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(54) **CYLINDERS OR TUBES ASSEMBLED BY MEANS OF A NEW METHOD FOR ELIMINATING INTERFERENCE**

(57) The present invention relates to a method for interference-joining concentric cylinders, where the smaller cylinder (102) does not fit into the larger cylinder (101), involving the use of auxiliary cylinders inside an assembly chamber (301), such that the interference is momentarily eliminated by means of isostatic pressure, and one cylinder is fitted into the other, yielding an interference-joined thicker cylinder. The pressure is released, and it is removed from the assembly chamber (301) finally leaving only the two interference-joined cylinders. It is possible to assemble 3 or 10 and more cylinders in the same way, assembling a thick cylinder, pre-compressed on the inside and pre-stressed on the outside. Several interference-joined cylinders exert the same stress when the cylinder withstands the maximum pressure, such that it withstands a greater pressure than a single cylinder with the same total wall thickness, which always reduces the stress from a maximum at the inside of the wall to a lower percentage at the outer edge.

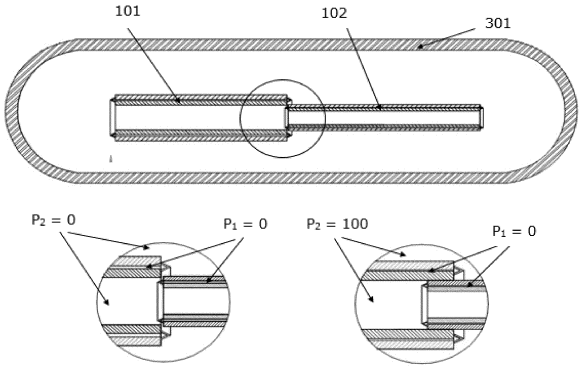

FIG. 1

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Description

Technical field

[0001] The present invention relates to devices that are used to put pressure on objects.

Background

[0002] When a pressurized fluid is poured into a chamber or a thick-walled cylinder, the reaction stress inside the wall is greater towards the central side and the intensity thereof decreases towards the periphery. If the stress is uniform at maximum pressure, the cylinder will withstand greater pressure.

[0003] Two cylindrical tubes, which are interference-joined, since the smaller cylinder does not fit inside the larger one - unless a gadget is made, cause the wall to be pre-stressed outwardly and pre-compressed inwardly, being the thick cylinder unpressurized. Interference-joined cylinders resist more pressure than non- interference-joined cylinders.

[0004] Nowadays, interference-joined cylindrical tubes are made and said interference is eliminated when the larger cylinder is heated, such that it dilates or expands, and/or the smaller one is cooled, such that it contracts; in that way the interference disappears, and the tubes can be assembled or joined by assembling them as a single tube. After recovering the normal temperature, they tend to recover their dimensions and cannot recover said dimensions, thus remaining "joined by the interference" or "interference-joined."

[0005] The interference that disappears momentarily by the effect of temperature variation is truly little, and the cylinders to be joined must have an inner diameter of the outer cylinder slightly smaller than the outer diameter of the inner cylinder. Furthermore, it is difficult to maintain the temperature differences for a few minutes to assemble them or to assemble a new cylinder into another one already assembled. This was used in the manufacture of Blakely guns more than 150 years ago.

[0006] The interference that disappears momentarily by the effect of temperature variation can be greater in order to join short sections and only once, such as a gear or a railroad wheel to an axle. But it is not possible to join a set of thin cylinders tightly together by interference achieved by temperature variations.

[0007] The first mechanism to obtain high isostatic pressure is the thick-walled cylindrical chamber, wherein the width of the wall is measured as a percentage of the cylinder diameter; obviously, the thicker it is, the more pressure it withstands. But when it becomes thicker, the greater the difference is in the reaction stress between the inner and outer edge that makes the wall of the chamber, as can be seen in FIG. 2 and the description thereof.

[0008] The way to obtain higher pressure than a thick-walled cylinder is the "coiled chamber": around the axial axis of a cylinder kilometers of calculated stressed plate are joined, which create pressure up to 600 MPa, that is, two- and three-times higher pressure than a simple thick-walled chamber of 30% of the cylinder diameter.

