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(54) **A method for making a ceramic product.**

(57) A method for making ceramic products comprises the following steps: filling a porous mould (1), composed of at least two parts (2, 3) joined to each other to form at least one moulding cavity (4) for casting a liquid mixture or slip at an initial pressure; forming the thickness (S) of the ceramic product (M) by pouring in more slip at a higher pressure than the initial pressure in such a way

as to separate out the water from the mixture, this water being drained out through the walls of the mould (1), that is to say in a direction (DE) outwards from the cavity (4); emptying the excess slip out of the mould (1); the step of emptying the excess slip is followed by a step of applying a negative pressure (D) inside the cavity (4) in order to enable the moisture content of the ceramic product (M) to be reduced.

FIG.3

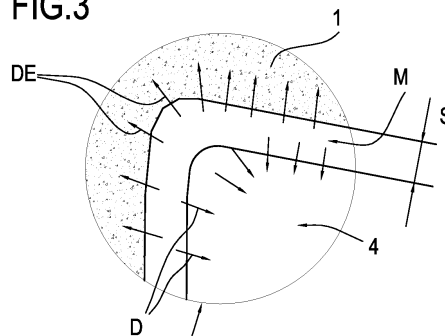
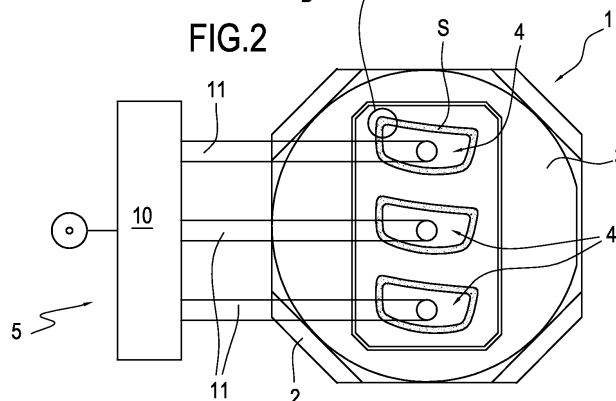


FIG.2



Description

[0001] This invention relates to a method for making a ceramic product, in particular ceramic sanitaryware.

[0002] As is well known in this trade, ceramic sanitaryware (such as washbasins, toilet bowls, bidets and the like) are made by pressure casting a liquid mixture, known as slip, consisting of water, clay and very small quantities of other substances, in "shell" moulds made preferably of porous resin. The mould gives the article of sanitaryware the required shape and after a certain length of time (necessary to draw out the water) the article is extracted from the mould in a defined form and further processed according to a well-known sequence of steps until it is completely finished. Sanitaryware made in this way can be broadly divided into two main categories, namely: "solid cast" products and "liquid cast" products, as they are known in the jargon of the trade.

[0003] The first category of products (solid cast), typical examples of which are lidded cisterns, are thus defined because the thickness of the product wall is formed between the surfaces of the male and female parts of the mould.

[0004] The second category of sanitaryware, that is, liquid cast sanitaryware allows maximum freedom of form for the cistern and lids (referring again to this type of product). The mould may have different dimensional ratios within it and the casting cavities may be very large.

[0005] In this case, the casting cavity is not divided between a male and a female part, as in the previous case, but the walls of the product are formed by a single surface within the mould. Products of this type are made in installations of known type comprising the above mentioned mould and designed to utilize a high-pressure casting process which, in its simplest and most basic form, comprises the following steps:

- flushing the feed circuits with fresh slip;
- filling the mould at an initial pressure;
- forming the product wall thickness with pressure profiles greater than the filling pressure;
- emptying the mould and returning, normally, to atmospheric pressure;
- consolidating the product;
- extracting the product after opening the mould parts.

[0006] Immediately after being demoulded, the product is easily subject to plastic deformation and is referred to as "greenware" in the jargon of the trade.

[0007] The casting cycle starts with the mould closed and the moulding cavity perfectly clean and empty and ends with the mould closed but with the cavity containing the product just made and whose mechanical strength must be sufficient for it to bear its own weight when it is extracted from the mould.

