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(73) Owner/s:

**UNIVERSITY OF CANTABRIA (100.0%)**
**Government Pavilion, Avda. de los Castros s/n**
**39005 Santander (Cantabria) ES**

(72) Inventor/s:

**ARROYO MARTÍNEZ , Borja and**
**ÁLVAREZ LASO , José Alberto**

(54) Title: **Device for carrying out a miniature punching test under conditions of immersion in a liquid solution**

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Notice: Consultation may be carried out as provided for in art. 40.2.8 LP.

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(57) Summary:

Device for performing a miniature punching test, with load alignment and friction minimization, which allows the mechanical characterization of a specimen (25, 35) immersed in a liquid and comprises:

- a test device (11, 21, 31, 41, 61) comprising: the specimen (25, 35) to be tested between an oppression matrix (27) and a support matrix (28); a punch (26, 66) with a hemispherical head; the oppression matrix (27) which has an opening configured to serve as a guide to the punch (26, 66); the support matrix (28) which has an opening configured to allow deformation of the specimen (25, 35); and at least one tightening element;
- a stress transmitter system (12, 32, 42, 62) comprising two sections (320, 321, 420, 421) configured to transfer the force generated by the testing machine to each of the two ends of the testing device (11, 21, 31, 41, 61);
- a container (13, 43, 53, 63, 83) configured to house a liquid inside in which to completely immerse the specimen (25, 35), comprising two openings (60) on two of its opposite sides configured to place the test device assembly (11, 21, 31, 41, 61) during the test, and stress transmitter system (12, 32, 42, 62) along the axis between the two openings (60);
- a bracket (14, 74) configured to support the test device (11, 21, 31, 41, 61), the stress transmitter (12, 32, 42, 62) and the container (13, 43, 53, 63, 83).

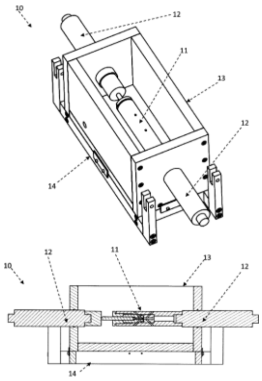

Figura 1

ES 2 534 613 B2

Notice: Consultation may be carried out as provided for in art. 40.2.8 LP.

## DESCRIPTION

# DEVICE FOR PERFORMING A MINIATURE PUNCHING TEST UNDER CONDITIONS OF IMMERSION IN A LIQUID SOLUTION

**FIELD OF INVENTION**

The present invention belongs to the field of devices for the characterization of the mechanical properties of a sample immersed in a liquid and, more specifically, to the field of devices for the characterization of a sample in liquid.
conditions of stress corrosion and environment-induced embrittlement.

**BACKGROUND TO THE INVENTION**

At present, the characterization of materials under submersion conditions in a Liquid is a practice of interest, regardless of the type of material and the area of application.

Specifically, metals are a very important element at a structural level, both in industrial, energy, building or any other type of work
This importance is due to their numerous qualities that make them optimal for the work they perform, either due to their resistance, rigidity, hardness or tolerance to high temperatures. However, despite possessing excellent qualities, metals are susceptible to so-called corrosion or degradation effects when in contact with certain liquid media. Only metals
Noble metals, such as gold or platinum, are exempt from these phenomena, but their use in civil works is unusual due to their high cost and lower mechanical properties than other metals.

Because of this variability that most metallic materials suffer, it is

It is advisable to control its mechanical properties during its life of SERV1C10, by means of various techniques and instruments that allow characterizing the material under conditions of immersion in a liquid of greater or lesser aggressiveness for it.

For example, on many occasions industrial or structural elements are designed, such as pipes, tanks, support gantries, etc., which are submerged or in direct contact with liquids or solutions of various indoles. There are many cases in which it is necessary to transport, contain or treat liquid elements such as wine products, animal fats, effluents from the

Mineral and vegetable oils, milk, agricultural liquid effluents, effluents for purification plants, mortar slurries, etc.

There are devices to characterise materials immersed in these organic liquids (milk, fats, animals, wine products, liquid waste, etc.) and to study its evolution over time, thus preventing possible failures.

On countless other occasions the materials are in contact with corrosive environments, such as off-shore wind turbines, oil platforms, buried metal pipes, port facilities, the naval industry, etc. In these In these cases, it is vitally important to know the properties of the constituent materials of these installations in relation to the environment to which they are going to be exposed, and it is very useful to be able to study their evolution over time.

The effects of corrosion can present themselves in many different ways; however, it is stress corrosion (CBT) is the most dangerous form of corrosion, as it usually occurs in elements of certain structural responsibility. CBT is a phenomenon by which a solid, exposed to the action of certain corrosive media, fractures at stress values much lower than those of dysefium. It occurs as a result of the simultaneous action of three factors:

Material susceptible to corrosion under stress.

Corrosive environment for such material.

Presence of stresses due to mechanical stresses.

CBT is often alleviated by the imposition of protective systems Against it, the most widely used technique in the energy and industrial sectors is known as cathodic protection, through which the loss of material due to this phenomenon is avoided due to a passivation of the metal to be protected. The system consists of the interconnection of a sacrificial anode, of a less noble metal than the one to be preserved, and the component in question that will act as a cathode, closing the circuit thanks to the electrolytic fluid in which they are submerged. In this way, a flow of electrons is generated between cathode and anode that will produce the aforementioned passivation; generally, as a stabilization of the process, an external source of current is interposed in the connection between cathode and anode, the range of external potentials used oscillates around 1V, in those situations in which the structure or component to be protected is of large dimensions (e.g. an oil platform) several years of slaughter and external sources of potential will be placed to achieve a homogeneous process throughout it.

While the above protection systems are effective against corrosion, they generate in the metal to protect problems of embrittlement by Hydrogen, which implies a significant reduction in mechanical resistance, this phenomenon is known as Environmentally Induced embrittlement (FIA), or more specifically Hydrogen embrittlement (HE) for this specific case. The damage produced by this process is not detectable in routine inspections and can be trigger rapid associated fracture mechanisms and resounding failures of components and structures. There are numerous losses caused as a result of these processes, including rupture of high-pressure gas transmission pipes, explosion of boilers, destruction of power plants or oil refineries.

