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(54) Title: METHOD FOR SAFELY COMMINUTING LITHIUM-ION BATTERIES

(57) Abstract: The invention relates to a method for safely comminuting batteries, comprising the steps of: a) providing one or more batteries to be comminuted; and b) mechanically comminuting the batteries, wherein the comminuting process takes place in the presence of: i) at least one metal flame retardant suitable for preventing or suppressing combustion of the batteries; and ii) at least one binding agent suitable for binding acids and/or bases.

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Description

Title

Method for safely comminuting lithium-ion batteries

Prior art

Lithium-ion batteries and lithium-ion polymer batteries are currently disposed of at the end of their service life (also referred to as EOL for “end of life”) in accordance with known recycling processes, which makes it possible to recover valuable elements such as cobalt and nickel. A well-known example of a disposal and recycling concept for lithium-ion batteries is the melting process (VAL'ES™) by Umicore. In this process, lithium-ion or lithium-ion polymer cells, for example from cell phones or laptops, are disposed of on an industrial scale and melted down or incinerated as individual cells or assembled units at very high temperatures.
The known methods for recycling lithium-ion systems are currently designed for lithium-ion cells or modules that come from the consumer market. These are commercially established products, such as lithium-ion cells in hard cases or soft packs and lithium-ion stacked cells in soft packs. Soft packs or pouch cells are cell units that are packaged in an aluminum composite foil; the term lithium-ion polymer cells is used for them as well. The nominal capacities of the underlying single lithium-ion or lithium-ion polymer cells, which are currently recycled on an industrial scale with such methods, are typically between 0.1 Ah and 3 Ah.

The recycling processes described above cannot currently be used for lithium-ion batteries used in the automotive sector, because their volume, weight and nominal capacities are too large for the existing system concepts. The nominal capacities of individual lithium-ion cells for cars or trucks range from 3 to 300 Ah and typically from 4 to 80 Ah. Lithium-ion cells, modules or batteries with such high nominal capacities cannot be destroyed and recycled with the current large-scale recycling concepts.

Another shortcoming is the fact that lithium-ion batteries, especially lithium-ion batteries with a nominal capacity of at least 3 Ah, cannot be transported at all in an undefined state and therefore cannot easily be fed into a decentralized recycling system. In addition to the lost raw materials, which cannot be recovered in this case, there is also a major safety risk on

the premises of the cell manufacturer, the assembler or even on the tester's premises (especially after a so-called abuse test in a fully charged state, usually greater than or equal to 4.2 V). An example of the relevant battery tests is the so-called drop test, in which cells are dropped vertically a distance of approx. 1.5 m at an operating voltage of 4.25 V, or the so-called oven test according to UL (storage at 130°C; 4.2 V operating voltage for 10 minutes (UL 1642)). Even if the cells pass the test in accordance with the test specification, it has been found in practice that these tested cells can ignite spontaneously days or weeks later during the subsequent storage, for example on a factory or test site. This constitutes a very high potential risk.

The object of the present invention is to reduce or avoid one or more disadvantages of the prior art. In particular, it is the task of the invention to provide a method with which batteries can be safely prepared for disposal.

Disclosure of the invention

The task is solved by providing a method for the safe comminution of batteries, comprising the steps:
a) Providing one or more batteries to be comminuted; and
b) Mechanically comminuting the batteries provided, wherein the comminuting process takes place in the presence of:

i) at least one metal flame retardant suitable for preventing or suppressing combustion of the batteries; and of
ii) at least one binding agent suitable for binding acids and/or bases.

The method according to the invention makes it possible to safely destroy batteries, in particular higher-capacity lithium-ion batteries with a nominal capacity of typically more than 3 Ah per cell, and to bind and eliminate the released energy quantities as well as hazardous battery materials and process materials in a controlled manner and without any danger to humans and the environment.

