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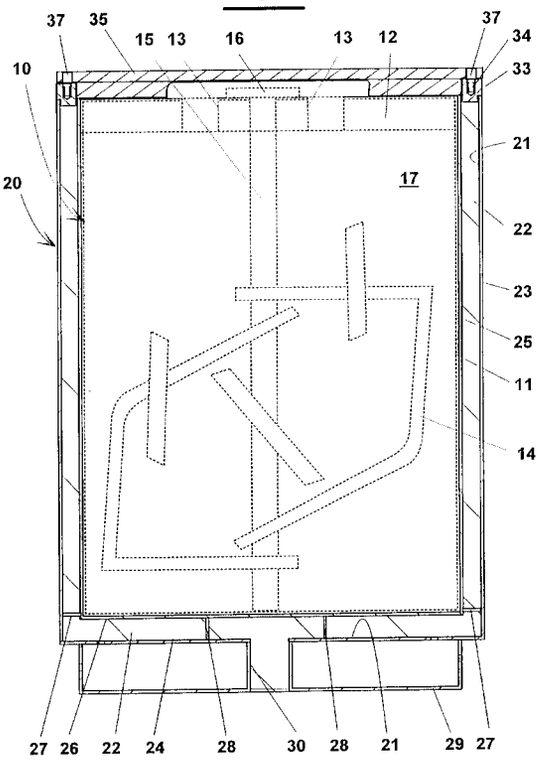
(54) Method for transporting, stacking and storing radioactive material, shielding shells for radioactive material and process for the production of this shell

(57) A method for transporting, stacking and storing radioactive material carried out by means of a metallic implemented container (10) disposed of in a shielding shell (20). The implemented container (10) forms a block (17) suitable for being put into the shell (20), which comprises a jacket (21) in which lead (22) and/or lead alloys suitable for being cast are cast. The jacket (21) can be formed by an outer cylindrical wall (23) closed by a bottom plate (24) and by an inner cylindrical wall (25) closed by a bottom plate (26). The disposal method allows transporting and containing special waste and in particular inertised radioactive material with the advantageous aspects of: lower size and lower weight versus amount of inertised radioactive material contained; shielding isotropy; high mechanical resistance and low damages in case of collision; maintenance of shielding capacity and homogeneity even after collision; possibility of recycling the shell after the radio decay of the inertised material; easy handling and stacking step.

Fig. 1



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Description

Field of the invention

[0001] The present invention relates to the disposal of radioactive waste and more precisely it relates to a method for transporting, stacking and storing radioactive material.

[0002] Furthermore, the invention relates to a shielding shell that carries out this method.

[0003] The invention relates also to a process for the production of this shell.

Background of the invention

[0004] The problem is felt of disposing of radioactive waste or other very dangerous waste deriving from industrial processes, nuclear power plants, etc.

[0005] One of the methods presently used is that of embedding the waste in a concrete matrix which, once solidified, forms a block. The block in turn is put into a shielding shell of plain concrete, preferably baritic plain concrete .

[0006] The concrete matrix has the function of neutralising the waste and preventing it from the diffusion both volatile or in solution. The shell has the object of creating an appropriate shielding barrier with respect to the gamma ray emitted by the radioactive waste, thus shielding both the operators and the environment.

[0007] Normally, the inert matrix and the waste are mixed directly in a metal container that is already located in the shell, equipped with a system of disposable blades that remain embedded in the block and are disposed of along with it.

[0008] The shell, sealed with a lid made of the same material, is then carried with the block in it contained and disposed of, in appropriate areas.

[0009] The shell made of plain baritic concrete, even if it has high shielding capacity with respect to other types of shielding means, has the following drawback:

- its thickness considerably increases the encumbrance of the block contained in it;
- owing to the anisotropic shielding capacity of the plain concrete, its thickness is oversized in order to assure a minimum constant shielding for all its surface;
- being the plain concrete a fragile material, the shell can break after collision, which can occur for an accident during the transporting, handling and stacking steps;
- in case of break of the shell after collision, the minimum shielding capacity from radioactivity is not assured in any case;
- to avoid the risk of collision as far as possible expensive additional safety devices are necessary during the filling step, the transportation, handling for stacking and disposal;
- after the radio decay, the shell of plain concrete cannot be recycled.

Summary of the invention

[0010] It is object of the present invention to provide a method for transporting, stacking and storing radioactive material that reduces the above drawbacks that affect the shielding shell made of plain concrete.

