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(54) **DEVICE AND METHOD FOR ELECTROPOLISHING BY MEANS OF A CONDUCTIVE SURFACE**

(57) Disclosed is a device for electropolishing by bringing a conductive surface (1) into contact with a metal piece (2) to be polished by producing relative movement between the conductive surface (1) and the metal piece (2) to be polished, wherein the piece (2) is connected to a power source (3) and the conductive surface (1) is connected to an electrode (4). Also disclosed is a method for electropolishing by means of a conductive surface, which comprises the following steps: a step of polishing, wherein the conductive surface (1) is brought into contact with the metal piece (2) to be polished by producing relative movement between the conductive surface (1) and the metal piece (2) to be polished, the piece (2) being connected to the power source (3) and the conductive surface (1) being connected to the electrode (4); and a step of regenerating or replacing the conductive surface (1), wherein the conductive surface (1) that was in contact with the piece in the previous step of polishing, is regenerated or replaced, so that the conductive surface maintains sufficient conductivity during the polishing step.

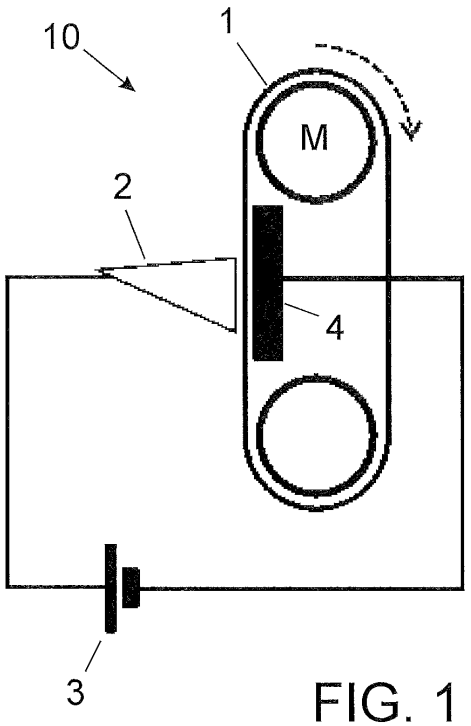

FIG. 1

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Description

OBJECT OF THE INVENTION

[0001] As expressed in the title of the present specification, the invention relates to a device and a method for electropolishing by means of a conductive surface which provides the intended function thereof with advantages and features that are described in detail below and entail an improvement over the current state of the art.

[0002] The object of the present invention relates to a device and a method for polishing metal surfaces by means of electropolishing which is essentially distinguished by the electrolyte being arranged on a conductive surface, and by comprising, among other elements, means for providing a relative movement between the part to be polished and said conductive surface; said device being able to be constituted as a portable device, wherein the device moves and the part is stationary, or as a fixed device, wherein it is the part that moves, so it is advantageously suitable for all types of parts of any shape and size, even for parts having large dimensions.

FIELD OF APPLICATION OF THE INVENTION

[0003] The field of application of the present invention is comprised within the sector of the technology dedicated for polishing metal surfaces, encompassing specifically apparatus, systems, and devices for electrochemical polishing.

BACKGROUND OF THE INVENTION

[0004] As is known, a large sector of the industry is dedicated to reducing the roughness of metal surfaces and polishing same. This is necessary for both aesthetic and technical purposes.

[0005] Currently, large metal surfaces such as, for example, bars, prisms, or plates, are usually polished by means of using mechanical methods, often with abrasives.

[0006] On the other hand, there is electrochemical polishing, in which parts, usually of medium or small size, are immersed in an electrolytic bath and their roughness is reduced by means of circulating an electric current. In addition to reducing roughness, this method is capable of generating passive protective layers that protect against corrosion, which is very advantageous. However, this process cannot be readily applied on plates, bars, or prisms having large dimensions.

[0007] Therefore, there is an industrial need for a process or device that allows polishing surfaces, plates, and bars of any shape and size in an easy manner and at the same time provides finishes which offer greater resistance to corrosion, with the objective of the present invention being to provide the market with a device that fulfills said need.