[0008] In order to be complete, the production cycle must, as is known, include a step of closing the mould prior to casting, and a step of demoulding the product

after it has been formed.

[0009] This type of casting, known as high-pressure casting, allows the product wall "thickness" to be formed in a relatively short space of time and appreciably reduces the overall production time. One example of an installation and related high-pressure process for making solid-cast products is known from document US 4,591,472.

[0010] In that solution, the "female" mould is provided with two separate channels at the bottom of it, one for feeding in the slip and the other for discharging the used slip after the thickness of the ceramic product has been formed. The slip can be discharged more quickly by introducing air into the mould cavity via the slip feed channel.

[0011] One of the drawbacks of the prior art method and related installations of this type is that the structure of the ceramic ware (that is, the thickness of the cast) is formed as the water in the slip fed in at high pressure is forced out of the product and drained out through the walls of the porous mould at a rate such as to diversify the moisture gradient along the thickness of the cast. This problem cannot be solved by prior art processes and installations which, in practice, simply attempt to optimize the operating pressures between the cavity on the inside and the draining parts on the outside in order to make the thickness of the product as uniform as possible while casting is in progress.

[0012] Thus, during and after the formation of the thickness, the moisture content, or gradient, rises considerably from the surface of the cast that is in contact with the mould to the opposite surface of the cast.

[0013] In other words, the final cross section of the cast (that is, when the cast has reached the desired thickness, estimated using defined process parameters based on the shape and size of the ceramic ware to be made) can be divided into a "drier" (outermost) part and an inner part where the moisture content of the cast is still high compared to that of the drier part.

[0014] The above applies to both solid cast and liquid cast ceramic ware, though it acquires more critical proportions in products of the latter type, which tend to have more complex surfaces and intricate geometries.

[0015] This steep moisture differential, or gradient, creates stress differences in the casts during the subsequent step of drying proper, which may eventually lead to cracking and other defects, making it necessary for the product to be scrapped. The casting cycle normally includes steps of pre-drying the cast by allowing it to stand for specified lengths of time, which, however, not only do not significantly reduce the moisture gradient but tend to cause the outer surface of the cast to solidify to a greater extent than the inner portion without effectively reducing the moisture differential through the cross section of the cast. This invention therefore has for an aim to overcome the above mentioned drawbacks by providing a method for making a ceramic product which is capable of reducing the overall moisture content of the product while remaining within standard process cycle times.

[0016] Another aim of the method according to the invention is to harmonize, or at least make more uniform, the moisture content in all the sections of the product just cast.

[0017] A further aim of the invention is to provide a method for making ceramic products where the uniformity of the moisture content is obtained without modifying the basic structure of the casting installations and moulds used to make the ceramic products. Accordingly, this invention achieves this aim by providing a method for making ceramic products, in particular for making ceramic sanitaryware and comprising the technical characteristics set out in one or more of the appended claims.

[0018] The technical features of the invention, with reference to the above aims, are clearly described in the claims below and its advantages are more apparent from the detailed description which follows, with reference to the accompanying drawings which illustrate a preferred embodiment of the invention provided merely by way of example without restricting the scope of the inventive concept, and in which:

- Figure 1 is a schematic representation, with some parts cut away in order to better illustrate others, of an installation for making ceramic products in which the method for making the ceramic products can be applied;
- Figure 2 is a schematic top plan view, with some parts cut away to better illustrate others, of the mould used in the installation of Figure 1;
- Figure 3 illustrates a scaled-up detail from Figure 2;
- Figure 4 is a Cartesian graph representing a controlled sequence of a step in the method according to the invention.

[0019] With reference to the accompanying drawings, in particular Figures 1 and 2, the method according to the invention is used for manufacturing ceramic products, in particular but not limited to, ceramic sanitaryware (such as, for example, washbasins, washbasin pedestals, toilet bowls, bidets, shower trays, and the like) using a liquid mixture known as slip.

[0020] The method is used in installations such as that illustrated in Figures 1 and 2, which show only the parts relevant to this invention.