[0011] It is another object of the invention to provide a shielding shell suitable for containing special waste, and in particular inertised radioactive material, that with respect to the prior art shell of plain concrete, has one or several of the following advantageous aspects:

- decreased encumbrance and weight with respect to the same contained mass of inertised radioactive material ;
- isotropy of shielding;
- high mechanical resistance and low physical damages in case of collision, maintaining the shielding capability and homogeneity even after the collision;
- possibility of recycling the shell after the radio decay of the inertised material ;
- easy handling and stacking steps.

[0012] It is a further object of the present invention to provide a process for the production of this shell that is not industrially complex.

[0013] These and other objects are achieved by the present invention, one of whose characteristics is to provide a method for transporting, stacking and storing inertised radioactive material, wherein the inertised radioactive material is put into a shielding shell comprising a lead jacket of predetermined thickness.

[0014] The lead jacket has high shielding capacity and, in case of collision after fall of the shell, it is deformed plastically without break and substantially without varying its thickness, whereby both the isotropy and the shielding efficiency are assured.

[0015] According to another physical aspect of the invention, a shell for shielding and containing inertised radioactive material has the characteristic of having walls comprising at least a lead shield of predetermined thickness.

[0016] In a preferred embodiment the shield comprises:

- an outer cylindrical wall,
- an inner cylindrical wall co-axial to the outer cylindrical wall and distanced from each other for an amount equal to said predetermined thickness,
- an inner bottom plate and an outer bottom plate welded respectively to the outer cylindrical wall and inner cylindrical wall, the bottom plates being parallel and distanced to each other for an amount equal to said thickness;
- lead that fills an interspace formed between the cy-

lindrical walls and between the bottom walls.

[0017] Opposite to the bottom plates the shell has a ring that connects the outer and inner cylindrical walls and that has holes for fastening a lid.

[0018] The outer bottom plate is connected to a cylindrical enlargement having function of frame base, the cylindrical enlargement having an inlet hole for casting from the outside molten lead in the interspace.

[0019] Advantageously, the inertised radioactive material comprises a concrete matrix solidified in an implemented container, having mixing blades rotatable with respect to a top plate. The diameter of the implemented container is slightly less than the diameter of the inner cylindrical wall of the shell. The top plate has preferably a thickness substantially equal to said predetermined thickness.

[0020] According to a further physical aspect of the invention, a method for the production of a shell for shielding radioactive substances comprises the steps of:

- preliminarily arranging empty shielding shells having an interspace defined by an inner and outer wall, the interspace having at least an inlet hole;
- arranging the shell on a carriage;
- introducing the carriage in a preheating oven;
- arranging the shell with the inlet hole under a mouth for casting molten lead ;
- filling the interspace.

[0021] According to a preferred embodiment the interspace is formed between two co-axial cylindrical walls closed by distanced bottom plates according to a predetermined thickness of the lead, the inlet hole being executed at the bottom, whereby the interspace is filled overturning the shell and filling it through the bottom.

[0022] Advantageously during the filling step bleed of air is carried out through holes made in the interspace at the bottom.

Brief description of the drawings

[0023] Further characteristics and the advantages of the method for transporting, stacking and storing radioactive material, of the shielding shell that carries out this method and of the process for the production of this shell will be made clearer with the following description of an embodiment thereof, exemplifying but not limitative, with reference to the attached drawings, wherein:

- figure 1 shows a cross sectional view of a shell for inertised radioactive material embedded in a concrete matrix solidified in an implemented container;
- figures 2 and 3 show the shell of figure 1 respectively in top plan view and in an axial cross section in open position ;
- figure 4 shows an implemented container for neutralising radioactive material suitable for being contained in the shell of figures 2 and 3;
- figure 5 shows a crash test of the shell of figure 1 after fall from a predetermined height, starting from a position with vertical axis (A), with horizontal axis (C) and with inclined axis (B).
- figure 6 shows the shell of figure 3 overturned during a lead filling step;
- figure 7 shows a plurality of shells like those of figure 6 put on a carriage that holds them during the preheating, filling and cooling steps;
- figure 8 shows a diagrammatical view of a filling plant that carries out the preheating, filling and cooling steps of the shell of figure 7.

Description of a preferred embodiment

[0024] With reference to figures from 1 to 4, a method for transporting, stacking and storing radioactive material is carried out according to the invention by means of a metallic implemented container 10 put in a cylindrical shielding shell 20.