[0008] On the other hand, and as a reference to the current state of the art, it should be pointed out that, the applicant, at least on its part, is unaware of the existence of any device for electropolishing by means of a conductive surface, nor of any other invention of similar application, which presents technical and structural characteristics equal or similar to those presented by the invention claimed herein.

DESCRIPTION OF THE INVENTION

[0009] The device for electropolishing by means of a conductive surface proposed by the invention is configured as the ideal solution to the aforementioned objective, the characterizing details that make it possible and that distinguish it being suitably set out in the final claims attached to the present description.

[0010] Specifically, as indicated above, the invention proposes a device for polishing metal surfaces by means of electropolishing which is essentially distinguished by the fact that the electrolyte is arranged on a conductive surface, and that furthermore, among other elements, it has means for providing a relative movement between the part to be polished and said conductive surface, where the device can be constituted as a portable device that moves over the part to be polished, or as a fixed device, wherein it is the part that moves, being advantageously suitable for all types of parts of any shape and size, even parts having large dimensions.

[0011] More specifically, the present invention provides a device for polishing metal surfaces by means of an electrochemical process in which the electrolyte is a conductive surface formed either by a solid electrolyte or by a non-conductive material with a liquid electrolyte retained therein. A part to be polished contacts the conductive surface. An electrode contacts one side of the conductive surface, whereas the portion of the part to be polished contacts the other side of the conductive surface. A power source provides a potential difference between the part to be polished and the electrode.

[0012] Specifically, the essential elements comprised in the device of the invention are:

- a power source;
- an electrode;
- a conductive surface
- a system that provides electrical connectivity to the metal part to be polished at a pole of the power source;
- a system that provides electrical connectivity to the conductive surface at the opposite pole of the power source; and
- a system that provides relative movement of the conductive surface with respect to the metal part to be polished.

[0013] By way of example, the operation of the invention can be as follows:
The part to be polished is electrically connected to a pole

of the power source by means of a suitable system.

[0014] The electrode, connected to the opposite pole, contacts the conductive surface.

[0015] The part to be polished contacts the conductive surface, on the side opposite that with which the electrode contacts.

[0016] A relative movement occurs between the part to be polished and the conductive surface.

[0017] The power source applies a potential difference between the part to be polished and the electrode.

[0018] When the device performs these steps, electric current passes between the part to be polished and the electrode through the conductive surface. This electric current causes redox reactions on the surface of the metal part at the points of contact.

[0019] By geometry, the points of contact are preferably roughness peaks. As the process progresses, the peaks will undergo more oxidation. The same conductive liquid retained on the conductive surface is also capable of dissolving the oxides formed. This peak oxidation and oxide elimination process results in a reduction of the roughness peaks, which translates into a polishing result.

[0020] Next, the elements of the device are described in detail.

[0021] Conductive surface is used herein to refer to an element having electrical conductivity that can be measured between the two sides of the surface.

[0022] The conductive surface can be manufactured from a solid electrolyte material, such that the material has conductivity that can be measured between the two sides of the surface. For example, conductive surfaces based on ionomeric polymers, Nafion, Hycar, ion exchange membranes, polystyrene sulfonate, sulfonated styrene and divinylbenzene copolymer, gel-type structures including polyether chains, among others.

[0023] Preferably, the solid electrolyte material is a laminar material in order to allow sufficient conductivity between both sides, one connected to the electrode and the other which contacts the part to be polished.

[0024] The conductive surface can also be manufactured from a non-conductive material that retains a conductive liquid solution (liquid electrolyte), such that the material with the retained liquid has an electrical conductivity that can be measured between the two sides of the surface. Furthermore, the liquid retained on the conductive surface enables the dissolution of metal oxides and salts.

[0025] Preferably, the non-conductive material is a fabric, a non-woven fabric, a sheet, a membrane, a paper, a polymer, a cloth, a cardboard, or a bundle of fibers.

[0026] The liquid retained on the conductive surface is a liquid electrolyte, i.e., it is capable of conducting electricity. Furthermore, it is capable of dissolving the metal oxides formed in the part to be polished. The retained liquid can include acids to increase conductivity and improve metal oxide solubility.

