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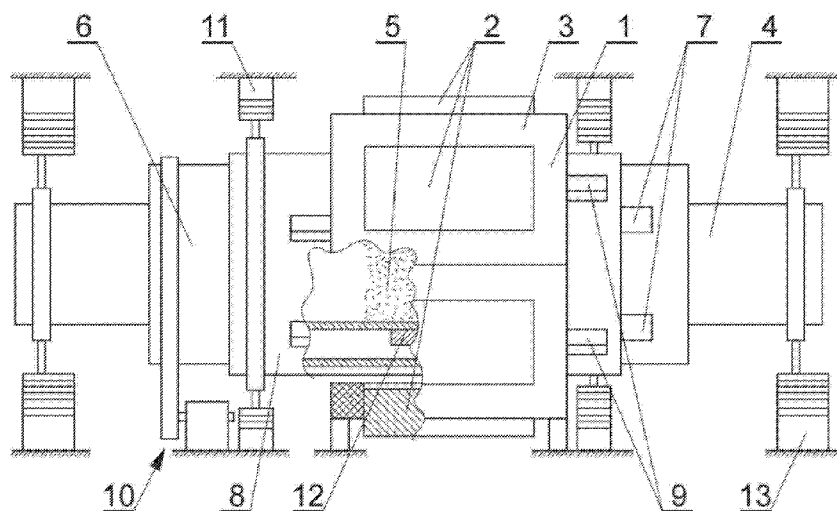


Fig. 1

(57) Abstract: A cylindrical working chamber (4) with ferromagnetic milling elements (5) is situated inside a body (1). Between magnets (2) and an outer side surface of the cylindrical working chamber (4) there is rotatably set an inner covering pipe (6) introduced into the rotary motion by means of a driving unit (10), said pipe being made of a magnetically insulating material, and having on its circumference longitudinal cut-outs (7) in order to guide magnetic field into the cylindrical working chamber (4). An additional covering pipe (8) made of a magnetically insulating material is fastened on supports outside the inner covering pipe (6), the additional covering pipe (8) having longitudinal cut-outs (7) coincident with at least some of longitudinal cut-outs (7) in the inner covering pipe (6).

## Magnetic mill

This invention refers to a magnetic mill designed to crush and mix materials by means of milling elements placed in a working chamber, said milling elements being moved by means of magnetic field.

## 5 Background Art

An electromagnetic mill known from US 4134557 patent specification comprises a cylindrical working chamber having electromagnets placed symmetrically on its circumference. Ferromagnetic crushing means as milling elements are placed  
10 inside the working chamber. These crushing means are rotated by alternating electromagnetic field. The rotational speed of the magnetic field, and by the same the speed with which milling elements are moved inside the working chamber, is regulated by changing the frequency of the magnetic field.

15 US 3869251 discloses a device for materials mixing in reaction vessels using ferromagnetic particles. This device comprises a coil creating variable electromagnetic field around a funnel into which a reaction vessel is introduced. The created alternating magnetic field moves ferromagnetic particles  
20 rotationally in order to intensively mix the material in its whole volume. Additional cyclic movements of the vessel caused by a driving unit comprising a connecting rod cause the greater complexity of the movement of ferromagnetic particles, and in effect the material is better mixed.

25 From US3848363 patent specification there is also known a device intended for working objects having ferromagnetic

elements driven by rotary magnetic field. This device comprises archwise windings, partially overlapping, powered by phase-shifted sources of electric current so that opposite electromagnets have opposite polarity. The created whirling  
5 electromagnetic field causes the whirling movement of ferromagnetic elements and their contact with workpieces.

From US4632315 patent specification a device for electromagnetic crushing and mixing is also known, said device comprising an annular working chamber with electromagnets  
10 placed opposite one to another on an outer and inner side of said ring. The greater variability of the magnetic field affecting ferromagnetic crushing elements is achieved by rotating an annular working chamber fastened rotatably in relation to fixed electromagnets.

