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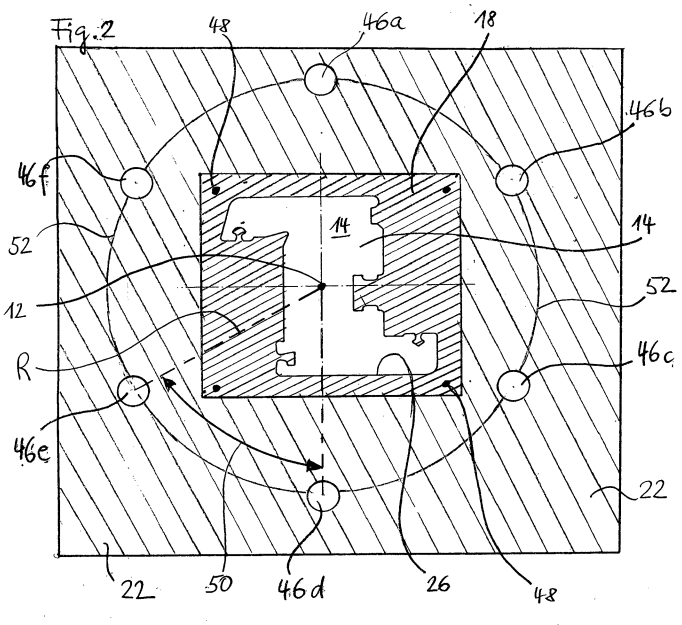
Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) APPARATUS FOR COATING A WORKPIECE ALL AROUND

(57) The invention concerns an apparatus for coating a workpiece all around, comprising a chamber (10), a pump for generating a pressure in the chamber (10) that is smaller than the pressure outside the chamber (10), an entrance opening (14) through which the workpiece (24) can be conveyed into the chamber (10), an exit opening (16), through which the workpiece (44) can be conveyed out of the chamber (10), and an application unit (20, 22, 24) for applying the coating onto the workpiece (44) comprising at least two plates (20, 22), which surround said entrance opening (14) and which form a hollow space (42) through which coating material flows to said entrance opening (14), wherein at least six nozzles (60) are provided through which said coating material is injected into said hollow space (42).



EP 3 141 364 A1

Description

[0001] The invention concerns an apparatus for coating a workpiece all around comprising a chamber, a pump for generating a pressure inside the chamber smaller than the pressure outside the chamber, an entrance opening (leading opening) through which the workpiece can be moved into the chamber, an exit opening (trailing opening) through which the workpiece can be moved out of the chamber, and an application unit for applying coating onto the workpiece, the application unit comprising at least two plates surrounding the entrance opening and defining in between the plates a hollow space through which the coating flows in direction of said entrance opening.

[0002] Such an apparatus is known from EP 2 628 549 A1.

[0003] German patent DE 43 37 438 C2 describes an apparatus for coating a workpiece with two separate nozzles at the entrance opening for applying a coating onto a workpiece.

[0004] The technology of the above-mentioned type is also called "passage-coating" (Durchlaufbeschichten).

[0005] The apparatus according to EP 2 628 549 A1 comprises four nozzles injecting the coating (e.g. varnish) into a hollow space formed between two plates at the entrance opening of a chamber.

[0006] The technical problem underlying the present invention is to improve the prior art apparatuses such that, in particular in connection with workpieces having a relatively complex profile, a coating is achieved that is very homogenous and continuous all around the workpiece, i.e. the coating is complete and has a uniform thickness.

[0007] A typical workpiece to be coated by an apparatus according to the present invention is an elongated element made of plastic, like a so-called "profile" of a window or a door. Such elements, e.g. beams ("profiles") of window sashs, typically have a cross-section with a relatively complicated contour comprising recesses, cavities, protrusions, undercuts etc. creating an obstacle against obtaining a continuous coating of uniform thickness all over the coated workpiece. Another typical example of a workpiece that can be coated by means of the apparatus according to the present invention is an elongated element made of wood or wood-like material.