Surprisingly, the method according to the invention makes it possible to comminute batteries, in particular lithium-ion batteries with nominal capacities of at least 3 Ah, in a safe and controlled manner. Subsequently, these components can be fed into an actual recycling process, e.g., the VAL'ES™ process by Umicore, since the materials are compatible with the current large-scale industrial recycling process after they have been treated in accordance with the method according to the invention. In a mechanical comminuting process for high-capacity cells, modules and batteries according to the invention, the battery material is mechanically comminuted in the presence of known flame retardants. Completely unexpectedly, the destruction of the battery is moderate even when fully charged. The presence of metal flame retardants makes it possible for fire spots to be covered locally and not to further drive other cells of the overall battery or surrounding batteries into a “thermal runaway.” The binding agent binds acid and/or base components that have been formed, in the case of lithium-ion batteries in particular hydrofluoric acid (HF), preferably calcium fluorite (CaF_2). In the case of lithium-ion batteries, hydrofluoric acid, which has highly toxic and corrosive properties, is produced by the hydrolysis or thermal decomposition of the conductive salt lithium hexa-fluorophosphate ($LiPF_6$). The materials comminuted and treated in this way can be placed in a water bath, which is slightly basic due to the presence of binding agents such as potassium hydroxide ($Ca(OH)_2$), in order to bind any further hydrofluoric acid (HF) that may still be present, forming CaF_2. The aqueous medium also hydrolyzes residual lithiated graphite, forming lithium salts such as lithium hydroxide (LiOH). The hydrolyzed materials can be filtered out, air-dried and fed into a subsequent recycling process. Thus, a method is provided with which high-capacity lithium-ion batteries can be safely comminuted and made transportable on site, if necessary, and then fed to a suitable, remote, central recycling plant.

The first step is to provide one or more batteries that are to be safely comminuted. Both batteries of one type only and mixtures of batteries of different types, configurations and nominal capacities can be comminuted together. One, a plurality or all batteries can be in a fully charged, partially charged and/or an uncharged state. One, a plurality or all batteries can be intact, in a fully assembled state, partially assembled and/or in an undefined state. An undefined state includes, in particular, battery states after environmental tests, abuse and/or misuse tests, damaged batteries and also battery states that can occur in the event of accidents.

In principle, batteries of any type and configuration can be comminuted in the method according to the invention. The term “battery” is understood in this context to refer to electrochemical energy storage devices, in particular batteries or accumulators of all commonly used accumulator technologies. Batteries or accumulators of the type Pb - lead-acid battery, NiCd - nickel-cadmium battery, NiH2 - nickel-hydrogen battery, NiMH - nickel-metal hydride battery, Li-Ion - lithium-ion battery, LiPo - lithium-polymer battery, LiFe - lithium-metal battery, Li-Mn - lithium-manganese battery, LiFeP04 - Lithium iron phosphate battery, LiTi - lithium titanate battery, RAM - rechargeable alkaline manganese battery, Ni-Fe - nickel iron battery, Na/NiCl - sodium nickel chloride high temperature battery, SCiB - super charge ion battery, silver zinc battery, silicon battery, vanadium redox battery and/or zinc bromine battery can be used. In particular, batteries of the lead/acid, nickel-cadmium, nickel-metal hydride and/or sodium/sodium-nickel-iodide battery type can be used. Batteries of the lithium-ion type are particularly preferred. The term “battery” is used both for individual cells and for modules consisting of a plurality of cells, as well as for more complex architectures comprising a plurality of cells and/or modules.

High-capacity batteries with a nominal capacity of at least 3 Ah are preferred. Particularly preferred are batteries from 3 Ah to 300 Ah, especially from 4 Ah to 80 Ah. The nominal capacities of lithium-ion single cells for cars or trucks range from 3 to 300 Ah and typically from 4 to 80 Ah. The specified nominal capacity values can refer either to the entire intact battery or to a single cell of a battery.

Preferably, the batteries provided are partly or exclusively lithium-ion and/or lithium-ion polymer cells, modules and/or batteries with a nominal capacity of at least 3 Ah per cell.

In the method according to the invention, the batteries provided are subjected to a mechanical comminution. This can be a shredding process, for example. A shredder can be used for this purpose. A shredder is a mechanical device for comminuting a wide variety of materials; for the purposes of the invention, the shredder is designed such that it is capable of comminuting a plurality of batteries without any significant impairment. The principle of shredding is based on the operation of a grinding mechanism, which can be driven, for example, by appropriately dimensioned electric motors or combustion engines. The grinding mechanism can, for example, consist of a gearbox with offset rollers. When a battery is fed into the shredder, it is broken down into small components by

grinding, crushing, tearing or cutting. Shredders of various shapes, sizes and dimensions are known to a person skilled in the art, so that a person skilled in the art has no difficulty in selecting or adapting a suitable shredder for selected batteries.