[0025] The implemented container 10, according to the known art, comprises a containing wall 11 closed by a lid 12 having openings 13 for the introduction of a concrete mixture in which radioactive waste is embedded.

[0026] In container 10 blades 14 are provided integral to a shaft 15 pivotally connected to lid 12 and are operated from the outside by means of a mechanical interface 16. The rotation of blades 14 allows a solidification of the concrete matrix this and the radioactive substances are uniformly dispersed in it.

[0027] Notwithstanding implemented container 10 is the system most frequently used for making inert radio waste, other known methods can be used to cast a block 17 of cylindrical shape suitable for being put into shell 20.

[0028] The latter, according to a preferred embodiment of the invention, comprises a jacket 21 in which lead 22 and/or a lead alloy is contained suitable for being cast.

[0029] Preferably, jacket 21 is formed by an outer cylindrical wall 23 closed by an outer bottom plate 24 and by an inner cylindrical wall 25 closed by an inner bottom plate 26. Spacers 27 and 28 are provided, for example distanced 120 degrees from one another, maintaining a substantially uniform thickness in lead 22.

[0030] To outer bottom plate 24 a cylindrical enlargement 29 is welded having a central connection hole 30 between the outside and jacket 21.

[0031] In order to make easier the exit of air when casting lead 22 into jacket 21, described hereinafter, small bleed holes 31 and 32 are provided respectively in bottom plate 24 and in cylindrical hollow enlargement 29.

[0032] Jacket 21 formed between the two inner cylindrical wall 25 and outer cylindrical wall 23 is closed at the top by a ring 33 having holes 34 for fastening screws

not shown of a lid 35 for closing inner space 36, that is defined by inner cylindrical wall 25 and in which the block formed by implemented container 10 is housed.

[0033] Lid 35 has a flange 35a with holes 37 and notches 38 for fixing ring 33 by means of the screws.

[0034] Lid 35 can have also a lead plate for completing the shielding provided by the lead of shell 20.

[0035] Alternatively, as shown in figure 3, lid 35 is made of steel and the shielding is completed by lid 12 of implemented container 10 shown also in figure 4.

[0036] Collision tests have been done leaving shell 20 fall from the above, implemented container 10 already loaded of neutralising concrete matrix 17 being in the shell.

[0037] In concrete matrix 17 a test radio material has been dispersed. As shown in figure 5, shell 20 fell from a height H of 1.20 m, starting from a vertical axis position (A), a horizontal axis position (C) and an inclined axis position(B).

[0038] The experiments confirmed that further to free fall the shielding capacity is not remarkably decreased.

[0039] In use, shell 20 and the implemented container 10 can be produced for example in carpentry working shops. Shell 20, moreover, can be filled with lead along an appropriate plant described hereinafter. The casting step of radioactive material into implemented container 10 and the introduction in shell 20 of the solidified blocks thus obtained is, instead, carried out directly from specialised operators for processing radioactive waste in the plants that have generated them, in order to avoid any pollution risk.

[0040] For the production of shell 20 and for its filling with lead a preliminary step is provided of welding bottom walls 24 and 26 the cylindrical walls 23 and 25, along with spacers 27 and 28, ring 33 and cylindrical enlargement of base 29.

[0041] With reference to figure 6, shell 20 is then overturned so that hole 30 is oriented towards the above. Then, molten lead 22a is cast through hole 30 in order to fill completely jacket 21.

[0042] In this step, the small holes 31 and 32 allow the bleed of air during the rise of the level 22b of the molten lead. At the end of the casting step, a cooling period is provided for lead 22 shrinkage, then the lead level is topped up to compensate .

[0043] These steps, as shown in figure 7, can be advantageously carried out arranging a plurality of overturned shells 20 on a carriage 40.

[0044] As shown in figure 8, carriage 40 is located in a region of inlet/outlet of empty/filled shells. A carriage 40 with the empty shells runs on a track 41 for being put into a shell heating tunnel 42 up to a temperature close to that of molten lead .

[0045] Then, in turn, shells 20 are carried under a lead sprue hole 43. Lead has been molten in an oven 44 supplied with ingots 45 by means of a conveyor belt 46. Sprue hole 43 carries out the filling step as shown in figure 6. Shells 20, after a cooling period, are carried again by carriage 40 in turn under sprue hole 43 for topping up so that the room left by shrinkage of lead during the cooling step is filled.