[0021] The installation, denoted in its entirety by the numeral 5, basically comprises:

- a porous mould 1 comprising at least two parts 2, 3 which can be coupled to each other to form at least one cavity 4 for casting the ceramic product M;
- a unit 6 for feeding/discharging the liquid mix or slip at predetermined pressures and comprising a first pipe 7 connected at one end to a tank 8 containing the slip and at the other, to at least one of the parts 2, 3 of the mould 1;
- a unit 9 for controlling the product M casting cycle, connected at least to the unit 6 for feeding/discharging

ing the slip.

[0022] As shown by way of a non-limiting example in Figures 1 to 3, the mould 1 comprises two parts 2, 3 (male and female) made of porous resin and forming three cavities 4, each used to make a washbasin pedestal (in this situation, the moulds are liquid casting moulds).

[0023] The accompanying drawings also schematically show customary controls (such as taps and solenoid valves) of the circuitry which feeds the fresh slip and discharges the used slip.

[0024] For making these ceramic products, the method according to the invention comprises the following steps:

- filling the porous mould 1, made up of the two parts 2, 3 coupled to each other to form one or more moulding cavities 4, with liquid mixture or slip at an initial pressure;
- forming the thickness S of the product M by adding more slip at a higher pressure than the initial filling pressure so that water is separated from the mixture and absorbed by the porous walls of the mould 1, that is to say, in an outward direction DE relative to the cavity 4;
- emptying the mould 1 of the excess slip and lowering the pressure until reaching a pressure value which, usually, is atmospheric pressure.

[0025] The step of emptying the excess slip is followed by a step of applying a negative pressure, indicated by the arrows D inside the cavity 4 in order to reverse the direction DE of the pressure previously applied to separate the water from the rest of the slip. The reversed direction enables the moisture content of the ceramic product M to be reduced.

[0026] In other words, applying a high negative pressure for a short time in the cavity or cavities 4 has the effect of making the moisture content along the thickness S of the cast product M more uniform, and hence of reducing the differences between the moisture contents of the product M along its thickness S, where the limit values of moisture content are those at the surface in contact with the mould (lowest moisture content) and at the innermost portion of the cavity (highest moisture content).

[0027] The negative pressure applied in the cavity 4 reduces the moisture of the innermost zone of the thickness S, thereby causing a general reduction in the moisture content through the product M as a whole.

[0028] Obviously, the step of applying a negative pressure may be performed in different ways and according to parameters that depend also on the type of product, that is to say, on the thickness of the product. Advantageously, this step of applying suction is performed during the step of pre-drying the interior (with the mould closed), which may take several minutes.

[0029] The graph of Figure 4, where the pressure values are on the ordinate axis and time (in seconds) is on the abscissa axis, shows different options.

[0030] A first option is to apply a negative pressure in a single step in a space of time T of between 1 and 100 seconds with a negative pressure value D of between 0.05 and 1 bar.

[0031] Preferably, the step of applying the negative pressure is performed in a shorter space of time T, for example between 1 and 10 seconds, again with negative pressure values D of between 0.05 and 1 bar.

[0032] The graph shows a first possibility, illustrated by the continuous line, with a time T of one second (products with reduced thickness) at a negative pressure of one bar, or, illustrated by a dashed line, with a time T of two seconds at one bar. Another possibility is that of performing the step of applying a negative pressure D in at least two sub-steps S1 and S2 separated by a pause P.

[0033] The dot-dashed lines in the graph show by way of a non-limiting example a first sub-step S1 of applying a negative pressure D in a space of time T1 of between 1 and 50 seconds (in this particular case, 3 seconds) and a second sub-step S2 performed in a space of time T2 again of between 1 and 50 seconds (in this case, one and a half seconds, for example) separated by a short pause P.

[0034] The two sub-steps S1 and S2 of applying the negative pressure D may, again, be performed with negative pressure values D of between 0.05 and 1 bar: as shown in the graph, the negative pressure applied in both the sub-steps S1 and S2 may be one bar.