[0008] A typical coating material applicable to a workpiece by means of an apparatus according to the present invention is a varnish or a liquid color. The apparatus according to the present invention is most useful in coating a workpiece with colors having no high concentration of a solvent, in particular without aqueous solvent. The viscosity of the coating material is preferably in a range of 25 to 200 mPa x s. In connection with a varnish preferably no solvent is used, in particular no water or other solvent is added. A varnish is preferably used at a temperature of 40 to 60°C and the apparatus is preferably kept on that temperature. A varnish providing good results when being applied onto a workpiece with an apparatus according to the present invention is called "High Solid" with 90 to 100% resin. Also UV-crosslinkable varnishes can be used.

[0009] According to a variant the apparatus according to the present invention comprises an application unit for applying the coating onto the workpiece with more than four nozzles for injecting the coating material into the above-defined hollow space. Such nozzles are arranged regularly around the above-mentioned entrance opening and it has been found surprisingly that by using at least six nozzles the uniformity (evenness) of the coating achieved on the workpiece is improved substantially, in particular with workpieces having a complex contour (profile). The achieved coating has a uniform thickness all over the workpiece and is continuous, i.e. without gaps or interruptions.

[0010] According to a variant of the present invention at least six nozzles are arranged around the entrance opening of the chamber at a radial distance with regard to the center line (direction) of conveyance of the workpiece.

[0011] The inventive apparatus comprises more than four, preferably six or more, nozzles adapted for injection of coating material into said hollow space wherein the nozzles are arranged at a curve (cam) surrounding said entrance opening of the chamber at a radial distance with an average pitch angle between the nozzles centers of 60° or smaller. The pitch angle is defined by the radii connecting a center of the entrance opening with a center of the respective nozzles.

[0012] With the present invention a homogenous varnish coating can be obtained with a thickness in the range of 5 to 50 μm.

[0013] According to another variant of the present invention the above-defined chamber in which the pressure is lower than outside the chamber is equipped with at least four vacuum ports for evacuating the chamber. Such vacuum ports are connected to one or more pumps. According to a variant of the invention, at least one vacuum port is provided on top of the chamber, at least one vacuum port is provided at the bottom of the chamber, and at least one vacuum port is provided at each side wall of the chamber. Providing at least four vacuum ports this way for evacuating the chamber through which the workpiece is conveyed results in better flow conditions of the coating material in the chamber and in the transitional area from said hollow space into the chamber to achieve a homogeneous and complete coating of the workpiece.

[0014] Below an embodiment of the invention is described in detail with reference to the figures:

Fig. 1 is a vertical cross-section of a chamber (10) of an apparatus according to the present invention;

Fig. 2 is a plan view of an outer plate (22) in direction of arrow 12 of Fig. 1; and

Fig. 3 shows the profile plate (18) with a workpiece (44) in detail.

[0015] A workpiece 44 (Fig. 3) is conveyed in direction of arrow 12 through the chamber 10 shown in Fig. 1. The workpiece 44 is introduced through an entrance opening 14 into the chamber 10 and conveyed out of the chamber 10 through an exit opening 16.

[0016] The entrance opening 14 is defined by a profile plate 18 which surrounds the entrance opening.

[0017] Two plates 20, 22 define inbetween them a hollow space 42. The profile plate 18 is fixed at the outer plate 22 by means of screws 48 (Fig. 2).

[0018] The plates 20, 22 define at their inner edges an allaround slot 24 surrounding the entrance opening 14. The slot 24 is continuous, i.e. surrounds completely a workpiece 44 moved through opening 14.

[0019] Coating material (not shown) is introduced into the hollow space 42 between the plates 20, 22 through six nozzles 46a, 46b, 46c, 46d, 46e and 46f. The locations of such nozzles are shown in Fig. 2 (but not in Fig. 1). The coating material is a fluid and passes the hollow space 42 in the direction of arrows 36, i.e. radially inwards with regard to the vector of direction 12 of conveyance of the workpiece.

[0020] Slot 24 surrounding the entrance opening 14 completely serves as a nozzle for spraying the coating material, e.g. varnish, onto the workpiece passing the opening 14. The coating material is sprayed onto the workpiece from all directions, e.g. the spraying is performed continuously over 360° around the workpiece and the sprayed material forms a "curtain" of coating material through which the workpiece is moved.