#### 15 Disclosure of Invention

A magnetic mill according to the invention has a cylindrical working chamber with ferromagnetic milling elements placed inside, and magnets placed in a body above an outer side surfaces of the cylindrical working chamber, said magnets  
20 being designed to create a magnetic field directed into the cylindrical working chamber interior. This solution is characterized in that between the magnets and an outer side surface of the cylindrical working chamber there is a rotatably embedded inner covering pipe rotated by means of a  
25 driving unit, said pipe being made of a material insulating the magnetic field. The inner covering pipe has on its circumference cut-outs directing the magnetic field inside the cylindrical working chamber. Outside the inner covering pipe

there is fastened an additional covering pipe located on fixed supports and made of a material insulating the magnetic field, as well as having longitudinal cut-outs covering at least a part of longitudinal cut-outs made in the inner covering pipe.

5 Advantageously, the inner covering pipe is driven by the driving unit, whereas the additional covering pipe is fastened firmly on the supports.

Advantageously, the inner covering pipe is supported rotatably on the cylindrical working chamber by means of bearings.

10 Advantageously, both covering pipes are made of the same magnetically insulating material. More advantageously, both covering pipes are made of different magnetically insulating materials.

Advantageously, the outer pipe is made of a superconductor  
15 that insulates the magnetic field.

Advantageously, the magnets are made as electromagnets with superconductive coils.

Advantageously, the magnets are made as permanent magnets, and more advantageously, they are made of neodymium.

20 Advantageously, the cylindrical working chamber has corrective inductors situated on its cylindrical surface.

When causing the rotary motion of the inner covering pipe made of a material insulating the magnetic field with cut-outs letting the magnetic field to path, an alternating magnetic  
25 field is created inside the working chamber, and consequently milling elements are accelerated what makes them collide with a material being ground. Moreover, achieving an alternating magnetic field variability in the working chamber on changing

the rotational speed of the inner covering pipe allows the magnetic field to be changed without causing losses related to magnetization and demagnetisation of electromagnets even when using very high currents.

5 An additional protecting pipe made of a material insulating the magnetic field fastened over the inner protecting pipe allows to better insulate the magnetic field in repeatable places. However, stopping the inner protecting pipe in a position in which slots are not overlapping allows, when it is  
10 needed, to block the magnetic field against penetrating into the working chamber.

Inductors placed on the outer surface of the cylindrical working chamber and connected with a sensor detecting a change in the magnetic field react when ferromagnetic milling  
15 elements are near the inner surface of that chamber, and as a result, they make it possible to initiate repulsive magnetic pulses to enable the protection of the working chamber against any damage.

#### Brief Description of Drawings

20 An object of the invention is shown in its embodiment in a drawing, where Fig. 1 presents a magnetic mill in the side view with a local cut-out showing the interior of a cylindrical working chamber together with milling elements, Fig. 2 presents the magnetic mill in the axial section, and  
25 Fig. 3 presents the main elements of the magnetic mill in an exploded view.

#### Best Mode for Carrying Out the Invention

A magnetic mill presented in its embodiment in Fig. 1 has its fixed body 1 shaped as a hexagonal prism having six magnets 2 placed on side walls 3. The suitable magnetic force has been achieved by using neodymium magnets. In an embodiment not shown in the drawing, electromagnets having their superconductive coils chilled with liquid nitrogen have been used in order to create greater magnetic forces.