[0035] According to the invention, the installation 5 described above comprises a unit 10 for generating the negative pressure D (illustrated as a block) equipped with a second pipe 11 leading into the cavity or cavities 4.

[0036] The unit 10 applies suction which extracts gaseous fluid through the second pipe 11 from the inside of the cavity 4 when the latter is emptied of the residual slip.

[0037] In practice, the unit 10 extracts gaseous fluid in a direction D opposite the above mentioned direction DE in which the watery part is separated from the rest of the slip while the thickness of the product is being formed.

[0038] The unit 10 is connected to and controlled by the casting control unit 9 of the installation 5 to enable suction to be applied after the cavity has been emptied of the used or residual slip.

[0039] In the embodiment illustrated purely by way of an example, the pipe 11 is connected to and passes through one of the parts 2, 3 of the mould 1 (in this case, the female part 3) and leads into the cavity 4 in a different zone from that of the first pipe 7 for feeding / discharging the slip.

[0040] More specifically, the second pipe 11 is connected to and passes through the top of the female mould part 3 on the side opposite that where the first pipe 7 is positioned.

[0041] Obviously, in the embodiment illustrated, there are three second pipes 11 leading into the respective cavities 4 of the mould 1.

[0042] The control unit 9 activates the negative pressure D after the used slip is discharged and the first pipe

7 is shut off to prevent any slip from flowing back into the cavity 4.

[0043] A method and an installation as described above, fully achieve the above mentioned aims thanks to the negative pressure in the product moulding cavity which partly dries the inner portions of the product or, rather, reduces the overall moisture content, making the moisture content more uniform along the thickness of the product.

10 [0044] The negative pressure is applied for a very short length of time compared to the total pre-drying time and does not therefore have a negative effect on process times but does significantly reduce the stresses on the product when it is removed from the mould and thus reduces the risk of having to scrap the product.

15 [0045] The invention described above is susceptible of industrial application and may be modified and adapted in several ways without thereby departing from the scope of the inventive concept. Moreover, all the details of the invention may be substituted by technically equivalent elements.

Claims

25 1. A method for making ceramic products, the method comprising at least the following steps:

- filling a porous mould (1), made up of at least two parts (2, 3) coupled to each other to form at least one moulding cavity (4), with fluid mixture or slip under pressure;
- forming the thickness (S) of the ceramic product (M) by pouring in more slip in such a way as to separate water from the mixture and drain this water out through the walls of the mould (1), that is to say in a direction (DE) outwards from the cavity (4);
- emptying the excess slip out of the mould (1); the method being **characterized in that**, after the step of emptying the excess slip, it comprises a step of applying a negative pressure (D) inside the cavity (4) in order to enable the moisture content of the ceramic product (M) to be reduced.

2. The method according to claim 1, **characterized in that** the step of applying a negative pressure (D) is performed according to predetermined times by a control unit (9) in order to make the moisture content along the thickness (S) of the cast product (M) more uniform.

3. The method according to claim 1, **characterized in that** the negative pressure is applied in a single step in a space of time (T) of between 1 and 100 seconds with a negative pressure value (D) of between 0.05 and 1 bar.