[0021] The plates 20, 22 and the profile plate 18 are attached at chamber 10 directly or indirectly, preferably removably such that the chamber 10 can be equipped with different plates. The distance D2 between plates 20 and 22 defines in the embodiment shown in Fig. 1 the diameter of the nozzle-like slot 24 and that distance can be adjusted by a ring-shaped spacer 30. Spacers 30 of different strengths are provided for adjusting the diameter size of the nozzle-like slot 24 and the size of hollow space 42.

[0022] The profile plate 18 has a profile 26 (Figs. 2 and 3) that corresponds exactly to the outer contour (profile) of the workpiece 44 (Fig. 3).

[0023] In the embodiment shown in Figs. 1 and 2, the profile plate is separate from the outer plate 22. However, the profile plate can be integral with the outer plate 22. In that case, the outer plate has radially inwardly a contour matching exactly the outer contour of the workpiece (see Fig. 3).

[0024] Furthermore, the embodiment shown in Figs. 1 and 2 can be amended such that the inner plate 20 can be replaced by the outer wall of chamber 10.

[0025] The embodiment shown in Figs. 1 and 2 can also be amended such that the profile plate 18 also forms the slot 24.

[0026] Fig. 2 shows in detail the outer plate 22 to which the profile plate 18 is removably attached by screws 48. Nozzles 46a, 46b, 46c, 46d, 46e, and 46f for injecting a fluid containing the coating material into hollow space 42 (Fig. 1) surround the entrance opening 14 of chamber 10. The means to flow the fluid containing the coating material to the nozzles 46a to 46f, i.e. the pressure generating pumps and lines, are not shown in the figures (see EP 2 628 549 A1). The chamber 10 is evacuated through four ports 32, 32a (only two ports are shown) by means of a pump (not shown). Therefore, coating material entering the chamber 10 is evacuated from chamber 10 through the ports. In the embodiment, four ports 32 are provided, one port on top of chamber 10, one port at the bottom of chamber 10, and two ports at the sides of chamber 10.

[0027] The nozzles 46a, 46b, 46c, 46d, 46e, 46f are arranged on a curve 52 surrounding the entrance opening 14. In the embodiment according to Fig. 2, the curve 52 is circular. A pitch angle 50 is defined between radii from the center of curve 52 to the nozzles. The pitch angle 50 is, in the embodiment shown in Fig. 2,60°. The pitch angle can also be smaller than 60°. Preferably, the pitch angle 50 between adjacent nozzles is equal.

[0028] The fluid containing the coating material is pumped through nozzles 46a to 46f into the hollow space 42 with high pressure and then sprayed through the slot 24 homogeneously onto the workpiece 44 passing entrance opening 14.

[0029] Fig. 3 shows the passage of a workpiece 44 through profile plate 18. The distance D_1 between the outer contour (profile) of the workpiece 44 and the inner contour (profile) of the plate 18 is constant, in the shown embodiment that distance is all around the contours at about 1 mm. The matching of both contours is such that the workpiece passes through the opening with minimum friction and such that the workpiece itself covers the entrance opening as much as possible so that the entering of air into the chamber is minimized. The workpiece can be supported in front of the entrance opening 14.

[0030] The slot 24 surrounding the workpiece all around is as close as possible to the workpiece.

[0031] The process parameters, in particular the pressure of the coating material in the hollow space 42, the distance between the slot 24 and the workpiece 44, the pump power for removing the excess coating material out of chamber 10, the speed of conveyance of the workpiece etc. are such that the flow of the fluid carrying the coating material to the workpiece is as laminar as possible. Such process parameters can be determined experimentally with a given apparatus and in dependency from the workpiece to be coated. It has been found that for obtaining mostly laminar flow of the fluid containing the coating material in the entrance opening 14 it is helpful to provide the slot 24 with sharp edges.

[0032] The following parameters have been found to be appropriate in connection with the illustrated apparatus. The slot 24, at its radial inner edge, has a diameter

in the range from 0,5 to 2 mm, preferably in the range of 0,8 to 1,5 mm and, most preferable, in the range of 1 mm ± 0,2 mm.

[0033] The distance between the inner edge of the profile plate 18 and the outer contour of the workpiece is e.g. in the range from 0.5 to 3 mm, in particular in the range from 1 to 3 mm and, most preferably in the range from 1 to 2 mm.