[0009] The coiled chamber has the serious disadvantage that it does not accept reaction stress in the axial direction, such that it must be fitted with large "yokes" on the outside for external support, thus supporting the caps, which may be one at each end of the cylinder, which must be completely displaced each time a chamber is loaded or unloaded.

[0010] High Pressure Processing (HPP technology) to prepare pressure pasteurized foods, or Hot Isostatic Pressing (HIP technology) used in metallurgy to make castings or remove imperfections, is well known.

[0011] The HIP technology is not used at such high pressure, only up to 300 MPa pressure, since it is used by compressing a gas, usually argon, which is heated. Furthermore, yokes and hydraulic cylinders required by the closing mechanism of the chamber make hot work more difficult.

[0012] The technology for joining by interference by temperature was used in the execution of the Blakely cannon, since he was the first one to build cannons formed of concentric tubes with varying degrees of elasticity, wherein the inner tube has a greater elasticity as it has to withstand greater stress. The straps or rings were placed in the slightly conical red-hot tube in such a way that when they cooled, they contracted and compressed it, leaving the cannon in initial stress. This allowed Blakely to build very resistant, large caliber and light weight cannons.

[0013] Even higher pressures of 10 or 100 GPa and more are exerted - for experimentation only, in microscopic dimensions in the Diamond Anvil Cell. Thousands of basic researches have been done only, since it cannot be conducted in natural size, which would be desirable to follow with applied research in new materials such as light material, super hard and tough material, electrical materials, superconductive material, etc.

[0014] The multi-wall chamber is another way to generate high pressure, but it could be said that they are attempts of other inventions, which were made for the same purpose (see patent application CL 201902913 and patent application CL 201902988). However, a new technical solution has been found that overcomes the drawbacks of the previously mentioned applications and is based on a new joint due to isostatic-pressure interference.

[0015] The new isostatic-pressure interference joining method, which is possible to conduct, serves to assemble two or ten and more cylindrical tubes of any dimension by interference, which facilitate the manufacture of ultra-high-pressure chambers or multi-chambers.

Brief description of the Figures

[0016] **FIG. 1** shows two tubular chambers within an assembly chamber 301, where the pressure within the

assembly chamber changes the diameters of the tubular chambers, since no pressure ever enters each tubular chamber.

Details:

[0017] View of A detail (left side): with no pressure between the two tubular chambers, the cylinders cannot be joined by interference.

[0018] View of B detail (right side): as the pressure in the assembly chamber increases, the internal diameter of the larger tubular chamber increases and the external diameter of the smaller tubular chamber decreases, which now allows one tubular chamber to be inserted into the other.

[0019] **FIG. 2** shows a cross-section of a thick-walled cylinder with the stresses developed by the pressure P_A it withstands; adjoining is a cylinder assembled by isostatic-pressure interference joint formed by six thin cylinders of the same wall thickness and the same material, which withstands P_B greater than P_A, which has the same stress on all cylinders as a result of being pre-compressed and pre-stressed when unpressurized.

[0020] **FIG. 3** shows a cylindrical tube to be assembled 101, which is preliminarily assembled with a larger auxiliary tube 201, thus forming a tubular chamber with ringed caps 211 and 212. Another tubular chamber must be assembled with a smaller cylindrical tube 102 having another auxiliary tube 202 smaller than the smaller cylindrical tube.

[0021] **FIG. 4** shows a chamber of several interference-joined cylinders, such that the smaller diameter cylinders are pre-compressed and the larger diameter ones are pre-stressed, being the chamber unpressurized. When the chamber is at maximum pressure, the cylinders, which were at the beginning pre-compressed and pre-stressed, are all pre-stressed at maximum pressure.

Description of the Invention

[0022] The invention relates to a method for joining two or more concentric cylinders (101, 102) by isostatic-pressure interference, which have certain roughness or fine grooves, allowing them not to slip once assembled.