[0027] Preferably, the conductive liquid solution contains at least one strong acid such as, for example, sulfuric acid or acids with sulfonic group. Due to its polarity and dissolving capacity, the preferred solvent of the conductive liquid solution is water.

[0028] The device comprises a system for supporting the part which can consist of clamps, firm gripping elements, pressure systems, magnets, etc.

[0029] The invention incorporates means for supporting the conductive surface, as well as a mechanism for creating a relative movement of the conductive surface with respect to the part to be polished.

[0030] In a preferred embodiment, these means and mechanism for moving the conductive surface are constituted in a form similar to a belt sander. This device for dry electropolishing by means of a conductive belt comprises two or more drums on which there is mounted a part with a continuous conductive surface in the form of a belt, with a motor that provides rotational movement to said belt. This embodiment can be portable, in which the device moves and the part is stationary; and it can also be stationary, in which the device does not move and it is the part that moves closer to the moving belt. In devices of this type, the electrode can be a flat element in contact with the belt, or alternatively a conductive drum that acts as an electrode.

[0031] In another preferred embodiment, the device for dry electropolishing by means of a flat conductive surface comprises means for supporting a flat conductive surface on a flat part. This flat part includes or is the electrode. This flat part is mounted on a mechanism which can move the surface. This movement can be a circular, orbital, circular translational, rotating, oscillating, linear movement, among many others.

[0032] The device can include a system for regenerating or exchanging the conductive liquid retained on the conductive surface so as to maintain the quality of the polishing process. This system can include a system for reading the conductivity between the two sides of the metal surface.

[0033] This system can include a retained liquid elimination point such as, for example, a pressure system between two drums, temperature, dry air application, among others. The system includes a point at which the conductive surface is impregnated with liquid electrolyte such as, for example, by immersion, aerosol, among others.

[0034] The power source is responsible for providing a potential difference between the part to be polished and the electrode. This power source provides direct current. The device can include the elements required for transforming direct current into an output current that suits the different needs of the polishing process. For example, it is possible to envisage a system which is capable of providing an output current in the form of pulses, with polarity inversion, with certain pause times at zero or analog voltage.

[0035] The poles of the power source are connected to the part to be polished and the opposite pole is connected to the electrode.

[0036] The electrode contacts the conductive surface, such that the source-part to be polished-conductive surface-electrode-source electric circuit is closed.

[0037] Another object of the invention relates to a method for electropolishing by means of a conductive surface which comprises the following steps

- A step of polishing, in which a conductive surface (1) contacts a metal part (2) to be polished, with a relative movement being caused between the conductive surface (1) and the metal part (2) to be polished, and wherein the part (2) is connected to the power source (3) and the conductive surface (1) is connected to an electrode (4)
- A step of regenerating or replacing the conductive surface (1), in which the conductive surface (1) which has been in contact with the part in the preceding step of polishing is regenerated or replaced so that the conductive surface maintains sufficient conductivity during the step of polishing.
  Preferably, the step of regenerating or replacing the conductive surface comprises the following substeps
- Completely or partially eliminating the liquid electrolyte used
- Adding new liquid electrolyte.

DESCRIPTION OF THE DRAWINGS

[0038] To complement the description that is being made and for the purpose of aiding to better understand the features of the invention, a drawing is attached to the present specification as an integral part thereof, in which the following is depicted in an illustrative and non-limiting manner:

Figure 1, which is the only figure, shows a schematic depiction of an embodiment of the device for electropolishing by means of a conductive surface object of the invention, where the main parts and elements which it comprises can be seen.

PREFERRED EMBODIMENT OF THE INVENTION

[0039] In view of the described figure and according to the numbering used therein, a non-limiting embodiment of the device for electropolishing by means of a conductive surface of the invention, which comprises what is described in detail below, can be seen.

[0040] In that sense, as can be seen in said figures, the device (10) of the invention basically comprises:

- a power source (3);
- an electrode (4);
- a conductive surface (1)
- a system that provides electrical connectivity to the metal part (2) to be polished at a pole of the power source (3);
- a system that provides electrical connectivity to the conductive surface (1) at the opposite pole of the power source (3); and
- a system that provides relative movement of the conductive surface (1) with respect to the metal part (2) to be polished,

wherein the electrode (4) contacts one side of the conductive surface (1) and the part (2) to be polished can be brought into contact with the conductive surface (1) on the other side, such that a polishing effect occurs when the power source (3) applies a potential difference between the part (2) to be polished and the electrode (4).