[0034] The process parameters regarding the geometrical dimensions of the slot 24 and the distance between the slot and the workpiece depend from the nature of the fluid carrying the coating material, in particular the viscosity, and the speed of conveyance of the workpiece and they can be optimized experimentally.

Claims

1. Apparatus for coating a workpiece all around, comprising

   - a chamber (10),
   - a pump for generating a pressure in the chamber (10) that is smaller than the pressure outside the chamber (10),
   - an entrance opening (14) through which the workpiece (24) can be conveyed into the chamber (10),
   - an exit opening (16), through which the workpiece (44) can be conveyed out of the chamber (10), and
   - an application unit (20, 22, 24) for applying the coating onto the workpiece (44) comprising at least two plates (20, 22), which surround said entrance opening (14) and which form a hollow space (42) through which coating material flows to said entrance opening (14), and nozzles adapted for injection of coating material into said hollow space (42),

   wherein

   - said nozzles (46a, 46b, 46c, 46d, 46e, 46f) are arranged at a curve (52) surrounding said entrance opening (14) such that an average pitch angle (50) between the nozzles is 60° or smaller.

2. Apparatus according to claim 1, wherein said curve (52) has a radial distance from said entrance opening.

3. Apparatus according to one of the claims 1 or 2, wherein each pitch angle (50) between neighboring nozzles is 60° or smaller.

4. Apparatus according to one of the preceding claims, wherein said curve (52) is a circle.

5. Apparatus to one of the preceding claims, wherein said nozzles (46) are mounted at one (22) of said plates (20, 22).

6. Apparatus according to one of the preceding claims, comprising a profile plate (18) removably attachable at one of said two plates (20, 22) and having a profile adapted to the profile of the workpiece (44).

7. Apparatus according to one of the preceding claims, comprising an exit plate (28) removably attached to the chamber (10) at said exit opening (16) and forming said exit opening (16) with a profile that is adapted to the profile of the workpiece (44).

8. Apparatus according to one of the preceding claims, wherein said chamber (10) comprises four or more ports adapted to be connected to one or more pumps for evacuating the chamber.

Amended claims in accordance with Rule 137(2) EPC.

1. Apparatus for coating the outer contour of a workpiece, comprising

   - a chamber (10),
   - a pump for generating a pressure in the chamber (10) that is smaller than the pressure outside the chamber (10),
   - an entrance opening (14) through which the workpiece (24) can be conveyed into the chamber (10),
   - an exit opening (16), through which the workpiece (44) can be conveyed out of the chamber (10), and
   - an application unit (20, 22, 24) for applying the coating onto the workpiece (44) comprising at least two plates (20, 22), which surround said entrance opening (14) and which form a hollow space (42) through which coating material flows to said entrance opening (14), and nozzles adapted for injection of coating material into said hollow space (42),

   characterized in that

   - said nozzles (46a, 46b, 46c, 46d, 46e, 46f) are arranged at a curve (52) surrounding said entrance opening (14) such that an average pitch angle (50) between the nozzles is 60° or smaller.

2. Apparatus according to claim 1, wherein said curve (52) has a radial distance from said entrance opening.

3. Apparatus according to one of the claims 1 or 2,

wherein each pitch angle (50) between neighboring nozzles is 60° or smaller.

4. Apparatus according to one of the preceding claims, wherein said curve (52) is a circle.

5. Apparatus to one of the preceding claims, wherein said nozzles (46) are mounted at one (22) of said plates (20, 22).

6. Apparatus according to one of the preceding claims, comprising a profile plate (18) removably attachable at one of said two plates (20, 22) and having a profile adapted to the profile of the workpiece (44).

7. Apparatus according to one of the preceding claims, comprising an exit plate (28) removably attached to the chamber (10) at said exit opening (16) and forming said exit opening (16) with a profile that is adapted to the profile of the workpiece (44).

8. Apparatus according to one of the preceding claims, wherein said chamber (10) comprises four or more ports adapted to be connected to one or more pumps for evacuating the chamber.