In view of the above, it is necessary to characterize the behavior of the materials when they are going to be subject to any of the above conditions. The tests carried out consist of reproducing in the laboratory the conditions that will be experienced in service, exposing the test specimen of the material in question to the corrosive environment, while at the same time applying protection against corrosion. determined corrosion (or not as appropriate). There are different types of tests to evaluate the resistance to CBT and FIA processes of metals and alloys. The tests can be divided according to the way the load is applied, as well as the type of specimen used, and there is a wide variety:

Uniaxial tensile tests: the basis of this type of test consists of subjecting a specimen to constant load, constant deformation, or in a situation of slow deformation speed.

Bending tests: they consist of bending a specimen using a specific template where it fits, preventing it from recovering its deformation. elastic.

U-Shaped Specimen Testing: U-shaped specimens are generally rectangular bars that are bent 180 degrees with a predetermined turning radius that remains constantly deformed during corrosion testing.

"C" Specimen Testing: "C" specimens are a very versatile type of specimens for determining the cracking susceptibility of various types of alloys in a wide variety of shapes. The "C" shaped specimens increase their tension to a certain value, for a subsequent application of both a constant load and a constant deformation.

All these tests are standardised according to the standardised standard ISO-7539 *(UNE-EN ISO 7539. Corrosion of meta/s and alloys. Stress corrosion tests).*

There are currently many devices for performing CBT tests (load test rings, slow strain speed testing machines, slow drive machine with horizontal axis. .. ); however, all these devices require the use of specimens according to the various regulations, whose size is calculated from a few centimeters in any of its dimensions. This

Limitation in the size of the specimens is a disadvantage since it limits and sometimes prevents the sampling of structural components in service, and therefore their mechanical characterization during this phase. Surveillance programmes in these cases are limited to forecasts in the design phase and the replacement of components periodically (with consequent economic implications).

or emergency repair when an evolution different from the expected one has produced a catastrophic failure before time in some component (with even greater economic implications than the previous ones, and sometimes also human).

On the other hand, to alleviate those situations of material scarcity, characterization techniques arise by means of miniature tests, which, as their name suggests, require much smaller quantities than conventional tests. The *Small Punch test* is one of the most popular miniature techniques, which has enjoyed great levels of development over the last decade. It is a mechanical test carried out on a

A sample of flat material a few millimeters and tenths of a millimeter thick, which consists of the application of a mechanical load on one of its surfaces, by means of a hemispherical head punch. As a result of this test, a record is obtained of the variables force and displacement of the punch (or of the lower face of the specimen depending on the measurement method), temperature, time, etc., which with the correct

Analytical methodology allows estimating mechanical properties of the test specimen such as yield strength, tensile strength, fracture or creep properties.

It is a methodology of high interest for the following aspects:

Mechanical characterization of components in service, since generally the

Small Punch *sampling* does not involve any risk to the structure or component under study or control.

Evaluation of the properties of irradiated or hazardous materials, since the smaller the volume of the sample, the lower the daphiin dose received, and the easier it is to handle.

Additional results can be obtained from specimens already tested by conventional methods, since it is possible to re-machine *Small Punch* specimens from their undamaged areas and retest the material.

Characterization of coating layers, thanks to the reduced thickness of the samples.

Determination of the properties of very localized areas, such as the different regions of a welded joint, which would not otherwise be possible. In general, characterization of materials in any shortage scenario where there is no availability to manufacture conventional specimens.

The experimental device used to perform *Small Punch tests,* as defined in the Code of Good Practice with recommendations for the performance of the tests *(CWA 15627:2007. Small Punch Test Method for Metallic Materials. European Committee for Standardization, 2007),* should be made up of the following elements *(Manahan, MP., Argon, A.* S. *and Harling,* 0. *K. "The Development of a Miniaturized Disk Bend Test for the Determination of Postirradiation Mechanical Properties". Journal of Nuclear Materials 103-104. 1981, pp. 1545-1550),* comprises:

A rigid matrix to support the specimen, perforated in its central part to allow its deformation.

A rigid matrix that presses the sample, embedding it throughout its contomo, and which is also perforated in its central part to allow the passage of the punch that is going to press the specimen.

A hemispherical head punch, responsible for exerting pressure on the specimen.

The sequence to follow to perform a *Small Punch* test is as follows:

Placement of the sample in the support matrix: to ensure that it is correctly placed, the support matrix has a recess in which the Specimen snaps in and is fixed, in order to facilitate the process.

Placement of the oppressor matrix on the sample, in such a way as to guarantee the correct embedding of the sample throughout its content.

Attachment of the tooling to a universal mechanical testing machine, or to a machine specially conditioned for this purpose.

Introduction of the punch into the specimen.

Completion of the essay. The test ends with the breakage of the specimen or when a decrease corresponding to 20% of the maximum load exerted is reached.

As discussed above, the *Small Punch assay* is very useful for characterize materials when there is no availability to manufacture conventional specimens, as is the case with materials in service. However, at present there is no device that allows the *Small Punch* test to be carried out on material immersed in a liquid, so to characterize a material under these conditions, which is required to predict its behavior in CBT or FIA situations, it is necessary to resort to existing conventional tests for such purposes, with the implications of sample dimensions that this entails.

**SUMMARY OF THE INVENTION**

The present invention seeks to solve the above-mentioned drawbacks by means of a device for carrying out a miniature punching test, with alignment of loads and minimization of friction, which allows the characterization of a specimen immersed in a liquid.

Specifically, in a first aspect of the present invention, a

Device for performing a miniature punching test, with alignment of loads and minimization of friction, configured to be coupled to a testing machine configured in turn to exert a force on the device.

The device allows the mechanical characterization of a specimen immersed in a liquid and comprises:

- a test device comprising: the specimen to be tested between an oppression matrix and a support matrix; a hemispherical head punch configured to transmit the test force to the specimen; the pressure matrix which presents, in the direction of the force, an opening configured to serve as a guide to the punch and which comes into contact with the specimen; the support matrix which presents, in the direction of the force and aligned with the opening of the pressure matrix, an opening configured to allow the deformation of the specimen on the opposite side where it is located. finds the punch; and at least one tightening element configured to, together with the dies, press and immobilize the specimen throughout its contomo; the punch, the pressure matrix and the support matrix being a rigid material considering the force to which they are subjected;

- a stress transmission system comprising two sections configured to transfer the force generated by the testing machine to each of the two ends of the testing device, so that each end of the test device is in contact with a different section;

- a container configured to house a liquid in which to completely immerse the specimen, comprising two openings on two of its opposite sides configured to, during the test, place the test device and stress transmission system along the axis between the two openings, in such a way that a part of each section included in the stress transmission system remains outside the container, and the test device and the remaining part of each section remain inside the container;

- A bracket configured to support the test device, stress transmitter system and vessel, so that identical load alignment and placement are achieved in all tests.