In the method according to the invention, the batteries provided are subjected to a mechanical comminution. This can be done, for example, in a laser cutting process. For this purpose, a laser cutter of a known design as it is already used in many industrial applications for cutting metallic and/or non-metallic materials can be used. A laser cutter is a mechanical device for comminuting a wide variety of materials. For the purposes of the invention, the laser cutter is designed to be capable of comminuting a plurality of batteries without a significant impairment. Suitable laser cutting methods and arrangements are known to a person skilled in the art and can be used and/or adapted without difficulty for the method according to the invention.

In the method according to the invention, the batteries provided are subjected to a mechanical comminution. This can be a water cutting process, for example. A water cutting machine can be used for this purpose. A water jet cutting machine is a machine tool that uses a high-pressure water jet to cut materials. The high-pressure water jet cuts the material to be processed. This high-pressure water jet can have a pressure of 6,000 bar or more and reach exit speeds of approx. 1,000 m/s or more. Pure water cutting essentially utilizes the jet energy of the water. This allows for a cutting performance where the cutting gap can be very narrow and as small as 0.1 mm. Polymers can be added to concentrate the jet. To increase the cutting performance, a cutting agent, a so-called abrasive, can be added to the jet. By adding such an abrasive (e.g. garnet, aluminum oxide or corundum), it is possible to cut harder materials that cannot be cut with a pure water jet even more effectively, or where processing with pure water is not economical, or where a higher cutting quality is required. In order to be able to cut with an abrasive, the water jet system has a cutting head that substantially consists of three components: a pure water nozzle, an abrasive mixing chamber and an abrasive focusing nozzle or focusing tube. First, the pure water nozzle forms the highly compressed water into a jet of preferably around 0.25-0.4 mm (depending on the nozzle). This jet shoots through the mixing chamber at a high speed, e.g., up to 1,000 m/s, and thus creates a vacuum in the cutting head. The abrasive can now be sucked into the mixing chamber through a small opening in the cutting head and mixed with the water jet. The water-abrasive mixture is then focused and exists with a

predetermined diameter. The abrasive can also be dosed in a CNC-controlled manner and fed to the cutting head, either with air as a carrier or in an emulsion.

A major advantage of the mechanical comminution with a water cutting process is that the material to be cut does not heat up significantly. Cutting under water, for example by increasing the water level in the jet catcher and/or by surrounding the nozzle with a water bell, is possible as well.

The mechanical comminution according to the invention by means of a water cutting process makes it possible to cut all of the cell components in a complex lithium-ion system. For example, stainless steel with a thickness of 5 mm, which is often used as the outer casing of the assembled lithium-ion battery, can be cut in this way. Other examples are the cutting of other components, in particular the cell housing, which can consist of aluminum sheets with a thickness of 2 mm, for example. Furthermore, electrodes and metallic collector foils can be easily separated; the thickness of common aluminum and copper collector foils is usually between 8 and 20 ppm, preferably between 10 and 15 ppm.

The use of a water cutting process has further advantages. The temperature of the battery, especially the lithium-ion battery, is not significantly increased by a cutting process that uses a water jet. This is particularly advantageous when highly charged lithium-ion batteries are destroyed, since no further secondary energies occur that drive the battery or surrounding batteries into an uncontrolled thermal runaway (in lithium-ion batteries, this refers to processes such as localized internal short circuits, for example punctures caused by metal objects (e.g., scalpels), which heat up the affected areas to such an extent that they are affected). In practice, the separator is then destroyed and the short-circuit current and heating increase, the processes feed off of each other and the stored energy is suddenly released. This can also lead to a violent explosion. Another advantage is the fact that structural changes at the cut edges can largely be ruled out. This is very important when cutting through the composite of the positive electrode, the separator and the negative electrode in the lithium-ion cell; any cut can cause high internal short circuits and thus high short-circuit currents, which in turn can be critical for the battery and cause explosions, especially in the comminution phase. Water as a separating medium also has major advantages over