[0046] The foregoing description of a specific embodiment will so fully reveal the invention according to the conceptual point of view, so that others, by applying current knowledge, will be able to modify and/or adapt for various applications such an embodiment without further research and without parting from the invention, and it is therefore to be understood that such adaptations and modifications will have to be considered as equivalent to the specific embodiment. The means and the materials to realise the different functions described herein could have a different nature without, for this reason, departing from the field of the invention. It is to be understood and the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Claims

1. A method for transporting, stacking and storing inertised radioactive material, **characterised in that** a block (10) of said inertised radioactive material is put into a shell (20) comprising a jacket (21) of predetermined thickness filled by lead (22), said shell (20) having a inner space (17) for housing said block (10) .

2. Method according to claim 1, wherein said jacket (21) extends along the side wall and the base wall of said shell (20), a lid (35) being provided for closing said space, said lid (35) comprising a lead coating (22) whose width is equal to said thickness.

3. Method according to claim 1, wherein said jacket (21) extends along the side wall and the base wall of said shell (20), a lid (35) being provided for closing said space, said block being formed by an implemented container (10) wherein a concrete matrix is cast wherein said radioactive material is dispersed, said implemented container (10) being closed at the top by a lead lid (12) whose width is equal to said thickness a lid (12.

4. A shell for containing inertised radioactive material **characterised in that** it has walls (21) comprising at least a lead shield (22) of predetermined thickness, said walls defining the structure of said shell (20) and the lead (22) having shielding functions.

5. Shell according to claim 4, wherein said lead shield (22) is defined by a steel jacket (21).

6. Shell according to claim 5, wherein said jacket (21) is formed by:

- an outer cylindrical wall (23),
- an inner cylindrical wall (25) co-axial to said outer cylindrical wall and distanced from it for an amount equal to said thickness,
- an inner bottom plate (24) and an outer bottom plate (26) welded respectively to said outer cylindrical wall (23) and inner cylindrical wall (25), said bottom plates being parallel and distanced to each other for an amount equal to said thickness;
- a ring (33) opposite to said bottom plates (24, 26) that connects and stops said outer cylindrical wall (23) and inner cylindrical wall (25), said ring having fastening holes (34) for a lid (35).

7. Shell according to claim 6, wherein a cylindrical enlargement (29) is connected to said outer bottom plate (24) having function of base frame, said cylindrical enlargement (29) having an inlet hole (30) connecting said jacket (21) to the outside for casting molten lead (22) into said jacket (21).

8. A process for the production of a shell for shielding radioactive substances **characterised in that** it comprises the steps of:

- preliminarily arranging an empty shielding shell having a jacket (21) defined by an inner wall (23) and an outer wall (25), said jacket (21) having at least an inlet (30) accessible from the outside;
- arranging said shell (20) on a carriage (40);
- introducing said carriage in a preheating oven (42);
- arranging said shell (20) with said inlet (30) under a sprue hole (43) for pouring molten lead (22);
- filling said jacket (21) with lead;

9. Process according to claim 8, wherein said shell (20) has said jacket (21) defined by two cylindrical co-axial walls (23, 25) closed by distanced bottom plates (24, 26), said inlet (30) being a hole made at said bottom, whereby said jacket (21) is filled with lead through said bottom by previously overturning said shell (20).

10. Process according to claim 8, wherein during the filling step bleed of air is carried out through bleed holes made in said jacket (21) through said bottom (24).