[0023] For this purpose, two tubular chambers or auxiliary chambers must be prepared, as shown in FIG. 1, formed by one of the cylinders to be joined (101) with an auxiliary cylinder (201), which are placed concentrically joined by two ringed caps (111 and 112). One cylinder (101) is fitted into the other (201), where they are no more than 15% of the radius apart, as shown in FIG. 3.

[0024] A second tubular chamber is built a little smaller compared to the previous one, wherein the cylinder to be joined by interference (102) may have roughness or grooves on the outside, and the smaller auxiliary cylinder (202) may have roughness or grooves inside, and they are joined with two caps (113 and 114) as in the previous case. The smaller tubular chamber does not enter into the inner cylinder of the larger tubular chamber under normal circumstances, as they interfere with each other.

[0025] The tubular chambers are successively subjected to high pressure within an assembly chamber (301) keeping the interior of each tubular chamber between the caps without pressure; such that in the larger tubular chamber the internal diameter□of the smaller cylinder increases in □1, and in the smaller tubular chamber the external diameter of the larger cylinder decreases in □2 due to the increase of pressure in the assembly chamber.

[0026] If the dimensions of the tubular chambers when subjected to high pressure are such that the internal diameter of the larger tubular chamber is equal to or greater than the external diameter of the larger cylinder of the smaller tubular chamber, then pressure interference has disappeared, and they can be assembled.

[0027] If the tubular chambers are subjected to a force that forces them to displace the smaller one into the larger one, when the pressure conditions are given and the diameters are forced to vary, then the smaller tubular chamber will enter into the larger tubular chamber. It can be by gravity, or an elastic band arranged, which is forcing a tubular chamber to enter into the other when the interference disappears, and they are accommodated smoothly.

[0028] When the pressure of the assembly chamber is lowered, the tubular chambers are tightly locked, since they tend to return to their diameters. The stuck tubular chambers are removed and disassembled only leaving the two cylinders joined by interference. Then, another cylinder by interference is placed and they are joined similarly, and then another one, until a cylinder formed by several concentric cylinders is formed. Then both caps are placed on them, and a chamber joined by interference of isostatic pressure is obtained.

[0029] It shall be noted that the interference-joined cylinder is pre-stressed on the outside and pre-compressed on the inside when it is without fluid, but that the pre-compressed side changes to compressed and the stress becomes uniform as fluid under pressure enters into the same.

[0030] This cylinder withstands higher pressure than a simple thick-walled cylinder of the same material and dimensions, since when it is at maximum pressure, it makes the same effort regardless of whether it is measured or calculated at a point more central or more external to the wall, as shown in FIG. 2.

[0031] There are alternatives to generate the new joint by isostatic pressure interference, which are variations of the tubular chambers, which are assembled with one, two or no auxiliary cylinders, caps that in some cases are circular and in others ringed.

[0032] It shall be noted that the chamber (301) does not need so much pressure to produce the joint by interference of tubes that may be to manufacture another chamber, which is intended to withstand high pressure. It is enough that the chamber (301) exerts a sufficient pressure to achieve that one of the cylinders to be joined

is a thin-walled one and is at maximum effort at the time of assembly.

[0033] Alternatively, only one cylinder to be joined can be used to manufacture the tubular chamber and the other cylinder to be joined neither contracts nor expands with pressure, but the interference with the expansion of the smaller cylinder in the tubular chamber is eliminated.

[0034] In order to avoid buckling due to the external pressure of the cylinders to be joined by interference -when they are under high external pressure, suitable internal supports are installed.

Example 1. Uses of the cylinder or joint chamber for isostatic pressure interference.

[0035] By manufacturing a thick interference-joined cylinder, chambers can be easily generated-such as the one shown in FIG. 4, by adding solid caps. It can be used for the same purposes of making pressure-pasteurized foods, but much simpler than the HHP system, which needs a large stress winder; or it may be applied in metallurgy by generating a system to replace the HIP system.

[0036] Also, it can be used as a cylinder for manufacturing barrels pre-compressed on the inside and pre-stressed on the outside; it is much better than a barrel with temperature interference; furthermore, it can be used for thin barrels of □ 0.5 centimeters or thick barrels of □ 50 centimeters.