[0041] The system that provides relative movement of the conductive surface (1) with respect to the metal part (2) to be polished can be, for example, by means of a rolling conveyor, as described below, or consist of a circular, orbital, circular translational, rotating, or linear oscillating movement of a flat conductive surface (1).

[0042] Figure 1 shows a schematic depiction of a preferred embodiment option of the device (10) of the invention, wherein the conductive surface (1) adopts a rolling conveyor belt-type configuration which comprises two or more drums on which the conductive surface (1) is mounted in the form of a continuous belt, with a motor (M) that provides rotational movement to the belt.

[0043] Alternatively, the conductive surface (1) adopts a configuration that can be compared to a VHS or a cassette. Initially, the conductive surface (1) is wound in a drum, arranged so that it can be wound in a second drum. The segment of the conductive surface (1) stretched between both drums is used for the polishing process. A motor (M) provides movement for the belt. This device successively winds and unwinds a certain length of the belt, causing the belt to move back and forth. When the conductive surface (1) of this certain length of the belt is saturated, working with the subsequent segment occurs. In this way, working with a conductive surface (1) is always performed in optimal conditions.

[0044] In turn, the part to be polished (2) is connected to the power source (3) and arranged such that it contacts the conductive surface (1).

[0045] The opposite pole of the power source (3) is connected to an electrode (4). In an embodiment option, the electrode (4) can be a flat element which is arranged in contact with the belt which constitutes the conductive surface (1) as shown in Figure 1, although, alternatively, it can be a conductive drum that acts as an electrode (4).

[0046] In one embodiment of the invention, the conductive surface (1) is made of a solid electrolyte-type material. For example, conductive surfaces based on ionomeric polymers, Nafion, Hycar, ion exchange membranes, polystyrene sulfonate, sulfonated styrene and divinylbenzene copolymer, gel-type structures including polyether chains, among others.

[0047] In another embodiment variant of the invention, the conductive surface (1) is a fabric, sheet, membrane, paper, polymer, cloth, cardboard, bundle of fibers, or other material with comparable characteristics that retains

a conductive liquid solution, such that the conductive surface has an electrical conductivity that can be measured between the two sides of the material.

[0048] Said conductive liquid solution preferably contains at least one strong acid, and it is preferably an aqueous solution. Strong acids improve the elimination of the metal oxides formed on the surface. Strong acids of preferred use are sulfuric acid or a sulfonic acid such as, for example, methanesulfonic acid or toluenesulfonic acid.

[0049] The conductive solution can contain phosphoric acid since it produces passive phosphate layers on the treated surfaces, which improves anti-corrosion resistance.

[0050] The conductive solution can be an emulsion of an organic phase in a polar phase or vice versa. The advantages of using emulsions as a conductive phase is the formation of structured layers on the metal surface to be polished, which allows obtaining very low final roughness.

[0051] The conductive solution can include one or more complexing agents or chelating agents. These compounds favor the dissolution of metal ions, so they contribute to a more effective dissolution of the oxides formed on the metal surface. Among chelating agents of preferred use are citric acid, EDTA, polyethers such as, for example, polyethylene glycol, among others.

[0052] Furthermore, in this second embodiment, although not depicted, the device comprises a system for partially or completely regenerating or exchanging the conductive liquid solution retained on the conductive surface (1).

[0053] In the preferred embodiment, the conductive surface (1) is made of a porous polymer material with functional groups capable of retaining and transporting metal ions. Preferably, these functional groups are sulfonic acid/sulfonate, carboxylic acid/carboxylate groups, or chelating functional groups. The presence of these groups facilitates ion retention, such that the concentration of metal ions in the retained liquid electrolyte is kept relatively low and the quality of the polishing process is maintained over time.

