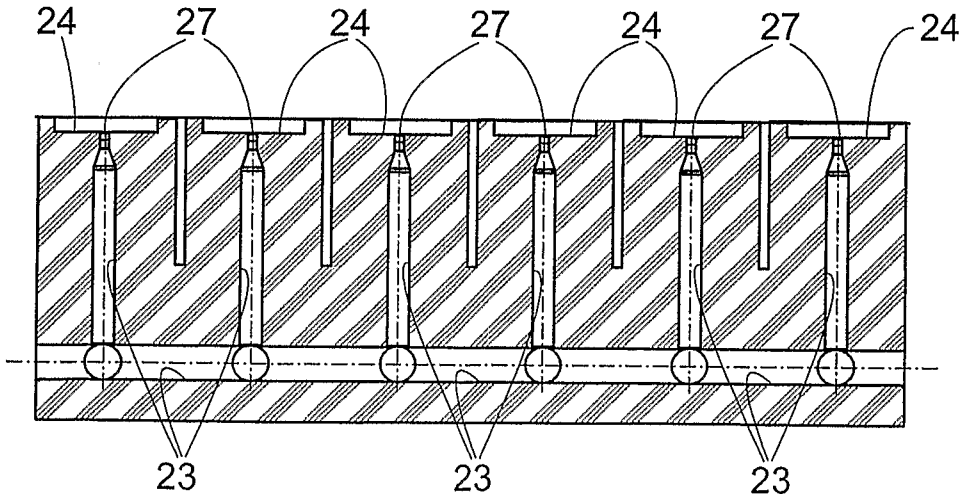

Fig. 8

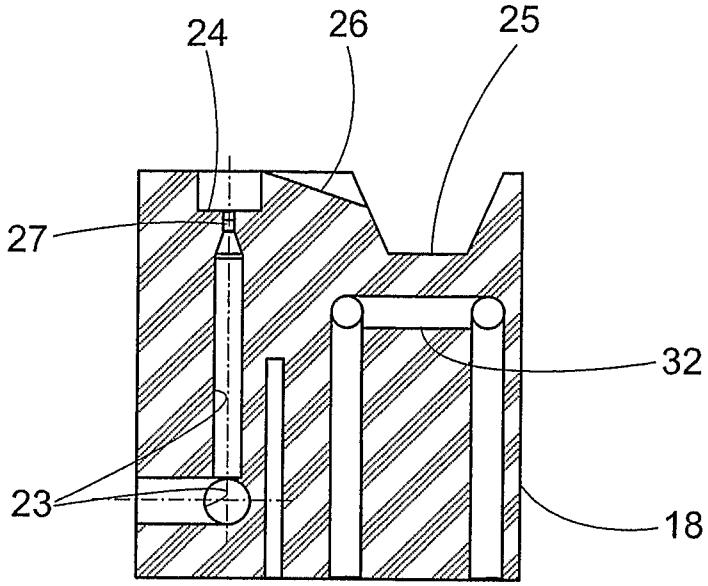

Fig. 9

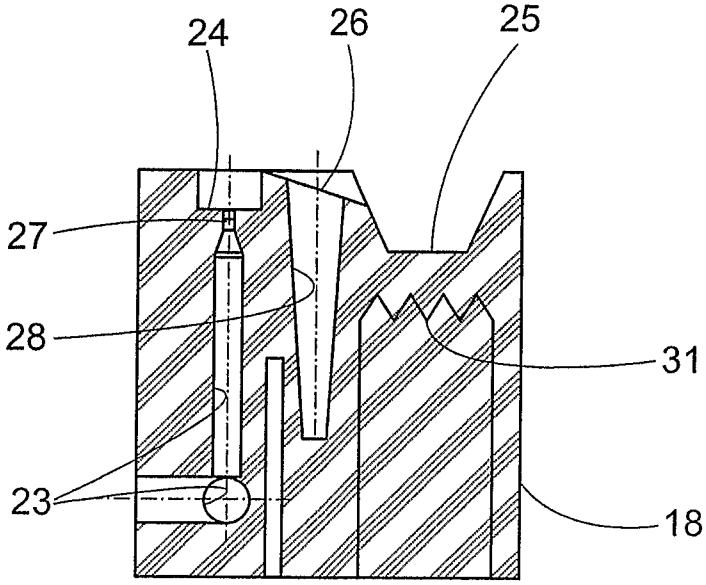

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2006/011261

A. CLASSIFICATION OF SUBJECT MATTER

H01M 2/10(2006.01)i, H01M 2/26(2006.01)i, H01M 2/02(2006.01)i

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)
IPC 8 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
KR.JP : classes as above

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO internal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 05836371 A, (GNB Technologies, Inc.), 17 November 1998 (17.11.1998) see the figure 4 and claims.	1 - 20
A	US 5756227 A, (Honda Giken Kogyo Kabushiki Kaisha), 26 May 1998 (26.05.1998) see the abstract, the figure 5 and the column 6.	1 - 20
A	US 05885731 A, (Enersafe Corp.), 23 March 1999 (23.03.1999) see the figure 1 and claims.	1 - 20

☐ 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 application or patent 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 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
28 DECEMBER 2006 (28.12.2006)	**28 DECEMBER 2006 (28.12.2006)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer JOUNG, Meyoung Ju Telephone No. 82-42-481-8493

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2006/011261

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 05836371 A	17.11.1998	US5836371A	17.11.1998
		US5972535A	26.10.1999
US 5756227 A	26.05.1998	JP08148187	07.06.1996
		JP3451142B2	29.09.2003
		JP8148187A2	07.06.1996
		US5756227A	26.05.1998
US 05885731 A	23.03.1999	EP01016147A1	05.07.2000
		EP01016147B1	22.11.2006
		EP01492174A2	29.12.2004
		EP01492175A2	29.12.2004
		EP1016147A1	05.07.2000
		EP1016147A4	19.03.2003
		EP1016147B1	22.11.2006
		EP1492174A2	29.12.2004
		EP1492174A3	10.08.2005
		EP1492174A2	29.12.2004
		EP1492175A2	29.12.2004
		EP1492175A3	10.08.2005
		US5885731A	23.03.1999
		WO9849736A1	05.11.1998