conventional metal-based separating components because it does not cause any internal short circuits in the lithium-ion battery. Metals in particular, which act on the lithium-ion batteries during the comminution, cause uncontrollable internal short circuits, which can lead to significant heat increases or even explosions. In addition, these metals may be exposed to highly caustic and corrosive acids, such as hydrofluoric acid (HF), during the comminuting process. If a thermal runaway should occur during the waterjet cutting anyway, in-situ cooling takes place using the surrounding water.

According to the invention, the comminuting process takes place in the presence of at least one metal flame retardant. The metal flame retardant is selected in such a way that it can prevent, suppress, reduce or extinguish combustion in the batteries to be comminuted. This can be achieved, for example, by the metal flame retardant influencing the amount of oxidizing agent available or by the energy generated, in particular thermal energy, being absorbed by the metal flame retardant before other batteries or battery components are involved in the combustion. The choice of the metal flame retardant can depend on the type and composition of the batteries to be comminuted. Preferably, the at least one metal flame retardant can comprise or consist of water, sodium chloride (NaCl) and/or quartz sand (SiO_2). If a water cutting process is used to mechanically comminute the batteries, the water of the water cutter can also be the metal flame retardant within the meaning of the invention. Water present in the comminution chamber can also serve as the at least one metal flame retardant according to the invention.

In the method according to the invention, the mechanical comminuting process additionally takes place in the presence of at least one binding agent suitable for binding acids and/or bases. Depending on the battery material to be processed, different acids and/or bases are released during the comminution or can be formed as a reaction product if previously cut components of the batteries now come into contact. The choice of binder(s) can therefore depend on which battery types are to be comminuted. Particularly when processing lithium-ion batteries, the binding agent can be basic and suitable for binding acids, especially hydrofluoric acid. Binding agents that are suitable for binding fluorine, so-called fluorine scavengers, can be used. Suitable binders or acid regulators are known to a person skilled in the art. Preferably, the at least one

binder may comprise or consist of calcium oxide (CaO), calcium chloride ($CaCl_2$) and/or potassium hydroxide ($Ca(OH)_2$).

More than one binder can also be used individually or as a mixture. The binder, the binders or the binder mixture can be used independently of one another in solid, liquid and/or gaseous form.

The quantity of the metal flame retardants and/or binders used in a mechanical comminuting process according to the invention depends not only on the choice of metal flame retardant and/or binder, but can also be determined by the volume and nature of the comminution chamber and by the quantity, weight, capacity, type and composition of the batteries to be comminuted. Thus, it may be necessary to first determine the required quantities and/or types of metal flame retardant and/or binding agent in a test run in connection with an intended operation of a specific device to carry out the method according to the invention, depending on the weight and capacity of the batteries to be comminuted. A person skilled in the art will not find this determination difficult, because the parameters and possibilities of influencing them are known and can be easily controlled by a person skilled in the art. The determination of the required of metal flame retardant and binding agent quantities is therefore within the range of routine experiments that a person skilled in the art can carry out independently without further instruction, based on their specialist knowledge.

Solid metal flame retardants and/or binders are preferably used as a fine-grained, at least predominantly solid material. Particularly preferred is material with a d_{50} value of no more than 5 µm, especially preferred with a d_{50} value of no more than 3 µm. If the metal flame retardant contains NaCl and/or quartz sand, the material is preferably used in a grain size with a d_{50} value of 2 µm +/- 0.5. If the binding agent contains calcium oxide and/or potassium hydroxide, the agent is used in a grain size with a d_{50} value of 1 µm +/- 0.25.

Liquid flame retardants can be used as well.

In order to avoid undesirable reactions, in particular oxidation, as much as possible, the comminuting process can be carried out in whole or in part under an atmosphere with an inert gas or an inert gas mixture which is less reactive, in particular with battery components. Preferably, the mechanical

comminuting process is carried out in whole or in part under an atmosphere with a proportion of an inert gas or an inert gas mixture of more than 30%, preferably more than 60%, particularly preferably more than 90%. Suitable inert gases or mixtures of inert gases are known to a person skilled in the art. Preferably, the inert gas atmosphere may contain or consist of nitrogen (N_2) and/or argon (Ar).