[0037] Additionally, it can be used in a multi-chamber, where it is very advantageous to exert ultra-high pressure and it is not possible to apply the coiled chambers due to the external support yokes they have. It can be further used to produce hydrogen storage tanks manufactured by cylinders joined by isostatic pressure interference, which are better than the new coiled tanks without yokes. It is necessary to produce different models for the specific function: for pressure, for size, for temperature, etc.

NUMERICAL REFERENCES

[0038]

101, 102: Cylinders to be joined by interference fit
201, 202: Auxiliary cylinders
211, 212, 213, 214: Ringed cylinder caps
301: Assembly chamber

Claims

1. Method for joining two or more concentric cylinders (101, 102) by isostatic-pressure interference, being one or two of said cylinders already interference-joined; auxiliary cylindrical tubes (201, 202), caps (211, 212, 213, 214) and assembly chamber (301) of high pressure to be used as tools of the process for joining by isostatic-pressure interference; elastic and structural guides to push one cylinder into another, being inside the assembly chamber (301); wherein each pair or set of concentric cylinders (101, 201) and (102, 202) is prepared with the respective caps (211, 212), (213, 214) welded or glued forming auxiliary or tubular chambers such that they are subjected to pressure within the assembly chamber (301) with liquid or gas, taking into consideration that no pressure enters the interior of the tubular chambers through the caps, where both consecutive tubular chambers must be so assembled with a gadget and small guides, such that when the pressure rises and the interference disappears -as the pressure increases the diameter of the cylinder (101) of the larger tubular chamber and decreases the diameter of the cylinder (102) of the smaller tubular chamber, it is in conditions then to fit, slide and put the smaller tubular chamber into the larger tubular chamber through the guide that was made for such effect, thus fitting as the mechanism for such effect is activated, where said mechanism can go on the interior of the tubes of smaller radius or on the outside; after the sliding or adjustment is produced, the pressure of the assembly chamber (301) is released from the already fitted cylinders, variation in the diameters is produced and the tubes that are joined by interference (101 and 102) tend to return to the initial diameter; the auxiliary cylinders are removed and only both cylinders are left joined by interference.

2. The method according to claim 1, wherein a pair of cylindrical tubes (101 and 201) with caps is prepared, another tube (102) with circular caps or without caps is also prepared, and the interference takes place between the tubes (101, 102); analogously to the case of claim 1, the pressure in the assembly chamber (301) removes the interference, and then a cylindrical tube (102) slides into the other (101), the pressure in the assembly chamber is lowered and the auxiliary cylinder and the caps are disassembled, being the cylinders finally joined by the interference.

3. The method according to claim 1, wherein a pair of cylindrical tubes (102 and 202) with caps is prepared, another tube 101 without caps is also prepared; the interference also takes place in tubes 101 and 102: analogously to the previous case, the pressure removes the interference and then a cylindrical tube (102) slides into the other (101); the pressure in the assembly chamber (301) is lowered and the auxiliary cylinder and the caps are disassembled, being the cylinders finally joined by the interference.

4. The method according to claim 1, wherein a cylindrical tube 102 with circular caps is prepared, another tube 101 without caps is also prepared; the pressure removes the interference and then a cylindrical tube (102) is slid into the other (101); the pressure in the assembly chamber (301) is lowered and the

caps are disassembled, being the cylinders finally joined by the interference.