4. The method according to claim 1, **characterized in that** the negative pressure is applied in a single step in a space of time (T) of between 1 and 10 seconds with a negative pressure value (D) of between 0.05 and 1 bar. 5
5. The method according to claim 1, **characterized in that** the step of applying a negative pressure (D) is divided into at least two sub-steps (S1, S2) separated by a pause. 10
6. The method according to claim 5, **characterized in that** the first sub-step (S1) of applying a negative pressure is performed in a space of time (T1) of between 1 and 50 seconds and the second sub-step (S2) is performed in a space of time (T1) of between 1 and 50 seconds. 15
7. The method according to claim 5, **characterized in that** the first and second sub-steps (S1, S2) of applying the negative pressure are performed at negative pressure values (D) of between 0.05 and 1 bar. 20
8. An installation for making a ceramic product according to the claims from 1 to 7, the installation (5) comprising at least: 25
 - a porous mould (1) comprising at least two parts (2, 3) which can be coupled to each other to form the cavity (4) for casting the ceramic product (M); 30
 - a unit (6) for feeding/discharging the slip at pre-determined pressures and comprising a first pipe (7) connected at one end to a tank (8) containing the slip and at the other, to at least one of the parts (2, 3) of the mould (1); 35
 - a unit (9) for controlling the product (M) casting cycle, connected at least to the first unit (6) for feeding/discharging the slip, the installation being **characterized in that** it comprises a unit (10) for generating a negative pressure (D) equipped with a second pipe (11) leading into the cavity (4) made by the mould (1) in order to extract fluid from the inside of the cavity (4); the unit (10) being controlled by the control unit (9). 40 45
9. The installation according to claim 8, **characterized in that** the second pipe (11) is connected to and passes through one of the parts (2, 3) of the mould (1) and leads into the cavity (4) in a different zone from that of the first pipe (7) for feeding/discharging the slip. 50
10. The installation according to claim 8, **characterized in that** the second pipe (11) is connected to and passes through one of the parts (2, 3) of the mould (1) in a zone of the cavity (4) opposite that where the first pipe (7) is positioned. 55
11. The installation according to any of the foregoing claims from 8 to 10, **characterized in that** the second pipe (11) is connected to and passes through a mould part (3) at the top of the latter, opposite where the first pipe (7) is positioned.