Parts of the reactions that take place during the process according to the invention are exothermic, which causes the temperature to increase during the mechanical comminuting process. It can therefore be useful to allow the mechanical comminuting process to run completely or partially in a cooled environment. This can be achieved, for example, by making the comminution chamber double-walled and providing a cooling medium between the two walls. Alternatively, or additionally, the chamber can contain a coolant for carrying out the comminuting process. This coolant can, for example, be added before and/or during the comminuting process. The gases in the atmosphere in which the comminuting process takes place can, for example, be present in a cooled state or be cooled in a continuous manner. However, it is also possible to pre-cool the batteries to be comminuted and then feed them into the process according to the invention only after they have reached a predetermined low temperature. Alternatively, the batteries to be comminuted can be mixed with cooling medium before, after and/or during the comminuting process. This requires that the cooling medium used is substantially inert with regard to the battery components and the device used to carry out the process. The cooling medium can consist of a single substance or compound or a mixture of different substances or compounds. Water, liquid nitrogen and/or dry ice can be used for said cooling, for example.

In order to create a particularly advantageous environment for the mechanical comminuting process, the comminuting process can be carried out entirely or partially under water. This has the advantage that the water can act both as a medium with a considerable heat capacity of its own (and thus as the at least one metal flame retardant within the meaning of the invention), as well as a heat conductor to a further cooling medium, and also as a solvent for the at least one binding agent and, if necessary, for further metal flame retardants. This facilitates the provision of controlled reaction conditions on as many surfaces of the batteries to be comminuted or the already completely or partially comminuted batteries as possible, since the metal flame retardant and the binder are dissolved in precisely defined concentrations and evenly distributed

in the comminution chamber. In the case of lithium-ion batteries, lithiated graphite is hydrolyzed in the aqueous environment. This produces lithium salts such as lithium hydroxide (LiOH).

The method according to the invention may comprise further steps which follow the mechanical comminuting process.

In a first further step, the comminuted materials are transferred to or collected in a water bath. This water bath contains a binding agent which can have the same properties as the binding agent used during the mechanical comminuting process. In one embodiment of the method, the same binder does not have to be used during the comminuting process and in the subsequent water bath. Different binders can be used in both steps. Preferred binders for the mechanical comminuting process have already been described above.

The water bath can be followed by a further additional process step. In this second additional step, the discharge of the mechanical comminuting process, which may have been hydrolyzed, is filtered out. The purpose of this step is to separate the insoluble components of the discharge of the comminuting process from the liquid components. If necessary, these fractions can then be fed individually to further recovery steps and/or a recycling process. Suitable filter solutions are known to a person skilled in the art. If necessary, the filtrate can then be dried. This drying step reduces the weight of the filtrate, for example, which is particularly advantageous if the filtrate has to be stored and/or transported over longer distances before it is sent for further recycling.

The present invention also relates to a method for recycling batteries, preferably lithium-ion batteries with a nominal capacity of at least 3 Ah. In this method, the batteries are first comminuted in accordance with a method according to the invention described above and then fed into a recycling process. A recycling process or a recycling method is understood to refer to a process or method in which at least one raw material contained in the comminuted batteries is isolated and fed to a further use. An example of such a recycling process is the VAL'ES™ process by Umicore, which is described in patent specification EP1 589 121 B1. A person skilled in the art is familiar with other alternative or additional recycling processes.

The present invention also relates to a device for carrying out a method according to the invention for the safe comminution of batteries. To this end, the device comprises means for carrying out the comminuting process according to the invention. The disclosed method according to the invention can be realized by means known to a person skilled in the art. If the mechanical comminution is carried out at least in part by a comminuting process, a shredder of a known design can serve as the basis. If the mechanical comminution is carried out at least in part by a laser cutting process, a laser cutter of a known design can be used as the basis. If the mechanical comminution is carried out at least in part by a water cutting process, a water cutter of a known design can serve as the basis. Means for feeding and discharging the metal flame retardant or the binding agent as well as suitable designs of the shredding chamber are either known or are within the range of routine activities of a person skilled in the art trained in process engineering or mechanical engineering.