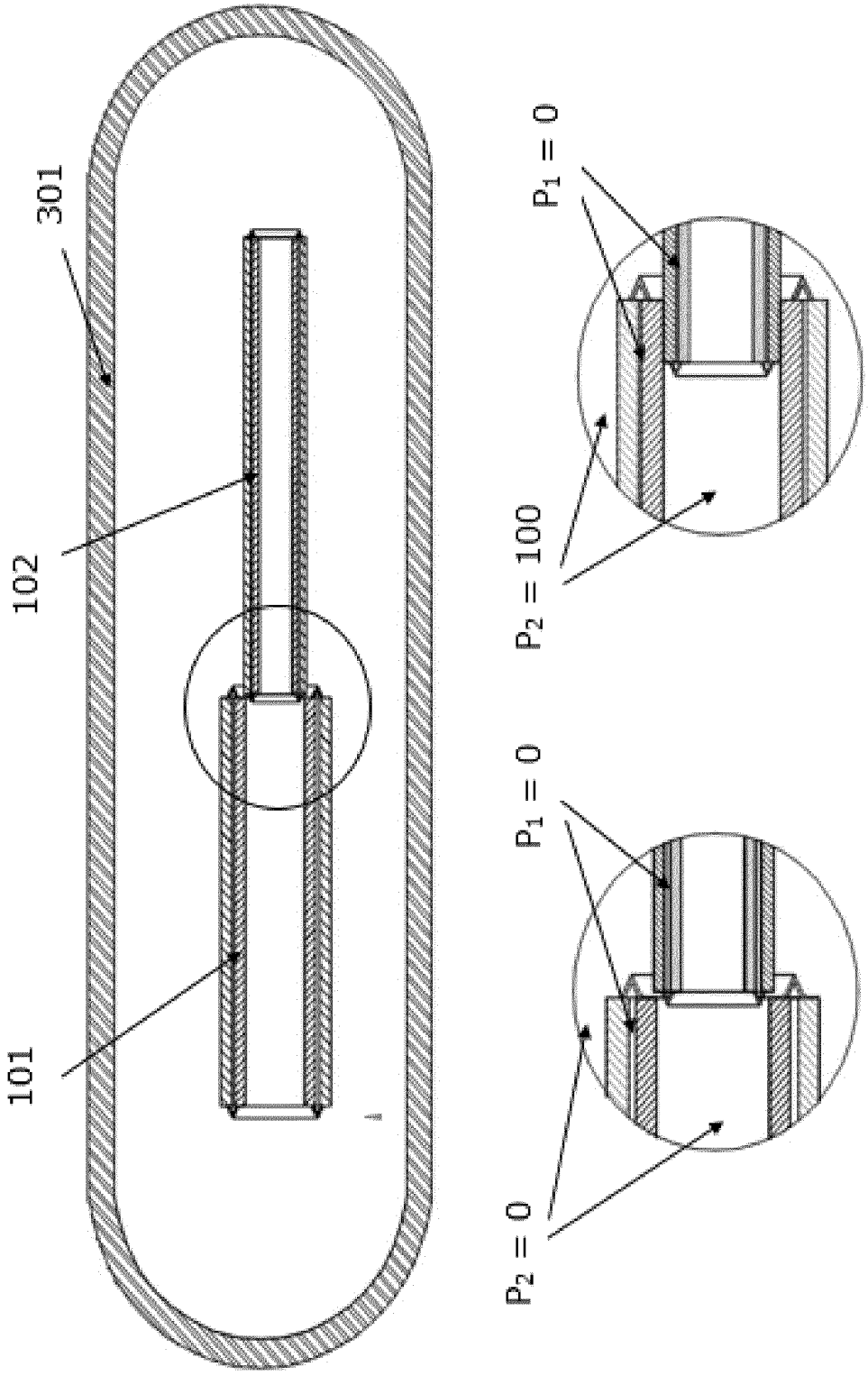
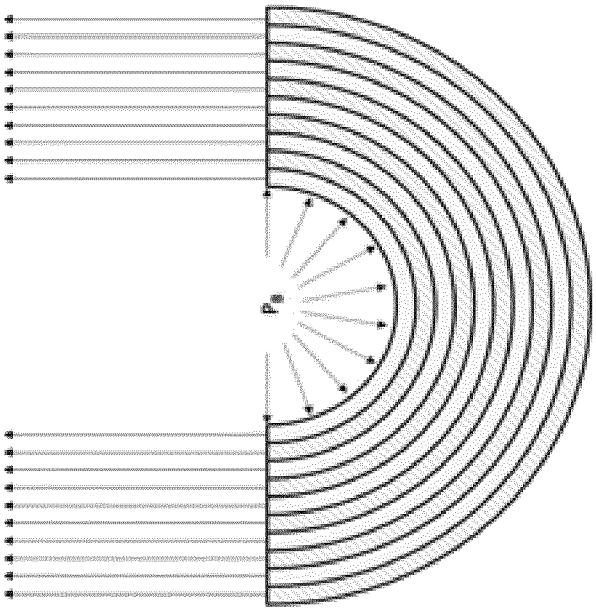