In a possible realization, the device is configured to perform the miniature test under conditions of stress corrosion or hydrogen embrittlement, and comprises an electrical circuit consisting of a first correctly insulated metal wire connected to the punch and an electrical source and a second insulated metal wire connected to said electrical source and to an electrode immersed in the liquid.
where such liquid is corrosive, acidic or aggressive as appropriate, and where each section included in the stress transmission system includes in turn at the end in contact with the test device, an insulating piece such that during the test each insulating piece is placed partly inside the container and partly outside the container, confining the electrical current inside the device essay.

In a possible realization, the device comprises two tightening elements, such that one of the tightening elements is located adjacent to the tightening matrix, and the remaining tightening element wraps around the outside of the dies, where the The tightening element adjacent to the pressure matrix has an opening, configured to allow the punch to pass through, in the direction of the force generated by the testing machine, this opening being aligned with the opening presented by the pressure die, and where the tightening element that surrounds the outside of the dies has a greater thickness on the inside of the opposite end where Penetrates the tightening element adjacent to the tightening matrix. Alternatively, the device comprises two tightening elements with a coupling system between them, such that one of the tightening elements is located adjacent to the tightening matrix and the remaining tightening element is located adjacent to the support matrix, and where the tightening element adjacent to the matrix of oppression has an opening in the direction of the force generated by the machine of tests, this opening being aligned with the opening presented by the pressure matrix.

In a possible realization, the at least one tightening element, the pressure matrix and The support matrix has a plurality of holes configured to facilitate the flooding of the specimen.

In a possible realization, the support is modular and comprises: four bars joined together in a parallel and configured to allow the anchoring of the container to the support; and four bars perpendicular to the previous ones located at the vertices of the parallelogern, and configured to allow the anchoring of the device to the testing machine.

In one possible realization, the container is modular and comprises a base plate in parallel-shaped and four side plates, these five plates being joined in such a way as to ensure the watertightness of the container in five of its spatial directions. Alternatively, the container is modular and comprises a base plate in the form of a parallel, four side plates and an upper plate, these six plates being joined in such a way as to ensure the watertightness of the container, and where The container also includes in at least one of its six plates, a hole with a watertight lid intended for filling the container.

In one possible embodiment, the openings of the vessel comprise a toroid-shaped polymer element configured to allow the transmitter of Efforts to slide correctly without stress and to prevent the loss of liquid from inside the container.

In a possible realization, one of the sides of the container has an opening where a tap is attached such that it is possible to empty the contents of said container and facilitate the handling of the test device.

**BRIEF DESCRIPTION OF THE FIGURES**

In order to aid a better understanding of the characteristics of the invention, according to a preferential example of practical realization of the same, and to complement this description, a set of drawings is accompanied as an integral part of it, whose character is illustrative and not limiting. In these drawings:

Figure **1** shows a schematic of the device of the invention, according to a realization of the invention, which includes a testing device, a stress transmission system, a container and a support.

Figure 2 shows a schematic of the testing device, according to a realization of the invention.

Figure 3 shows a diagram of the testing device and the stress transmission system, according to a realization of the invention.

Figure 4 shows a diagram of the test device, the efforts and the vessel, in accordance with a realization of the invention

Figure 5 shows a schematic of the vessel, according to a realization of the invention.

Figure 6 shows a schematic of the invention's device under stress corrosion conditions, according to a realization of the invention.

Figure 7 shows a schematic of the support, according to a realization of the invention.

Figure 8 shows a diagram of the support, fasteners and container, according to a realization of the invention.

**DETAILED DESCRIPTION OF THE INVENTION**

In this text, the term "includes" and its variants should not be understood in a In other words, these terms are not intended to exclude other technical characteristics, additives, components or steps.

In addition, the terms "approximately", "substantially", "around", "some", etc. should be understood as indicating values close to those to which such terms accompany, since due to calculation or measurement errors, it is impossible to obtain these values with total accuracy.

In addition, an ideal rigid body is understood to be one that does not suffer deformations due to the effect of external forces. However, real structures and machines are never absolutely rigid and deform under the action of forces acting on them, therefore, in the context of the present invention, a body, punch, matrix, joint or rigid material is understood to be one whose deformations under the action of the range of force values applied by the testing machine can be disregarded.

The characteristics of the device of the invention, as well as the advantages derived from them, can be better understood by the following description, made with reference to the drawings listed above.

The following preferred embodiments are provided by way of illustration and are not intended to be limiting to the present invention. In addition, the present invention covers all possible combinations of particular and preferred embodiments herein indicated. For experts in the field, other objects, advantages and characteristics of the invention will be derived partly from the description and partly from the practice of the invention.

invention.

The device for performing a miniature punching test, with load alignment and friction minimization, is described below, according to the diagram of the same in Figure 1. The device of the invention is configured to be coupled to a testing machine and allows characterizing a Cylinder immersed in a liquid. Non-limiting examples of specimen materials to be characterized are metal alloys. The specifications of the testing machine to which the device described is connected are outside the scope of the present invention.

The device of the invention comprises: a test device, a sisterna Stress transmitter, a container and a support. In addition, when the miniature punching test is performed under conditions of stress corrosion or hydrogen embrittlement, the device also comprises an electrical circuit that allows the electrical conditions necessary for the test to be generated. Figure 1 shows a particular embodiment of the device of invention 10, which comprises the test device 11, the stress transmitter system 12, the vessel 13 and the support 14.

It is important to note that the device of the invention allows it to test any material whose dimensions are in accordance with the test device.

Test device 21 comprises: specimen 25 to be tested, a hemispherical head punch 26, a tightening matrix 27, a support matrix 28, and at least one clamping element 291, 292. Figure 2 shows a particular embodiment of the test device 21.