[0054] Preferably, the described device (10) is a portable device, such that it is movable, and the part (2) to be polished is static. In this embodiment, the system that provides relative movement of the conductive surface (1) with respect to the metal part (2) to be polished comprises means for moving the conductive surface (1) with respect to the metal part (2) that remains stationary.

[0055] However, in an alternative embodiment, it also can be a fixed device (10), i.e., it does not move, with the part (2) to be polished being that which moves closer to the moving belt constituting the conductive surface (1). In this embodiment, the system that provides relative movement of the conductive surface (1) with respect to the metal part (2) to be polished comprises means for moving the metal part (2) with respect to the conductive surface (1) which is stationary.

[0056] It is also envisaged for the relative movement of the part (2) with respect to the conductive surface (1) to occur by means of the use of a robotic arm, which would allow the automatic application of complex shapes in the process.

[0057] Having sufficiently described the nature of the present invention, as well as the way of putting it into practice, it is not considered necessary to further expand on its explanation so that any expert in the field can understand its scope and the advantages derived from it.

Claims

1. A device for electropolishing by means of a conductive surface which, applicable for polishing the surface of a metal part (2), is **characterized by** comprising:

   - a power source (3);
   - an electrode (4);
   - a conductive surface (1);
   - a system that provides electrical connectivity to the metal part (2) to be polished at a pole of the power source (3);
   - a system that provides electrical connectivity to the conductive surface (1) at the opposite pole of the power source (3); and
   - a system that provides relative movement of the conductive surface (1) with respect to the metal part (2) to be polished,

   wherein the electrode (4) contacts one side of the conductive surface (1) and the part (2) to be polished can be brought into contact with the conductive surface (1) on the other side, such that a polishing effect occurs when the power source (3) applies a potential difference between the part (2) to be polished and the electrode (4).

2. The device for electropolishing by means of a conductive surface according to claim 1, **characterized in that** the conductive surface (1) adopts a rolling conveyor belt-type configuration and the system that provides relative movement of the conductive surface (1) with respect to the part (2) to be polished comprises two or more drums on which the conductive surface (1) is mounted, with a motor (M) that provides rotational movement to the belt.

3. The device for electropolishing by means of a conductive surface according to claim 2, **characterized in that** the conductive surface (1) adopts a continuous belt configuration.

4. The device for electropolishing by means of a conductive surface according to claim 2, **characterized in that** the conductive surface (1) adopts a configuration in which it is initially wound in a drum, arranged

so that it can be wound in a second drum.

5. The device for electropolishing by means of a conductive surface according to claim 1, **characterized in that** the system that provides relative movement of the conductive surface (1) with respect to the part (2) to be polished is a system that provides a circular, orbital, circular translational, rotating, or linear oscillating movement of a flat conductive surface (1).

6. The device for electropolishing by means of a conductive surface according to any of the preceding claims, **characterized in that** the conductive surface (1) is made of a solid electrolyte-type material, such that the conductive surface has an electrical conductivity that can be measured between the two sides of the material.

7. The device for electropolishing by means of a conductive surface according to any of claims 1 to 5, **characterized in that** the conductive surface (1) is manufactured with a non-conductive material that retains a conductive liquid solution, such that the conductive surface has an electrical conductivity that can be measured between the two sides of the material.

8. The device for electropolishing by means of a conductive surface according to claim 7, **characterized in that** the conductive liquid solution contains at least one strong acid.

9. The device for electropolishing by means of a conductive surface according to claim 7, **characterized in that** the conductive liquid solution contains sulfuric acid, methanesulfonic acid, phosphoric acid, citric acid, EDTA, polyethers, or polyethylene glycol.

10. The device for electropolishing by means of a conductive surface according to any of claims 7 to 9, **characterized in that** the conductive liquid solution is an emulsion.

11. The device for electropolishing by means of a conductive surface according to any of claims 7 to 10, **characterized in that** the conductive liquid solution contains complexing agents.

12. The device for electropolishing by means of a conductive surface according to any of claims 7-11, **characterized in that** the conductive surface (1) is made of a porous polymer material with functional groups capable of retaining and transporting metal ions, said groups consisting of sulfonic acid/sulfonate, carboxylic acid/ carboxylate, or chelating functional groups.