An immobile cylindrical working chamber 4 made of austenitic acid resistant steel X6CrNiTi18-10 according to DIN is fastened inside the body 1. Inside said chamber there are located cylindrical ferromagnetic milling elements 5. An inner covering pipe 6 made of magnetically insulating material (such as permalloy) comprising 80% Ni and 20% Fe is rotatably fixed between poles of the magnets 2 and an outer side surface of the cylindrical working chamber, said inner covering pipe 6 having on its circumference longitudinal cut-outs 7, by which magnetic field from the poles of the magnets 2 is directed into the working chamber 4. Above the inner covering pipe there is located an additional covering pipe 8 made of the same insulating material as the inner covering pipe 6 or of a material insulating the magnetic field, known as Mumetal, comprising 77% Ni, 16% Fe, 5% Cu, 2% Cr, or of a superconductive material cooled by liquid nitrogen. This pipe has longitudinal cut-outs 9 overlapping with the longitudinal cut-outs 7 made in the inner covering pipe 6 being fastened to the basis by means of grasps 11.

The inner covering pipe 6 is rotated by means of a driving unit 10. When rotating, the inner covering pipe 6 may be in a

fixed position in which some of the longitudinal cut-outs 7, 9 of both pipes 6, 8 are located opposite each other, enabling directing the magnetic field into the cylindrical working chamber 4 interior.

5 The cylindrical working chamber 4 has corrective inductors 12 situated symmetrically on a circumference of its outer cylindrical surface, said corrective inductors 12 being connected with a sensor device (not shown in the drawing) sensing changes in the magnetic field. When a suitably high  
10 voltage is induced in any of the corrective inductors 12 because of a dangerously short distance between the ferromagnetic milling elements 5 and the inner surface of the cylindrical working chamber 4, the sensor device sensing changes in the magnetic field sends alternating electrical  
15 pulses to the chosen corrective inductors 12 in order to create a force pushing away a suitable group of ferromagnetic milling elements 5.

As it is shown in Fig. 2, the working chamber is fastened on four supports 13, and the inner covering pipe 6 is moved by  
20 means of the driving unit 10 composed of an electric motor 14 and a belt gear 15. A driving wheel 16 of the belt gear 15 is fastened on the propeller shaft of the electric motor 14, and the driven wheel 17 is shaped on the outer surface of the inner covering pipe 6. The outer covering pipe is fastened on  
25 four supports 11.

In Fig. 3 basic parts of the magnetic mill are shown in an exploded view.

## Claims

1. A magnetic mill comprising a cylindrical working chamber (4) with ferromagnetic milling elements (5) located inside it and magnets (2) located in a body (1) above an outer side surface of the cylindrical working chamber (4) intended to  
5 create magnetic field directed into the cylindrical working chamber interior, characterized in that between the magnets (2) and the outer side surface of the cylindrical working chamber (4) there is a rotatably fastened inner covering pipe (6) rotated by means of a driving unit (10), said pipe being  
10 made of a magnetically insulating material, and it has on its circumference cut-outs (7) to introduce the magnetic field into the cylindrical working chamber (4) interior, whereas an additional covering pipe (8) is fastened on supports (11), on an outer side of the inner covering pipe (6), said pipe (8)  
15 being made of a magnetically insulating material with cut-outs (9) coincident with at least some of the cut-outs (7) in the covering pipe (6).

2. A magnetic mill according to claim 1 characterized in  
20 that the inner covering pipe (6) is driven by the driving unit (10), whereas the additional covering pipe (8) is fastened permanently on the supports (11).

3. A magnetic mill according to claim 1 or 2 characterized  
25 in that the inner covering pipe (6) is supported rotatably on the cylindrical working chamber (4) by means of bearings (17).

4. A magnetic mill according to claim 1 to 3 characterized in that the covering pipes (6, 8) are made of the same magnetically insulating material.

5

5. A magnetic mill according to claim 1 to 4 characterized in that both covering pipes (6, 8) are made of different magnetically insulating materials.

10 6. A magnetic mill according to claims 1 to 5 characterized in that the outer covering pipe (8) is made of a magnetically insulating superconductor.

15 7. A magnetic mill according to claims 1 to 6 characterized in that the magnets (2) are made as electromagnets with superconductive coils.