Specimen 25 of the material to be tested is located between the oppression matrix 27 and the support matrix 28, which oppress and innovate specimen 25 throughout its contometer. The pressure matrix 27 has an opening in the direction of the force generated by the testing machine, this force being longitudinal to the device test 21, so that, during the test, punch 26 passes through this matrix of pressure 27 until it comes into contact with specimen 25, thus transmitting the strength of the test. The support matrix 28 also has an opening in the direction of force, and aligned with the opening of the pressure matrix 27, such that it allows the deformation of specimen 25 on the opposite side where the punch 26 is located.

In this way, specimen 25 is pressed and immobile in its external area, and only in the area delimited by the opening of the support matrix 28 (area exposed to punch 26) is it deformed as a result of the force generated by the testing machine and transmitted by said punch 26 being applied to it.

An expert in the field shall understand that the test conditions as well as the characteristics (materials, dimensions, shapes, etc.) of the dies and the punch are set out in the Code of Good Practice for the Conduct of Small Punch Miniature *Tests.* For example, the dies and the punch must be rigid considering the force to which they are subjected by the testing machine.

For example, the opening of the support matrix has certain dimensions specified in the Code of Good Practice, necessary for the deformation of the specimen, because if its shape changes, the result of the test may be different.

In addition, in order to achieve perfect immobilization and sealing of specimen 25 between the two dies 27, 28, the test device comprises at least one tightening element.

In a possible realization, test device 21 comprises two elements of 291, 292, so that one of the tightening elements is located adjacent to the pressure matrix, and the remaining tightening element wraps around the outside of the dies. As shown in Figure 2, the clamping element adjacent to the pressure matrix is a thyme 291 with external threading 294 and the remaining tightening element a tube 292 with internal threading 293, such that inside said tube 292 are the matrices 27, 28, the specimen 25, the puncture 26 and the thyme 291. In addition, tube 292 has a greater thickness on the inside of the end

The opposite is where the thyme 291 penetrates, so that thanks to the threading of both tightening elements 291, 292, a perfect tightening is achieved and the impossibility of relative movement of the set of dies 27, 28 and specimen 25. In addition, and to allow the passage of the puncture 26 through the matrix of oppression 27, the thyme 291 It has an aperture 290 in the direction of the force generated by the testing machine, this aperture being aligned with the aperture presented by the pressure matrix 27.

In another possible realization, the test device comprises two elements of tightening, in such a way that one of the tightening elements is located adjacent to the pressure matrix, and the remaining tightening element is located adjacent to the support matrix. Preferably, both tightening elements are joined by an element that guarantees the union and immobility of both tightening elements. In addition, and to allow the punch to pass through the pressure matrix, the Tightening adjacent to the pressure matrix has an opening in the direction of the force generated by the testing machine, this opening being aligned with the opening presented by the pressure matrix.

In another possible embodiment, the test device comprises a single element of A tightening that wraps around the matrix and specimen assembly, and that allows the punch to pass through the pressure matrix, guaranteeing the immobilization of the specimen.

Preferably, the test device is shaped like a bar. In a possible realization, the pressure matrix and the support matrix have a cylindrical and They incorporate grooves and protrusions that prevent the relative rotation between the two matrices. In addition, in this possible realization, the tube-shaped clamping element is also cylindrical, with a fine, solid exterior machining made of stainless steel or conventional.

The stress transmitter system comprises two sections configured to transfer the force generated by the testing machine to the testing device.

During the test, and as can be seen in Figure 3, the two ends of the test device 31 are in contact with these two sections 320, 321 included in the stress transmission system 32, in such a way that each end of the test device 31 is in contact with a different section 320, 321.

The end of each section 320, 321 that is not in contact with the test device is connected to the testing machine, so that the sections 320, 321 transmit the forces generated by the test machine to the test device 31, and thus to specimen 35.

In a possible realization, sections 320,321 of the stress transmitter system 32 are solid and made of stainless steel or conventional with fine external machining. Preferably, each section 320, 321 is shaped like a bar.

The coupling of the stress transmission system to the testing machine is outside the scope of the present invention, since it depends on the specific type of testing machine used. However, a person skilled in the art will understand that such coupling must be stable for the full duration of the coupling.
test and ensure repeatability of results.

As can be seen in Figure 4, the test device 41 and part of sections 420 and 421 of the stress transmission system 42 are located, during the test, inside the vessel 43, thanks to two openings located on two opposite sides of the vessel 43. In this way, the test device set 41 and system
Stress transmitter 42 is located along the axis between the two openings, such that a part of the stress transmitter system remains outside the vessel 43, and the test device 41 and the remaining part of the stress transmitter system 42 remain inside the vessel 43.

The container is configured to be able to pour the liquid necessary to carry out the corresponding test inside. For example, if you want to characterize the

In conditions of stress corrosion or hydrogen embrittlement, the liquid must be a corrosive medium, such as salt seawater or sulphuric acid diluted in distilled water as the case may be (these are the most common but by no means the (mic).

In a possible realization, and as shown in Figure 5, vessel 53 is modular and comprises a base plate 55 in the form of a parallelogram and four side plates 56, 57, 58, 59 these five plates 55, 56, 57, 58, 59 being joined in such a way as to ensure the watertightness of vessel 53 in five of its directions spatial. In other words, container 53 is watertight except for the upper part intended for filling, thus avoiding the loss of liquid inside. That is why, in this case, the device of the invention must work with the horizontal axis.

In another possible embodiment, the vessel is modular and comprises a base plate in parallelogram shape, four side plates and a top plate, these six plates being joined in such a way as to ensure the watertightness of the container. In addition, the container comprises in at least one of its six plates, a hole with a watertight lid intended for filling the container, such that once the corresponding liquid is introduced and the hole closed with the lid, the container is completely watertight. In this case, the device of the invention can work with the horizontal axis or with the vertical axis.

In addition, preferably, openings 60 of vessel 53 comprise a toroid-shaped polymer element, configured to allow the transmitting system to efforts to slide correctly without straining and to prevent the loss of liquid from inside the container 53.

In a possible realization, one of the sides of the container 53 has an opening 54 where a tap is attached in such a way that the contents of said container 53 can be emptied and facilitate the handling of the test device.

During the test, the specimen must remain completely submerged in the liquid. In this way, in order to promote the flooding of the specimen, in a possible realization, at least one clamping element, the pressure matrix and the clamping matrix, have a plurality of holes that communicate the specimen housing with the outside of the test device. For example, in Figure 2 we can see the plurality of holes 30 in the tube-shaped tightening element 292, in the pressure matrix 27 and in the support matrix 28.