13. The device for electropolishing by means of a conductive surface according to any of claims 7-12, **characterized in that** it comprises a system for partially or completely regenerating or exchanging the conductive liquid solution retained on the conductive surface (1).

14. The device for electropolishing by means of a conductive surface according to any of the preceding claims, **characterized in that** the system that provides relative movement of the conductive surface (1) with respect to the metal part (2) to be polished comprises means for moving the conductive surface (1) with respect to the metal part (2).

15. A method for electropolishing by means of a conductive surface, **characterized by** comprising the following steps:

- A step of polishing, in which a conductive surface (1) contacts a metal part (2) to be polished, with a relative movement being caused between the conductive surface (1) and the metal part (2) to be polished, and wherein the part (2) is connected to the power source (3) and the conductive surface (1) is connected to an electrode (4)
- A step of regenerating or replacing the conductive surface (1), in which the conductive surface (1) which has been in contact with the part in the preceding step of polishing is regenerated or replaced so that the conductive surface maintains sufficient conductivity during the step of polishing,

16. The method for electropolishing by means of a conductive surface according to claim 15, **characterized in that** the step of regenerating or replacing the conductive surface comprises the following substeps

- Completely or partially eliminating the liquid electrolyte used
- Adding new liquid electrolyte.

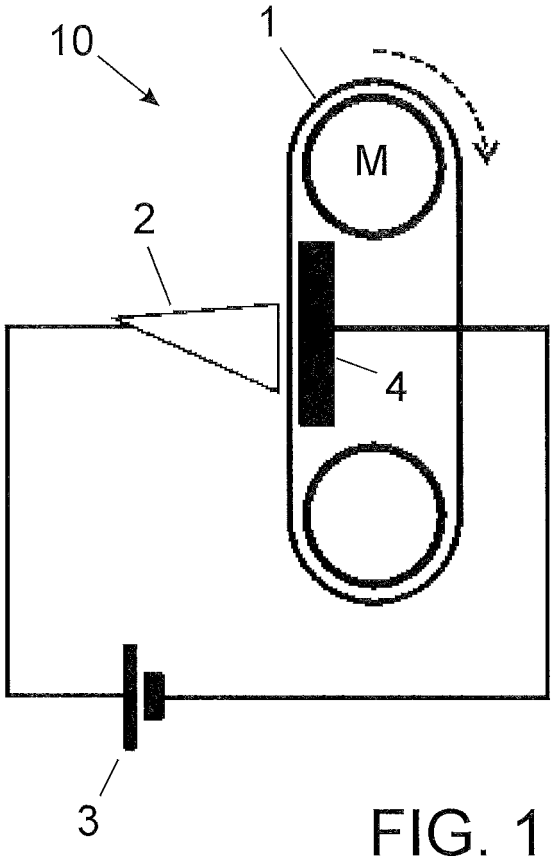

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2022/070304

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)
C25F

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)

EPODOC, INVENES

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RU 2734206 C1 (MINGAZHEV ASKAR DZHAMILEVICH) 13/10/2020, pages 3 - 9; figures 1 - 2.	1-16
A	WO 9910569 A1 (UNIQUE TECHNOLOGY INTERNATIONA ET AL.) 04/03/1999, Paragraphs [1 - 17]; figures 1 - 4.	1,6
A	ES 2239912 A1 (SARSANEDAS GIMPERA MARC ET AL.) 01/10/2005, column 1, line 1 – column 4, line 34;	1,10
A	ES 2734499 A1 (DRYLYTE SL) 10/12/2019, Pages 2 - 7;	1,11,12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance.
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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other documents , such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05/09/2022	**(06/09/2022)**
Name and mailing address of the ISA/ OFICINA ESPAÑOLA DE PATENTES Y MARCAS Paseo de la Castellana, 75 - 28071 Madrid (España) Facsimile No.: 91 349 53 04	Authorized officer O. Fernández Iglesias Telephone No. 91 3498500

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
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		ES2734415 B2	06.08.2020

Form PCT/ISA/210 (patent family annex) (January 2015)

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