8. A magnetic mill according to claims 1 to 7 characterized in that the magnets (2) are made as permanent magnets.

20

9. A magnetic mill according to claim 8 characterized in that neodymium magnets are used as the permanent magnets.

10. A magnetic mill according to claims 1 to 9 characterized  
25 in that the cylindrical working chamber (4) has corrective inductors (12) placed on its cylindrical surface.

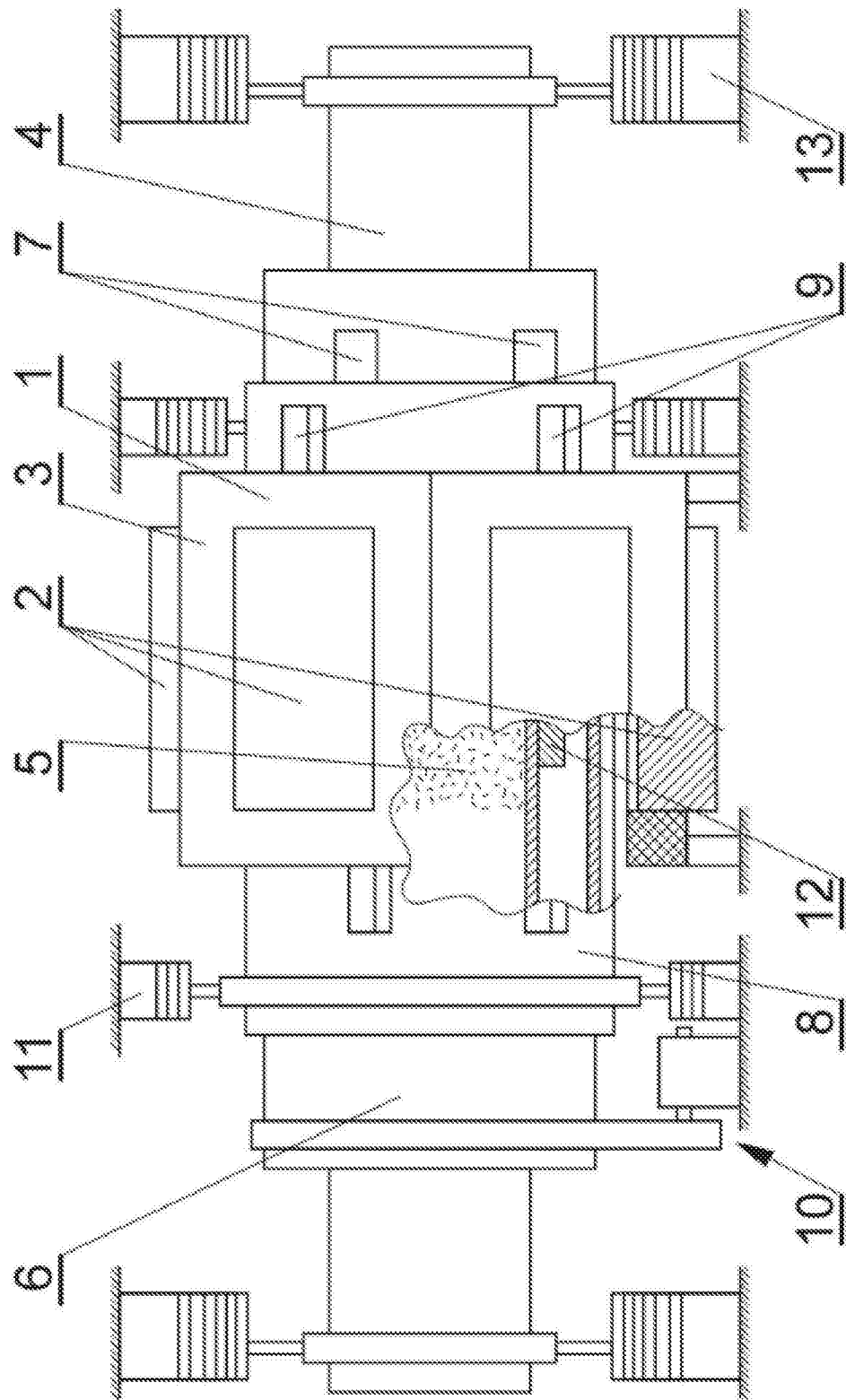
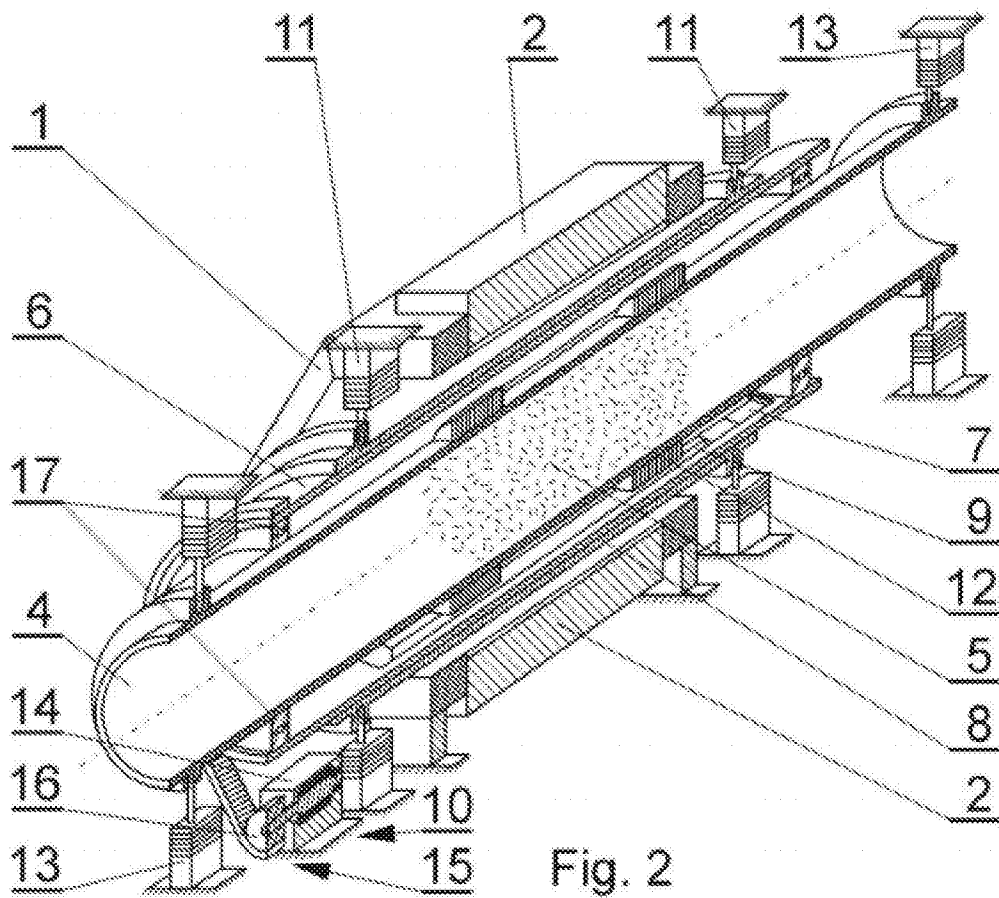