Fig. 1

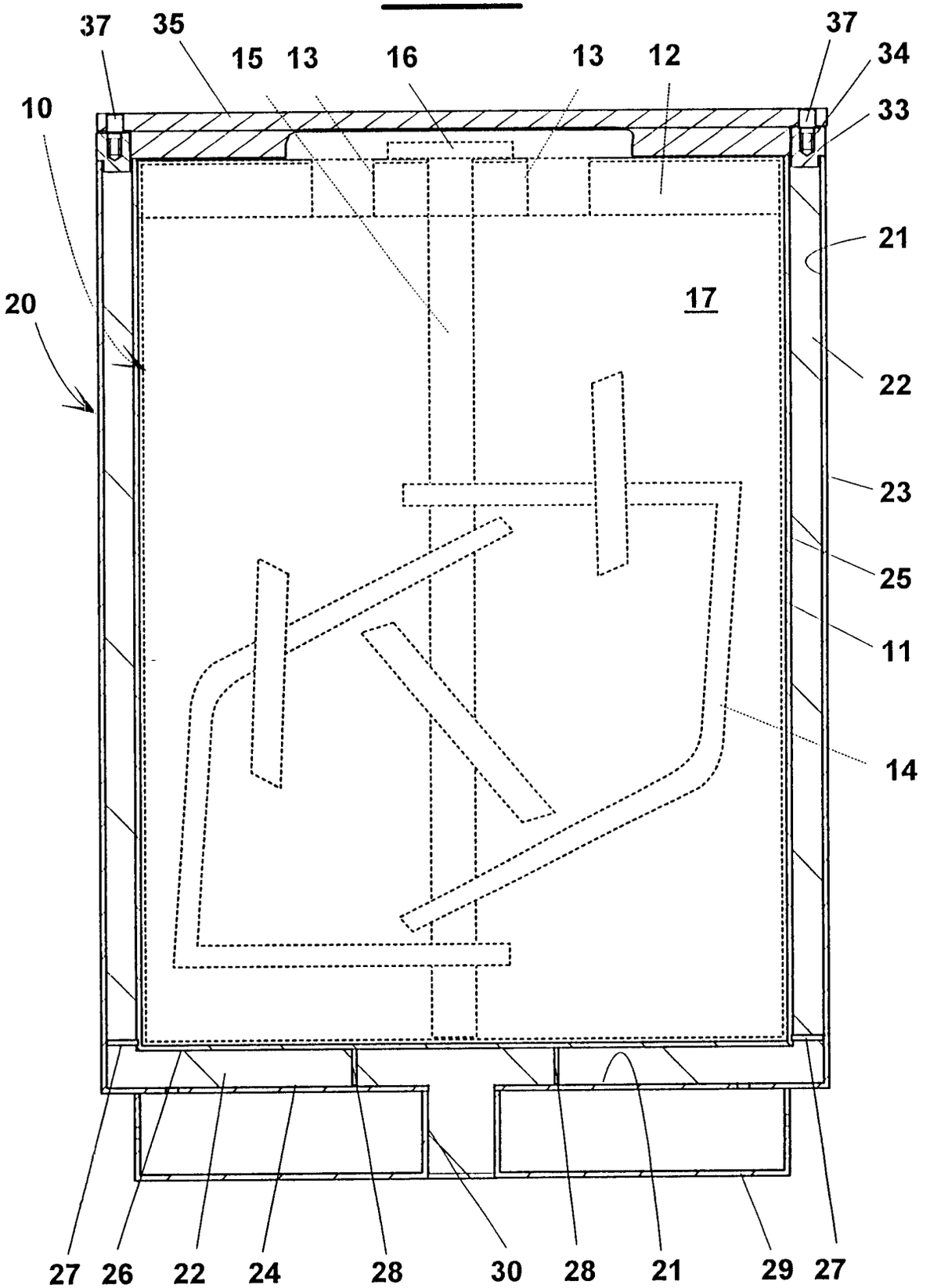
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Fig. 2

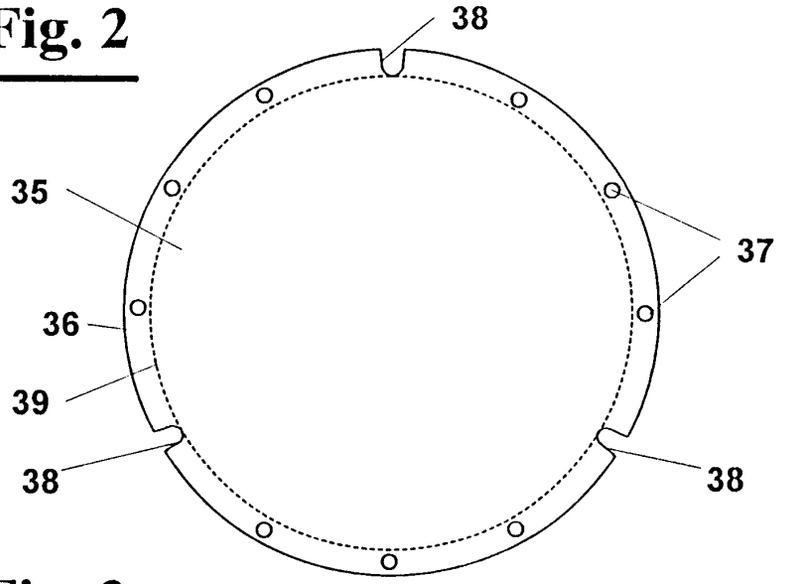
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Fig. 3