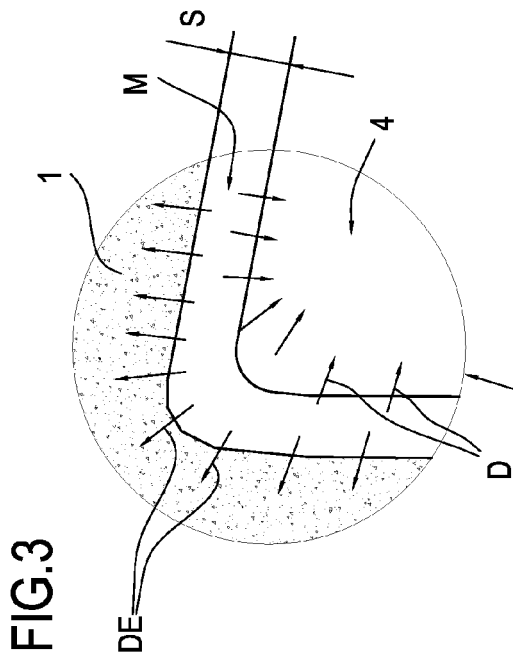
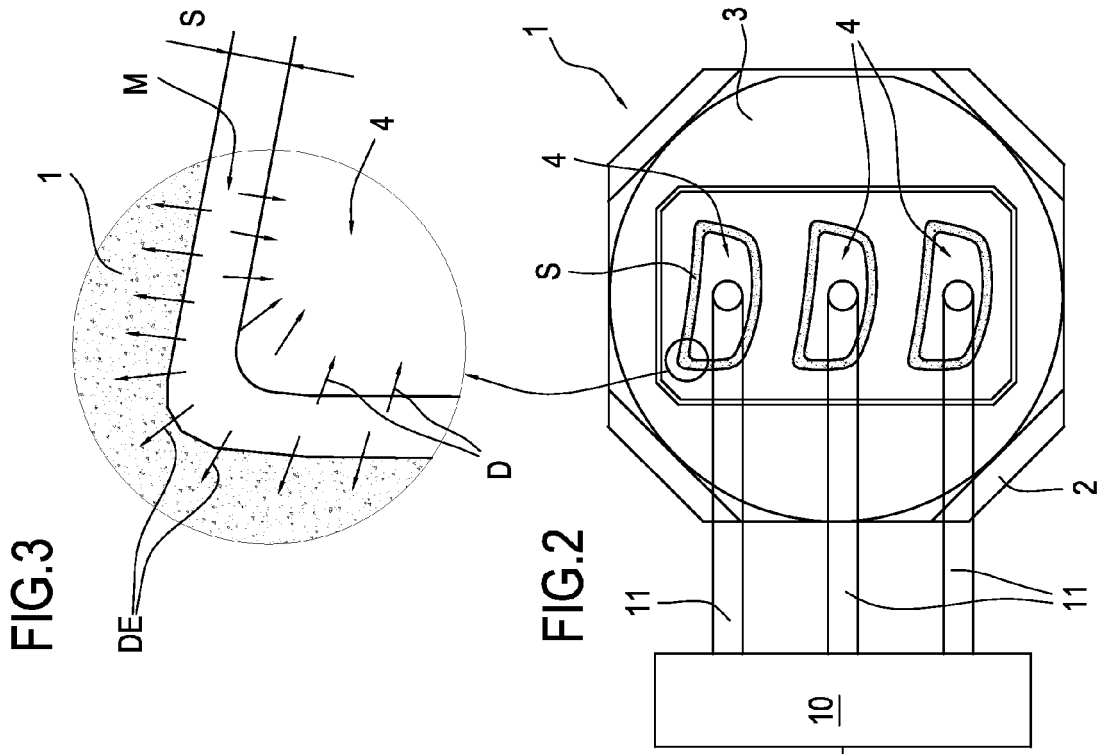
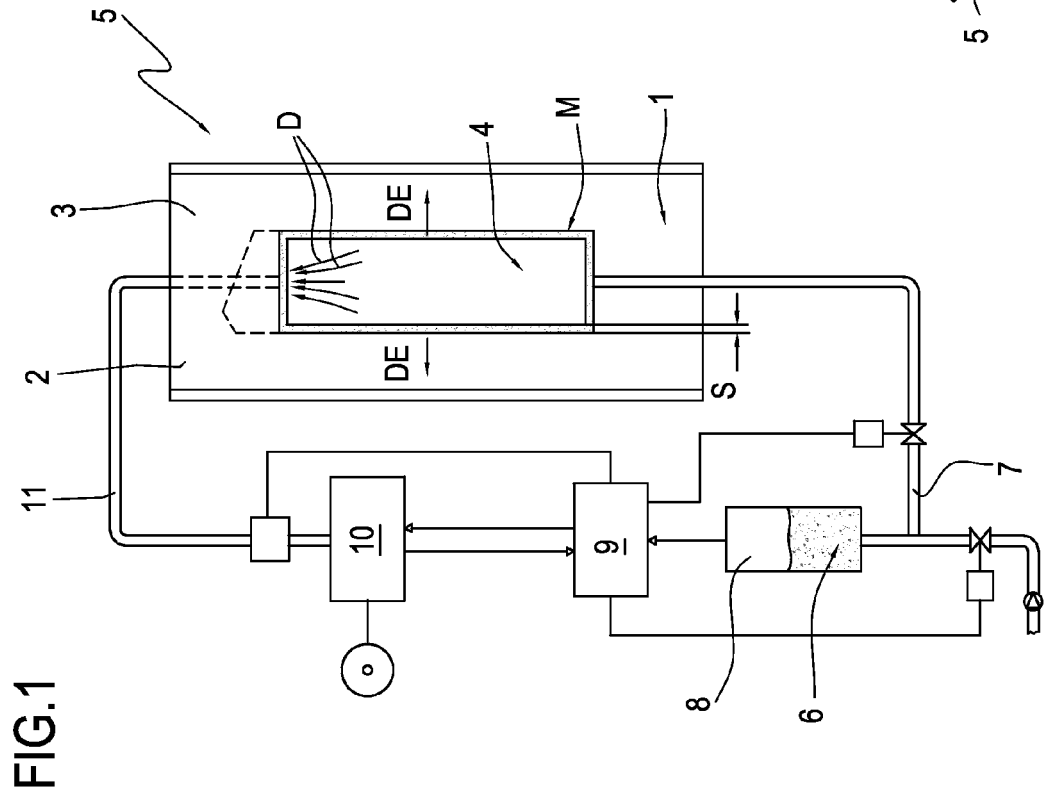
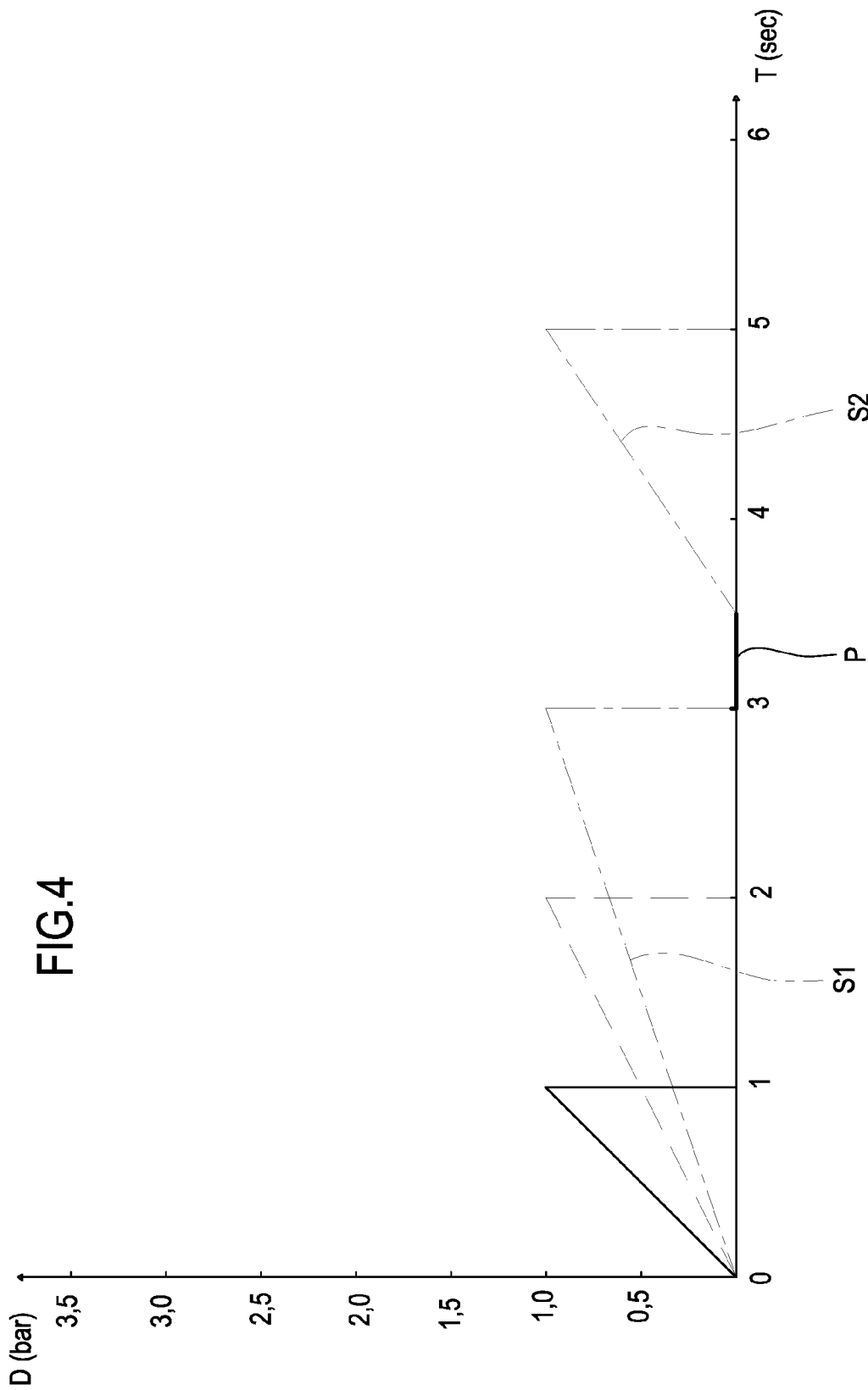


FIG.4





EUROPEAN SEARCH REPORT

Application Number
EP 10 16 6462

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search		Date of completion of the search	Examiner
The Hague		18 October 2010	Labre, Arnaud
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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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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