Fig. 1



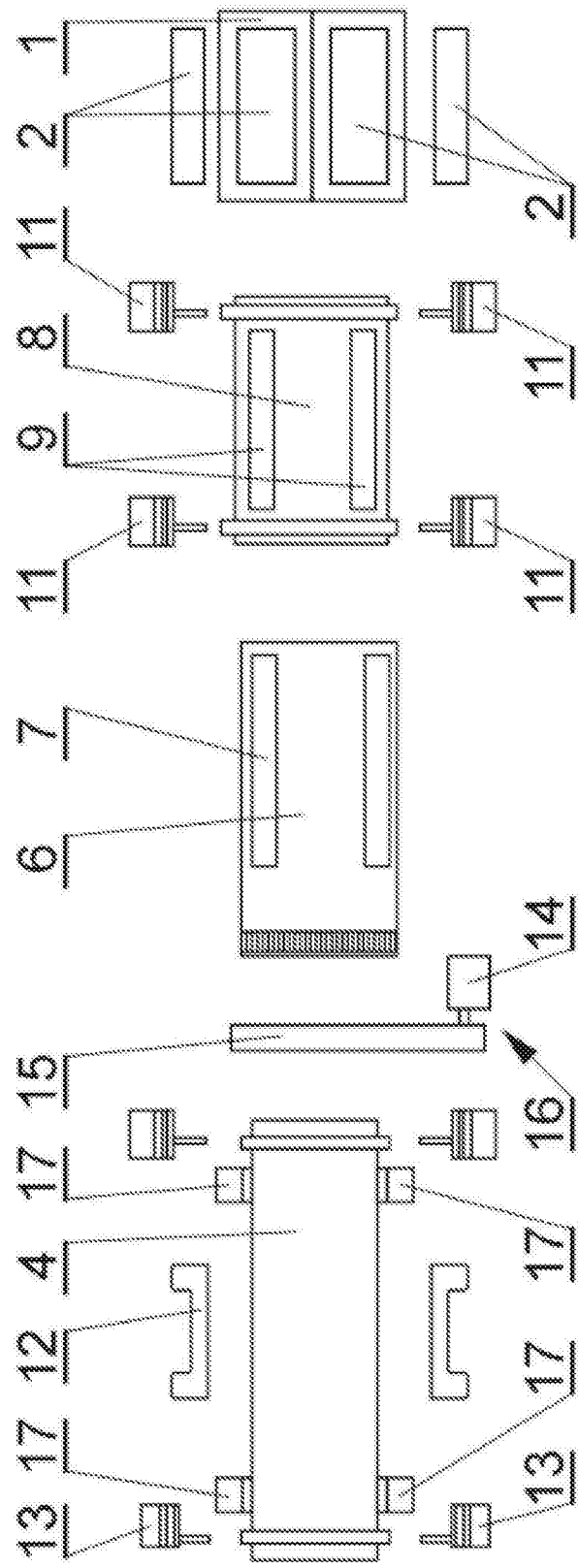


Fig. 3

# INTERNATIONAL SEARCH REPORT

International application No  
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| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br>INV. B02C17/00      B02C17/04      B02C17/18<br>ADD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                           |                                                                                                                               |
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| According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                           |                                                                                                                               |
| <b>B. FIELDS SEARCHED</b><br>Minimum documentation searched (classification system followed by classification symbols)<br>B02C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                           |                                                                                                                               |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                           |                                                                                                                               |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br>EPO-Internal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                           |                                                                                                                               |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                           |                                                                                                                               |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Citation of document, with indication, where appropriate, of the relevant passages                                                                        | Relevant to claim No.                                                                                                         |
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| <div style="display: flex; justify-content: space-between;"> <span><input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.</span> <span><input checked="" type="checkbox"/> See patent family annex.</span> </div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                           |                                                                                                                               |
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| Date of the actual completion of the international search<br><br><div style="text-align: center; font-size: 1.2em;">10 January 2014</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                           | Date of mailing of the international search report<br><br><div style="text-align: center; font-size: 1.2em;">23/01/2014</div> |
| Name and mailing address of the ISA/<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                           | Authorized officer<br><br><div style="text-align: center; font-size: 1.2em;">Swiderski, Piotr</div>                           |

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International application No

PCT/PL2013/050020

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                           |                       |
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Information on patent family members

International application No

PCT/PL2013/050020

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date                                                                                                                                                                                                        |
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