To control the method according to the invention, the device can have a so-called CNC control (Computerized Numerical Control). It is possible to correlate the CNC control of the device according to the invention with a design CAD (Computer Aided Design) program of the respective lithium-ion system in order to achieve a particularly uncritical comminution and accordingly to start at uncritical positions in the pack. CNC controls are very precise and, particularly in series production, it is not necessary to use a lot of personnel on the system itself. This minimizes the risk to people and increases the acceptance of such systems for the very dangerous lithium-ion battery comminuting processes.

Claims

1. Method for safely comminuting batteries, comprising the steps of:
   a) providing one or more batteries to be comminuted; and
   b) mechanically comminuting the batteries, wherein the comminuting process takes place in the presence of:
      i) at least one metal flame retardant suitable for suppressing or reducing a combustion of the batteries; and
      ii) at least one binding agent suitable for binding acids and/or bases.

2. Method according to claim 1, characterized in that the batteries provided comprise partly or exclusively lithium-ion and/or lithium-ion polymer cells, modules and/or batteries with a nominal capacity of at least 3 Ah per cell.

3. Method according to any of the preceding claims, characterized in that the at least one metal flame retardant agent comprises or consists of water, sodium chloride and/or quartz sand.

4. Method according to any of the preceding claims, characterized in that the at least one binder comprises or consists of calcium oxide, calcium chloride and/or potassium hydroxide.

5. Method according to any of the preceding claims, characterized in that the comminuting process is carried out partly or completely under an atmosphere with a proportion of an inert gas or an inert gas mixture of more than 30%, preferably more than 60%, particularly preferably more than 90%.

6. Method according to claim 5, characterized in that the inert gas atmosphere comprises or consists of nitrogen and/or argon.

7. Method according to any of the preceding claims, characterized in that the comminuting process is carried out in a partially or completely cooled manner.

8. Method according to claim 7, characterized in that water, liquid nitrogen and/or dry ice is used for cooling purposes.

9. Method according to any of the preceding claims, characterized in that the comminuting process is carried out wholly or partly under water.

10. Method according to any of the preceding claims, comprising the additional step
c) collecting the comminuted materials in a water bath containing at least one binding agent suitable for binding acids and/or bases.

11. Method according to claim 10, comprising the additional steps of
d) filtering the output of the comminution process; and
e) drying the filtrate, if necessary.

12. Method according to any of the preceding claims, characterized in that a water cutting process, a laser cutting process and/or a shredding process is used in the mechanical comminution.

13. Method for recycling batteries, preferably lithium-ion and/or lithium-ion polymer cells, modules and/or batteries, comprising the steps of:
- comminuting the batteries according to any of the methods according to any of claims 1 to 12; and
- feeding the comminuted batteries into a recycling process.

14. Method comprising means for carrying out a method according to any of claims 1 to 12.

15. Device according to claim 14, characterized in that the device comprises means for carrying out a water cutting process, a laser cutting process and/or a shredding process.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/058716

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01M6/52 H01M10/54 A62D1/00 B02C19/00 B02C23/00
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ADD.

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)

H01M A62D B02C B09B C22B

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 303 872 A (MILEWITS MARVIN [US] ET AL) 19 April 1994 (1994-04-19)	1-3, 7-10,12, 14,15
A	column 2, line 15 - line 32 column 3, line 64 - column 4, line 13 column 5, lines 30-44 column 6, lines 40-44; claim 4	4-6,11, 13

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[X] Further documents are listed in the continuation of Box C.