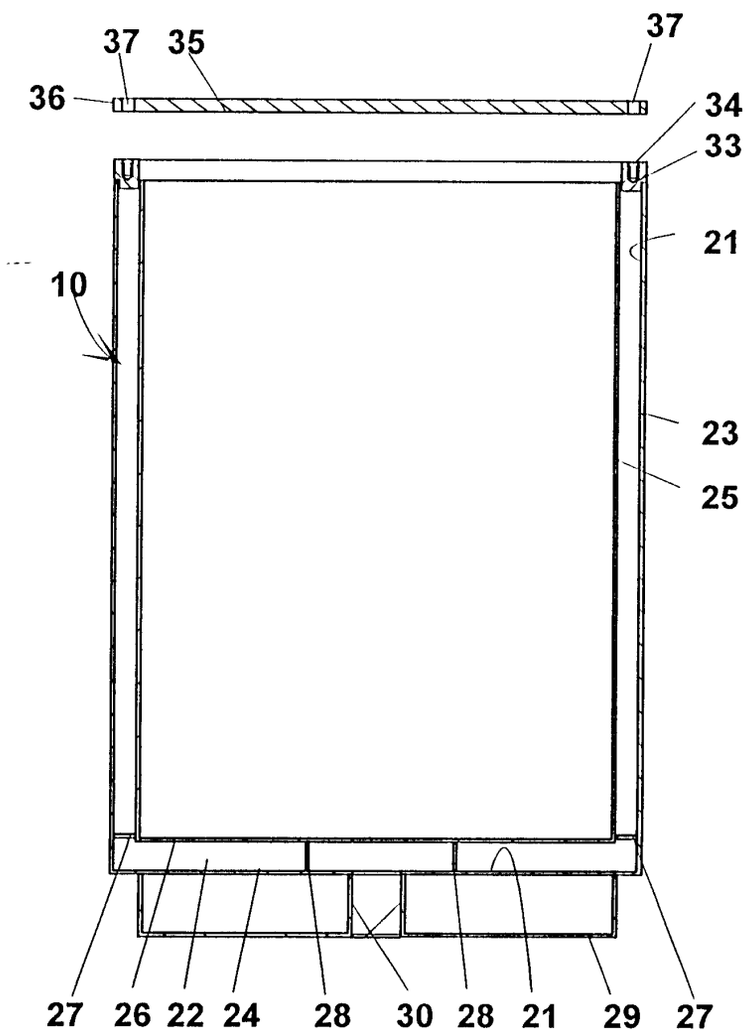
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Fig. 4