As mentioned above, one of the possible tests that can be to be carried out with the device of the invention, is the test under conditions of stress corrosion or hydrogen embrittlement. To this end, in this possible realization, and as can be seen in Figure 6, the device of the invention comprises an electrical circuit consisting of a first correctly insulated metal wire 65 connected to the punch 66 and to an electrical source 67 and by a second insulated metal wire 68 connected to said electrical source 67 and to an electrode 69 immersed in the liquid, being said electrolytic corrosive liquid, which closes the electrical circuit.

In this particular embodiment, each section included in the stress transmission system 62 comprises in turn at the end in contact with the control device. test 61, an insulating piece 70 such that during the test each insulating piece 70 is placed partly inside the container 63 and partly outside the container 63, confining the electric current inside the test device 61. Preferably, each insulating piece 70 is connected to the rest of the stress transmitter system 62 by threading. In addition, and although as mentioned above, Previously, the testing machine used during the test is outside the present invention, it should be noted that in the case of stress corrosion or hydrogen embrittlement, it must be of low speed.

The test device, the stress transmitter system and the vessel are supported thanks to the support, which provides load alignment and identical placement in all tests.

In a possible realization, as can be seen in Figure 7, support 74 is modular and comprises: four bars joined together forming a parallelogram 75 and configured to allow the anchoring of the container to the support 74; and four bars perpendicular to the previous 76 located at the vertices of the parallelogram, and configured to allow the Anchoring of the device to the testing machine.

Specifically, as can be seen in Figure 8, in a possible realization, each pair of these four bars perpendicular to those that form a parallelogram, is configured to allow the anchoring of a fixing piece 85, 86, in such a way that the longitudinal axis of each fixing piece 85, 86 is located parallel to the sides of the container 83 which have an opening. Preferably, each fixing piece 85, 86 has three openings, a central opening 851, 861 and two side openings 850, 860, 852, 862 located in such a way that the central openings 851, 861 of the two fixing pieces 85, 86 are aligned, as are each pair of side openings 850, 852 of one fixing piece 85 with side openings 860, 862 facing the second fixing piece 86.

In addition, the central openings 851, 861 are in turn aligned with the openings of the container 83, thus allowing the passage of the test device. Preferably, Inside each central opening is a bearing 87 configured to withstand the loads and protect the test device from rubbing against the fasteners 85, 86.

On the other hand, each 850, 852, 860, 862 side opening is configured to allow the passage of a bar 88 included in the testing machine, in such a way that, during the test, the device of the invention remains attached to the testing machine by two bars 88, 89, so that each bar 88, 89 is placed through the two side openings 850, 860, 852, 862 aligned and located in different fastening parts 85, 86, achieving optimal load alignment.

In addition, in another possible realization, each of these four bars that form a parallelogram include a plate on the outside configured to allow the anchorage of the container to always be the same.

An expert in the field will understand that for the device of the invention to work correctly, there must be a perfect alignment of forces and minimal friction along all the elements comprising, which is achieved by the following effects: the effect of rigid and stable joints between the testing machine and the stress transmission system, and between the latter and the testing device; and the effect of the hemispherical head of the punch on its contact with the test tube.

In addition, other preferential realizations that contribute to perfect alignment and minimal friction are: the effect of the alignment of the openings of the container with the bearings placed in the central openings of the fasteners, which minimise friction and compensate for the action of self-weight and other forces in directions other than the axis of the sections of the stress transmission system; and the effect of the toroid-shaped polymer elements located in the openings of the vessel, achieving its tightness as well as the smoothness of the sliding of the stress transmitting system through it.

**DEMANDS**

1. Device for performing a miniature punching test, with load alignment and friction minimization, configured to be coupled to a A testing machine configured to exert a force on the device, the device being characterized by the fact that it allows the mechanical characterization of a specimen (25, 35) immersed in a liquid and that it comprises:

- a test device (11, 21, 31, 41, 61) comprising: the specimen (25, 35) test object located between an oppressive matrix (27) and a support matrix (28); a hemispherical head punch (26, 66) configured to transmit the force of the test on the specimen (25, 35); the pressure matrix (27) which presents, in the direction of force, an opening configured to serve as a guide to the punch (26, 66) and that it comes into contact with the specimen (25, 35); the support matrix (28) it presents, in the direction of force and aligned with the opening of the pressure die (27), an opening configured to allow deformation of the specimen (25, 35) on the opposite side where the punch is located (26, 66); and at least one clamping element configured to, together with the dies (27, 28), to press and immobilize the specimen (25, 35) throughout its content; being the punch (26, 66), the matrix of oppression (27) and the support matrix (28) of a rigid material considering the force to which they are subjected;

- a stress transmitter system (12, 32, 42, 62) comprising two sections (320, 321, 420, 421) configured to transfer the force generated by the tests at each of the two ends of the test device (11, 21, 31, 41, 61), such that each end of the test device (11, 21, 31, 41, 61) is in contact with a different section (320, 321, 420, 421);

- a container (13, 43, 53, 63, 83) configured to hold a liquid inside in which to completely submerge the specimen (25, 35), which comprises two openings (60) on two of its opposite sides configured to, during the test, place the whole test device (11, 21, 31, 41, 61) and stress transmitter system (12, 32, 42, 62) along the axis between the two openings (60), so that a part of each section (320, 321, 420, 421) included in the stress transmission system (12, 32, 42, 62) remains outside the vessel (13, 43, 53, 63, 83), and

test device (11, 21, 31, 41, 61) and the remaining part of each section (320, 321, 420,421) remain inside the container (13, 43, 53, 63, 83);

- a stand (14, 74) configured to support the test device (11, 21, 31, 41, 61), the stress transmitter system (12, 32, 42, 62) and the vessel (13, 43, 53, 63, 83), so that identical load alignment and placement are achieved in all tests.

2. The device of claim 1 configured to perform the miniature test under conditions of stress corrosion or hydrogen embrittlement, comprising

an electrical circuit consisting of a first metal wire (65) correctly insulated connected to the punch (26, 66) and to an electrical source (67) and by a second insulated metal wire (68) connected to that electrical source (67) and to an electrode (69) immersed in the liquid, the liquid being corrosive, acidic or aggressive, and where each section (320, 321, 420, 421) included in the stress transmission system (12, 32, 42, 62) in turn comprises at the end in contact with the test device (11, 21, 31, 41, 61), an insulating piece (70) such that during the test each insulating piece (70) is placed partly inside the container (13, 43, 53, 63, 83) and partly on the outside of the container (13, 43, 53, 63, 83), confining the electric current inside the test device (11, 21, 31, 41, 61).