Fig. 1

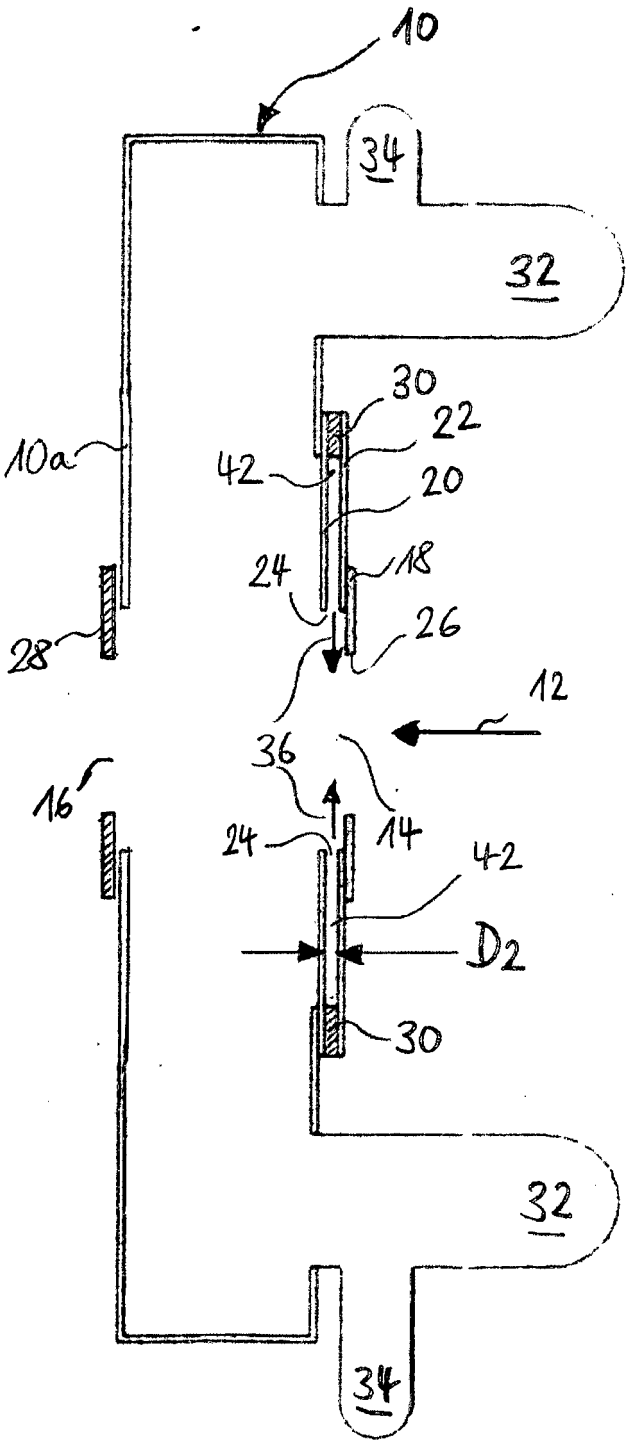


Fig. 2

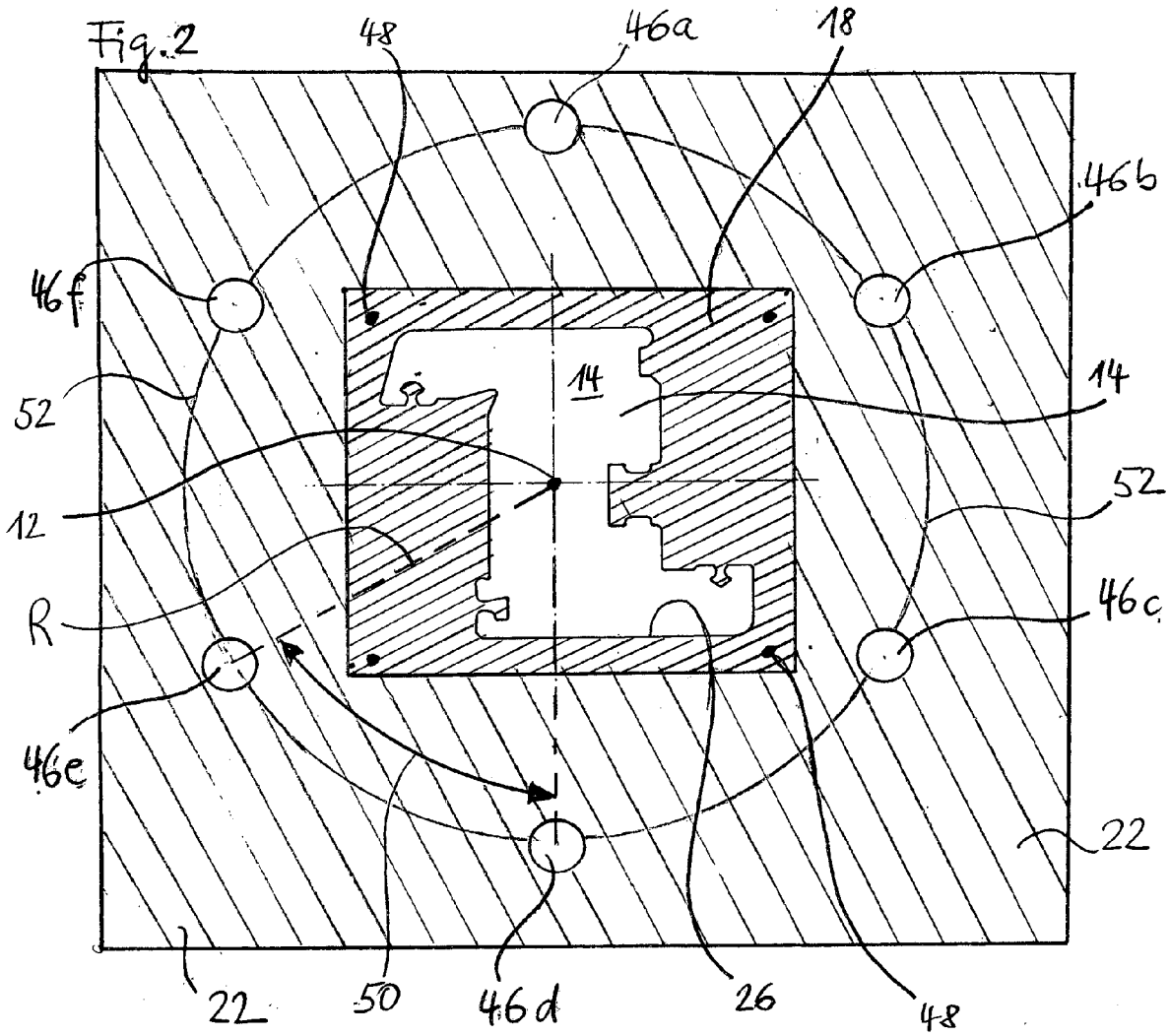
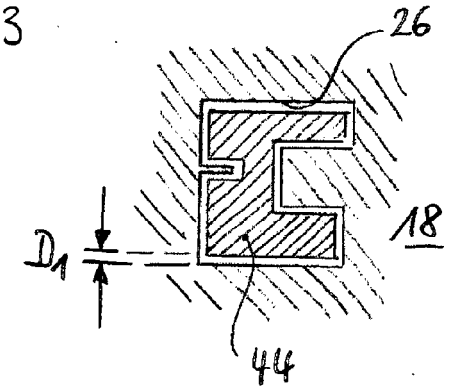

48
46a
18
46b
46f
52
14
14
12
52
R
46c
46e
22
22
50
46d
26
48

Fig. 3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EUROPEAN SEARCH REPORT

Application Number
EP 15 00 2649

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 409 778 A1 (DELLE VEDOVE DEUTSCHLAND GMBH [DE]) 25 January 2012 (2012-01-25) * figure 2 * * paragraph [0025] * * paragraph [0026] - paragraph [0027] * -----	1-8	INV. B28B11/00 B05C3/10 B05C3/15 B05C9/12 B05B13/02
A	EP 2 253 385 A1 (DELLE VEDOVE DEUTSCHLAND GMBH [DE]) 24 November 2010 (2010-11-24) * paragraph [0022] - paragraph [0023] * * figure 2 * -----	1-8	ADD. B05C5/02 B05B1/20

TECHNICAL FIELDS SEARCHED (IPC)
B28B B05C B05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 March 2016	Roldán Abalos, Jaime

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 00 2649

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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29-03-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2409778 A1	25-01-2012	DE 202010010497 U1	24-10-2011
		EP 2409778 A1	25-01-2012
EP 2253385 A1	24-11-2010	NONE	

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- EP 2628549 A1 **[0002] [0005] [0026]**
- DE 4337438 C2 **[0003]**