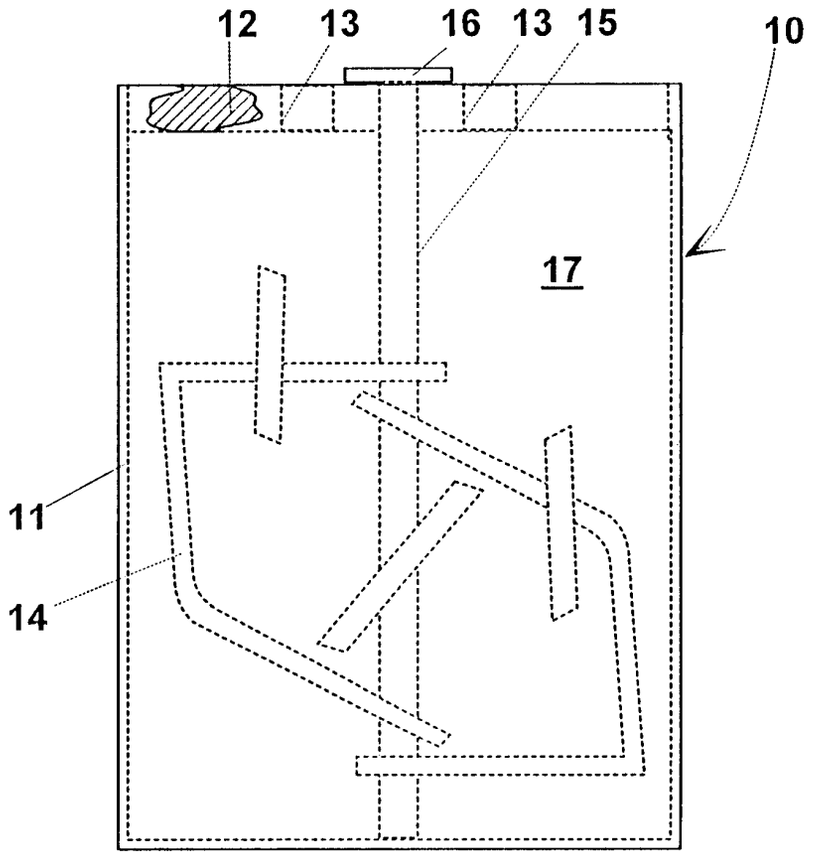


Fig. 5

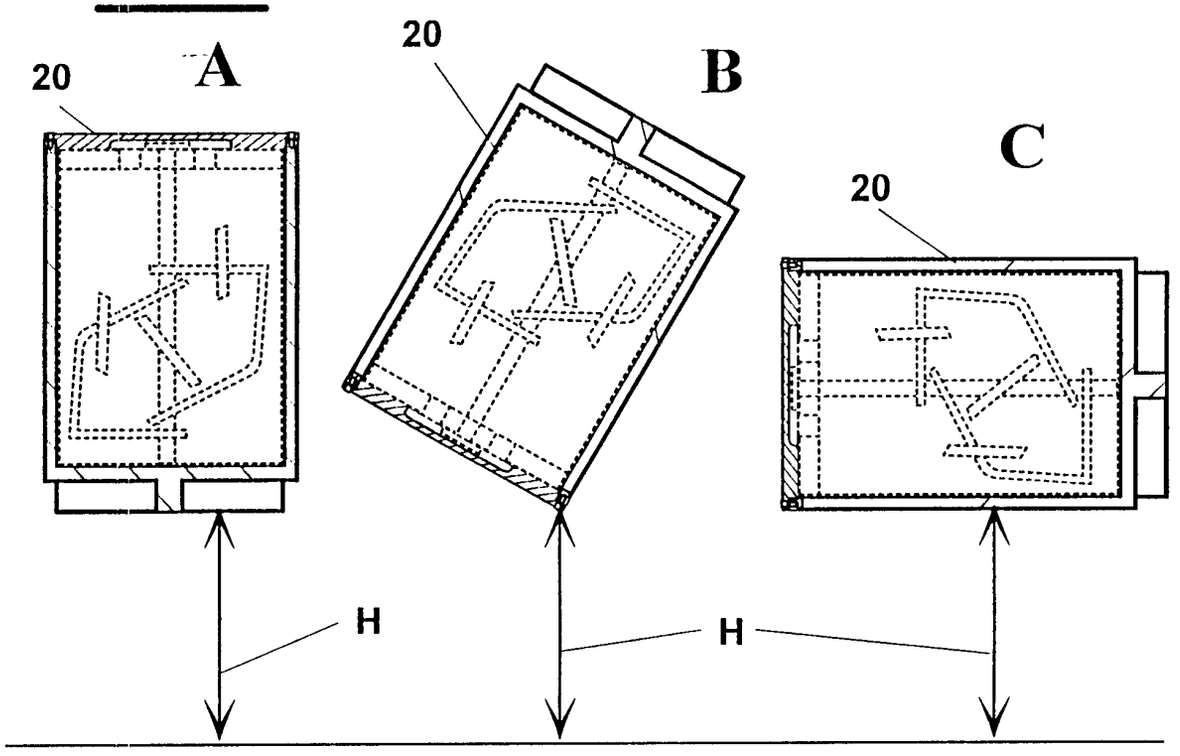


Fig. 6

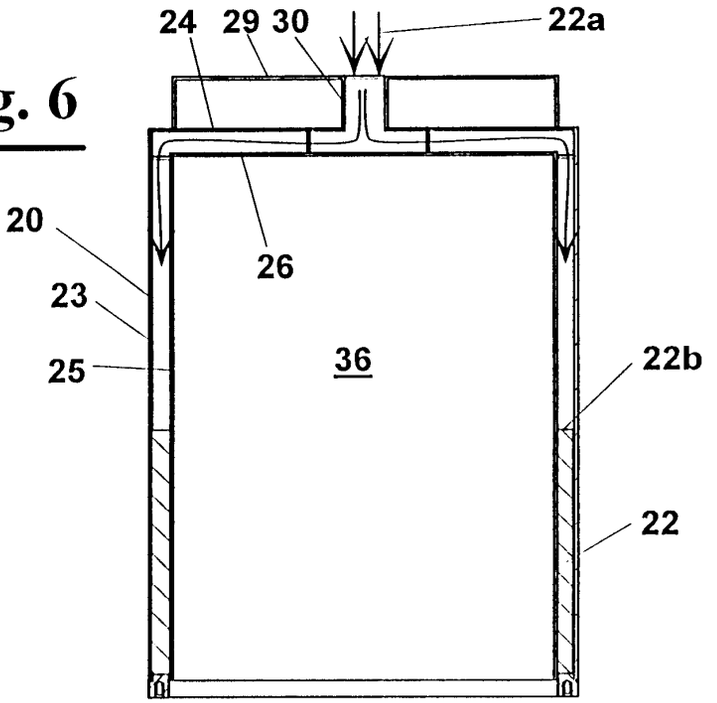


Fig. 7

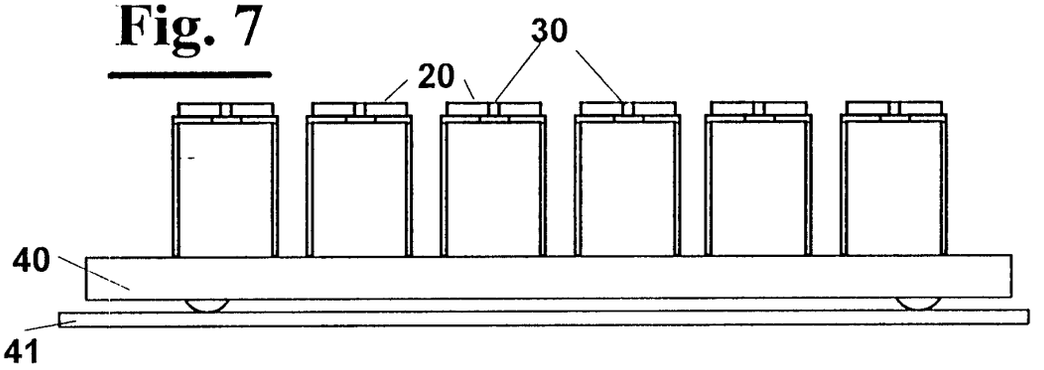
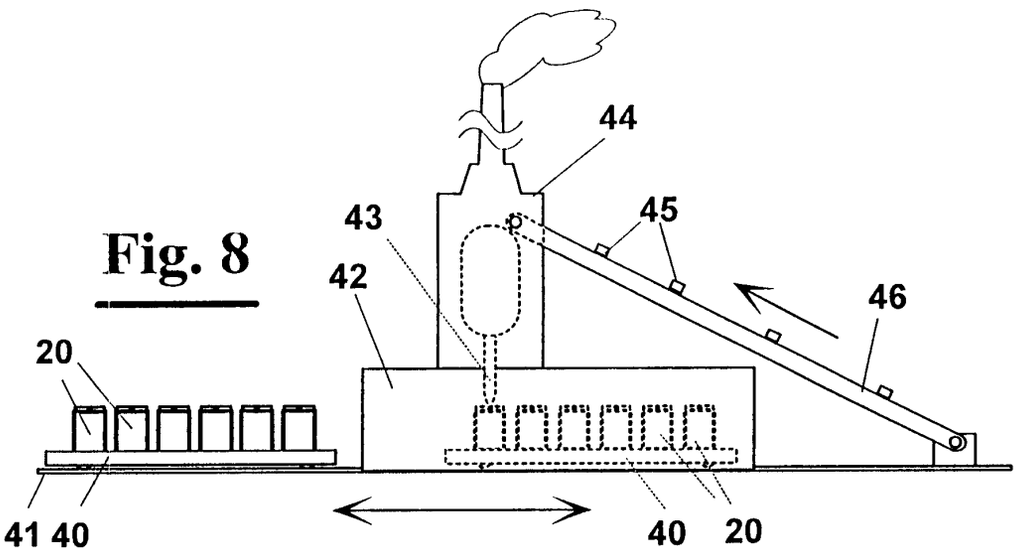


Fig. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 99 83 0739

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 May 2000	Brothier, J-A

CATEGORY OF CITED DOCUMENTS

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