3. The device of any of the foregoing claims comprising two tightening elements (291,292), such that one of the tightening elements (291) is located adjacent to the tightening matrix (27), and the remaining tightening element (292) wraps around the outside of the dies (27, 28), where the tightening element (27,28) is located on the outside of the dies.

Tightening (291) adjacent to the tightening matrix (27) has an opening (290), configured to allow the punch (26, 66) to pass through, in the direction of force generated by the testing machine, this opening being aligned with the opening presented by the pressure matrix (27), and where the tightening element (292) that surrounds the outside of the dies (27, 28) has a greater thickness on the inner face of the opposite end through which the tightening element penetrates (291) adjacent to the matrix of oppression (27).

4. The device of any of claims 1 to 2 comprising two clamping elements with a coupling system between them, such that one of the clamping elements is located adjacent to the clamping matrix (27) and The remaining tightening element is located adjacent to the support matrix (28), and where the tightening element adjacent to the pressure matrix (27) has an opening in the direction of the force generated by the testing machine, this opening being aligned with the opening in the pressure matrix (27).

5. The device of any of the above claims where the at least one clamping element (291, 292), the pressure matrix (27) and the support matrix (28), have a plurality of holes (30) configured to facilitate the flooding of the specimen (25, 35).

6. The device of any of the above claims, where the support (14, 74) is modular and comprises: four bars joined together in a parallelogram (75) and configured to allow the anchoring of the container (13, 43, 53, 63, 83) to the support (14, 74); and four bars perpendicular to the previous ones (76) located at the vertices of the parallelogram, and configured to allow the anchoring of the device to the essays.

7. The device of any of the above claims, where the vessel (13, 43, 53, 63, 83) is modular and comprises a base plate (55) in the form of parallelogram and four side plates (56, 57, 58, 59), these five plates being (55, 56, 57, 58, 59) joined together in such a way as to ensure the watertightness of the container (13, 43, 53, 63, 83) in five of its spatial directions.

8. The device of any of claims 1 to 6, where the container (13, 43, 53, 63, 83) is modular and comprises a parallelogram-shaped base plate, four side plates and a top plate, these six plates being joined together in such a way shape that ensure the watertightness of the container, and where the container also includes in at least one of its six plates, a hole with a watertight lid intended for filling the container.

9. The provision of any of the foregoing claims, where the openings (60) of the container (13, 43, 53, 63, 83) comprise a toroid-shaped polymer element configured to allow the stress transmitter system (12, 32, 42, 62) to slide correctly without stress and to prevent the loss of liquid from inside the container (13, 43, 53, 63, 83).

10. The device of any of the above claims, wherein one of the sides of the container (13, 43, 53, 63, 83) has an opening (54) where a tap is attached such as to allow the contents of the container to be emptied (13, 43, 53, 63, 83) and to facilitate the handling of the test device (11, 21, 31, 41, 61).