[X] 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

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Date of the actual completion of the international search	Date of mailing of the international search report
17 August 2010	24/08/2010

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International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 041 659 A1 (MITSUBISHI HEAVY IND LTD [JP]) 4 October 2000 (2000-10-04) paragraph [0094] paragraph [0074] paragraph [0077] paragraph [0080] paragraph [0085] paragraph [0090] paragraph [0143] - paragraph [0149] paragraph [0119] - paragraph [0122] paragraph [0128]; figures 1-27 -----	1-15
X	EP 0 613 198 A1 (CANON KK [JP]) 31 August 1994 (1994-08-31) page 4, left-hand column, line 18 - page 5, left-hand column, line 17 page 7, left-hand column, lines 10-42; figures 1,2 -----	1-15
X	WO 02/23651 A1 (AVESTOR [CA]; CARDARELLI FRANCOIS [CA]; DUBE JONATHAN [CA]) 21 March 2002 (2002-03-21) page 8, line 21 - page 10, line 11 -----	1-15

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/058716

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5303872	A	19-04-1994	NONE			
EP 1041659	A1	04-10-2000	CA	2311792	A1	06-04-2000
			WO	0019557	A1	06-04-2000
			JP	3495707	B2	09-02-2004
			US	6524737	B1	25-02-2003
EP 0613198	A1	31-08-1994	DE	69420438	D1	14-10-1999
			DE	69420438	T2	13-04-2000
			JP	2721467	B2	04-03-1998
			JP	6251805	A	09-09-1994
			US	5491037	A	13-02-1996
WO 0223651	A1	21-03-2002	AU	9155501	A	26-03-2002
			CA	2319285	A1	13-03-2002
			EP	1269554	A1	02-01-2003
			JP	2004508694	T	18-03-2004
			US	2004028585	A1	12-02-2004

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2010/058716

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES

INV. H01M6/52 H01M10/54 A62D1/00 B02C19/00 B02C23/00
B09B3/00 C22B7/00
ADD.

Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
H01M A62D B02C B09B C22B

Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)

EPO-Internal

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	US 5 303 872 A (MILEWITS MARVIN [US] ET AL) 19. April 1994 (1994-04-19)	1-3, 7-10,12, 14,15
A	Spalte 2, Zeile 15 - Zeile 32 Spalte 3, Zeile 64 - Spalte 4, Zeile 13 Spalte 5, Zeilen 30-44 Spalte 6, Zeilen 40-44; Anspruch 4	4-6,11, 13

-/--

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen [X] Siehe Anhang Patentfamilie

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Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
17. August 2010	24/08/2010
Name und Postanschrift der Internationalen Recherchenbehörde Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bevollmächtigter Bediensteter Maxisch, Thomas

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2010/058716

C. (Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	EP 1 041 659 A1 (MITSUBISHI HEAVY IND LTD [JP]) 4. Oktober 2000 (2000-10-04) Absatz [0094] Absatz [0074] Absatz [0077] Absatz [0080] Absatz [0085] Absatz [0090] Absatz [0143] - Absatz [0149] Absatz [0119] - Absatz [0122] Absatz [0128]; Abbildungen 1-27 -----	1-15
X	EP 0 613 198 A1 (CANON KK [JP]) 31. August 1994 (1994-08-31) Seite 4, linke Spalte, Zeile 18 - Seite 5, linke Spalte, Zeile 17 Seite 7, linke Spalte, Zeilen 10-42; Abbildungen 1,2 -----	1-15
X	WO 02/23651 A1 (AVESTOR [CA]; CARDARELLI FRANCOIS [CA]; DUBE JONATHAN [CA]) 21. März 2002 (2002-03-21) Seite 8, Zeile 21 - Seite 10, Zeile 11 -----	1-15

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/EP2010/058716

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie			Datum der Veröffentlichung
US 5303872	A	19-04-1994	KEINE			
EP 1041659	A1	04-10-2000	CA	2311792	A1	06-04-2000
			WO	0019557	A1	06-04-2000
			JP	3495707	B2	09-02-2004
			US	6524737	B1	25-02-2003
EP 0613198	A1	31-08-1994	DE	69420438	D1	14-10-1999
			DE	69420438	T2	13-04-2000
			JP	2721467	B2	04-03-1998
			JP	6251805	A	09-09-1994
			US	5491037	A	13-02-1996
WO 0223651	A1	21-03-2002	AU	9155501	A	26-03-2002
			CA	2319285	A1	13-03-2002
			EP	1269554	A1	02-01-2003
			JP	2004508694	T	18-03-2004
			US	2004028585	A1	12-02-2004