FIG. 1



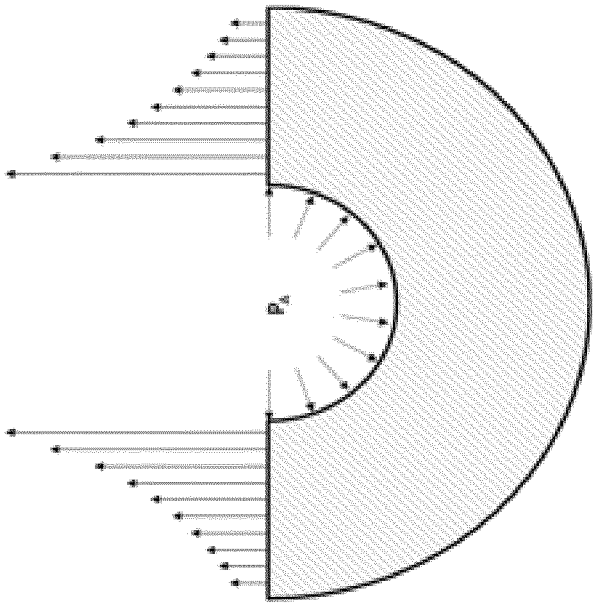


FIG. 2

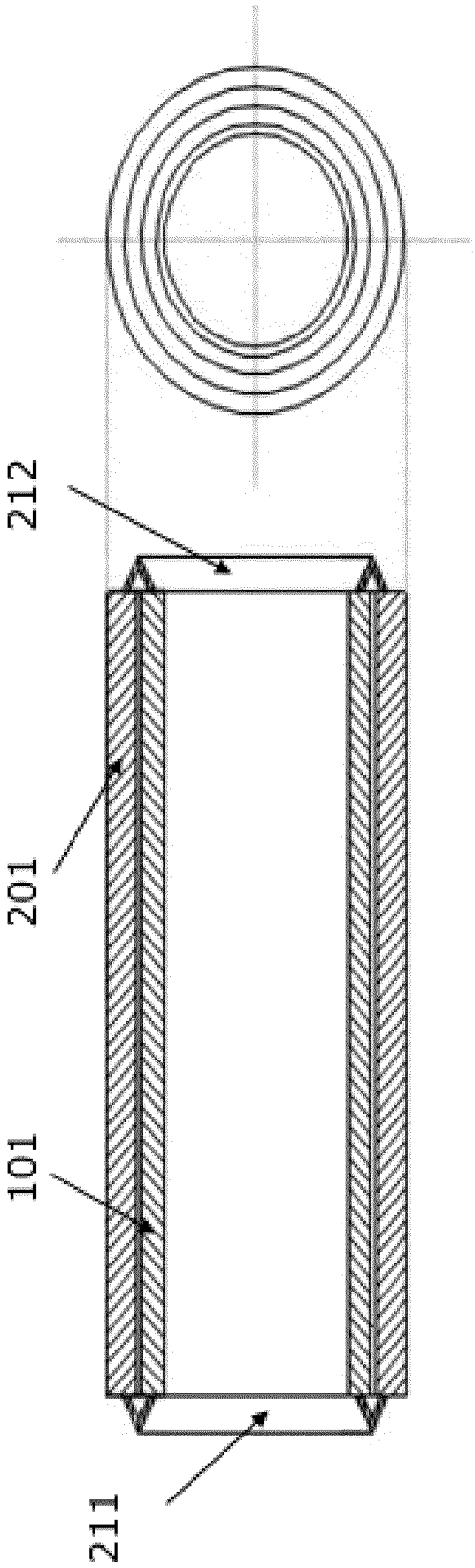


FIG. 3

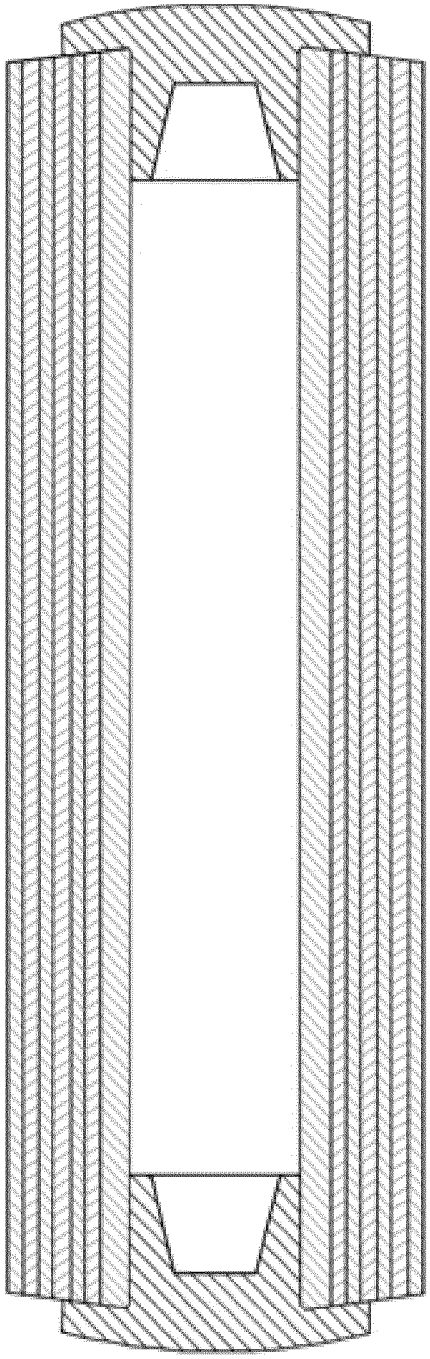


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CL2022/050069

A. CLASSIFICATION OF SUBJECT MATTER

(CIP) B21D39/04, 26/02, B23P11/02, B29C65/00, B21D51/24 (2022.01)

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)

(CIP) B21D39/04, 26/02, B23P11/02, B29C65/00, 65/68, B21D51/00, 51/24 (CPC) B23P11/022, B29C65/56, 65/565, Y10T29/49826

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)

Esp@cenet, Google Patents, EPOQUE-Net, INAPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ES 2635277 A1 (METRONICS TECHNOLOGIES, S.L) 03-10-2017 Abstract, Description, pag. 6, line. 5-35, pag. 7, line. 1-34, pag. 8, line. 1-4, Figs. 1-5 (refs. 1 , 2, 11 , 12, 21 , 22, 30, d, D,D')	1-4
A	US 3345732 A (GENERAL DYNAMICS CORPORATION) 10-10-1967 The whole document	
A	US 3068562 A (STRUTHERS WELLS CORPORATION) 18-12-1962 The whole document	
A	DE 102015117956 A1 (SALZGITTER FLACHSTAHL GMBH) 27-04-2017 The whole document	

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

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Date of the actual completion of the international search	Date of mailing of the international search report
11 August 2022	23 September 2022
Name and mailing address of the ISA/ INAPI Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CL2022/050069

ES 2635277 A1	03-10-2017	ES 2635277 B1	02-04-2019
US 3345732 A	10-10-1967	AT266556 (B)	25-11-1968
		BE664918 (A)	01-10-1965
		CH443794 (A)	15-09-1967
		DE1527547 (B1)	05-01-1972
		FR1435694 (A)	15-04-1966
		GB1082286 (A)	06-09-1967
		NL6507476 (A)	13-12-1965
		SE322751 (B)	20-04-1970
US 3068562 A	18-12-1962	None	
DE 102015117956 A1	27-04-2017	EP3365172 (A1)	29-08-2018
		KR20180071304 (A)	27-06-2018
		RU2690818 (C1)	05-06-2019
		US2018313471 (A1)	01-11-2018
		WO2017068008 (A1)	27-04-2017

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 201902913 A **[0014]**
- WO 201902988 A **[0014]**