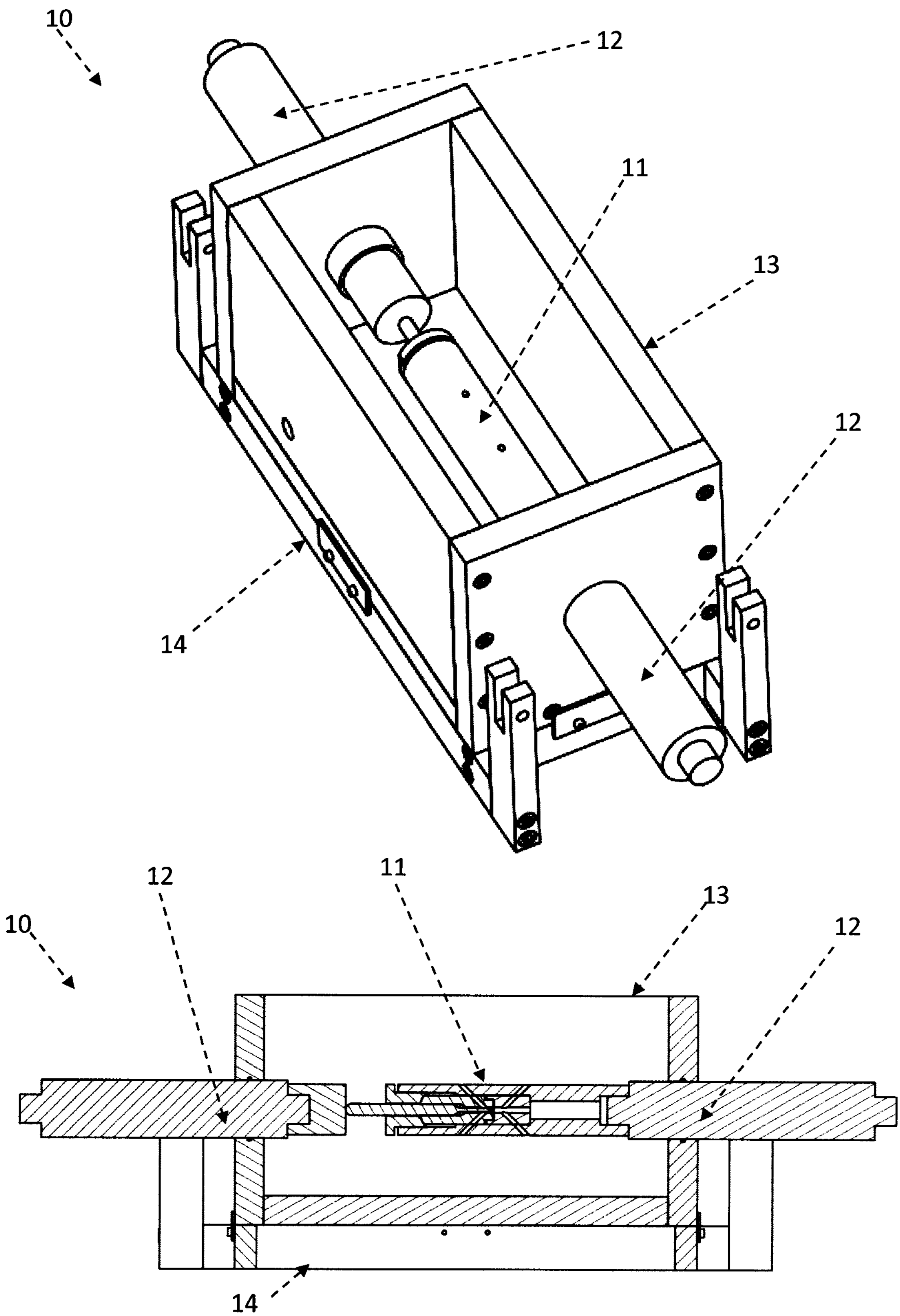


Figura 1

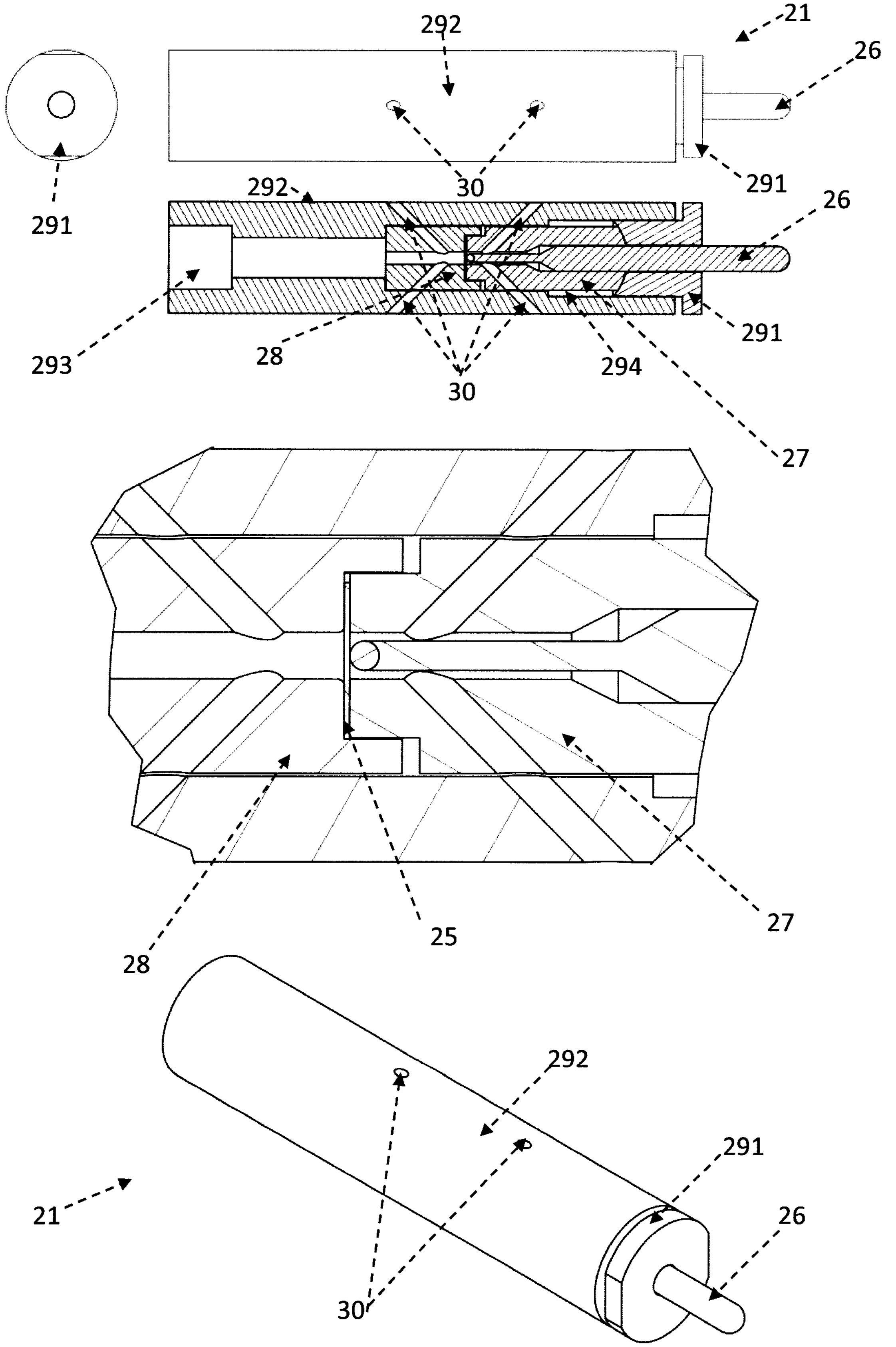

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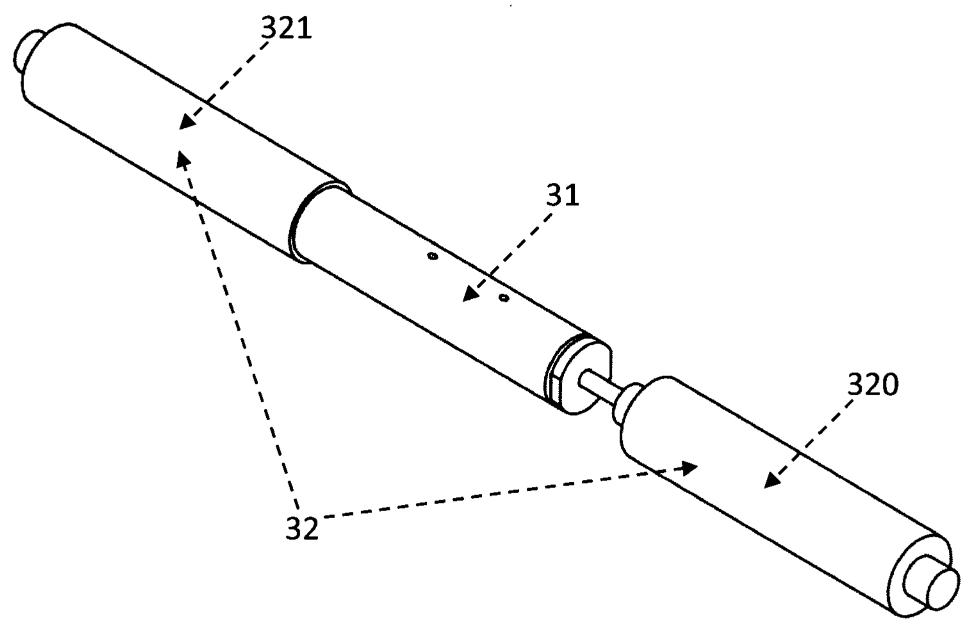
Figura 2



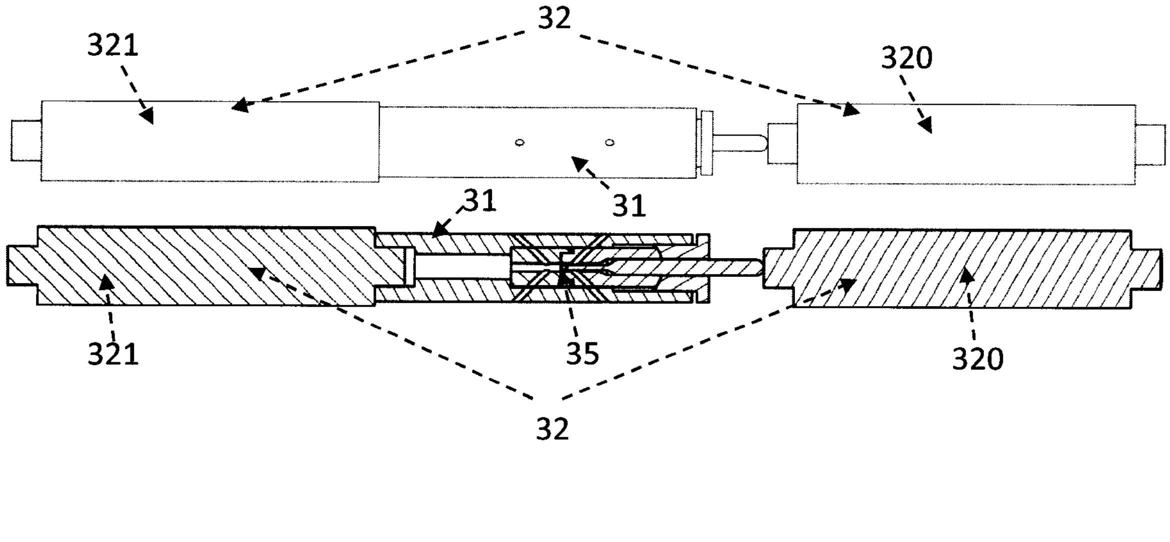




Figura 3

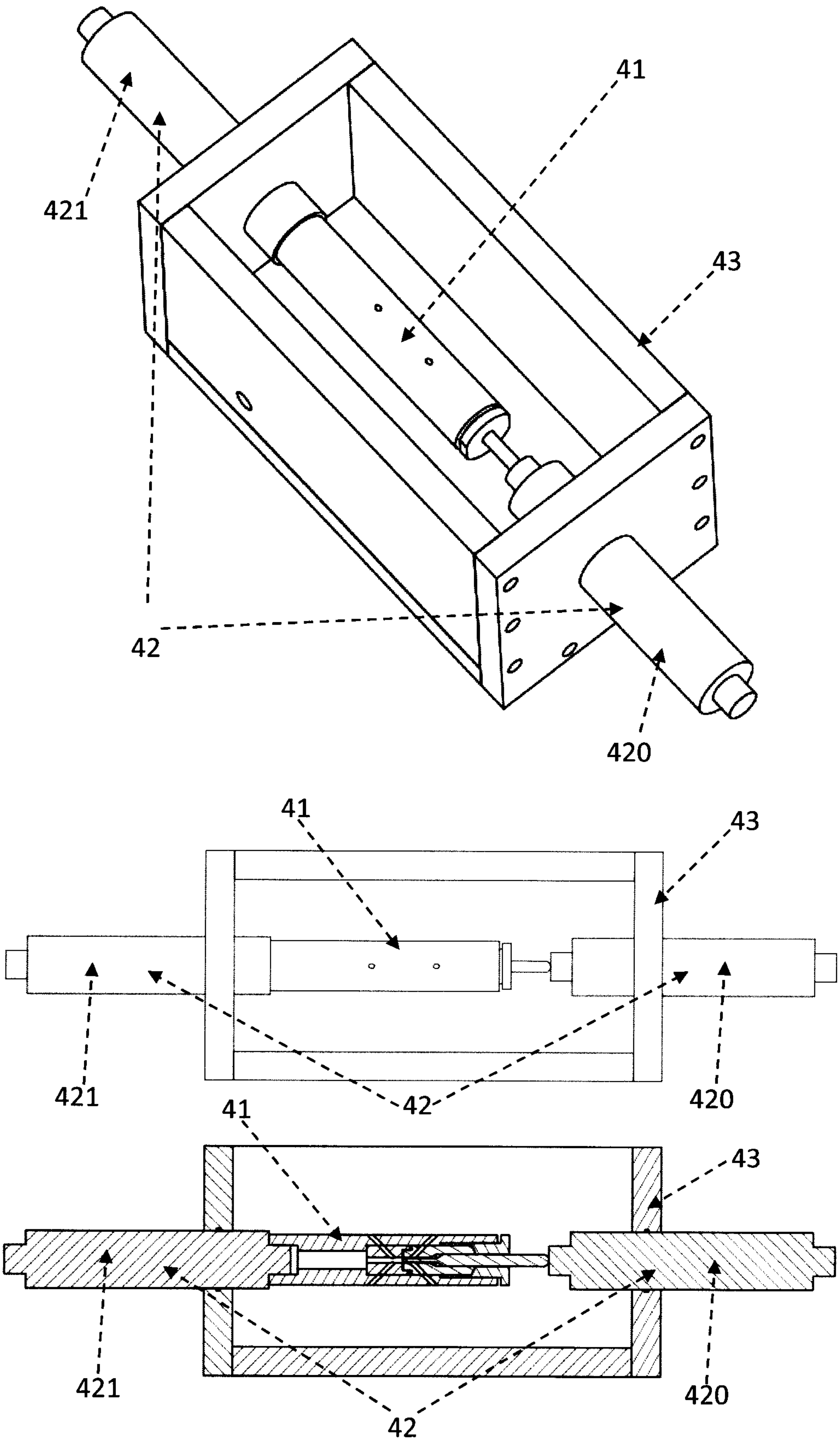



Figura 4

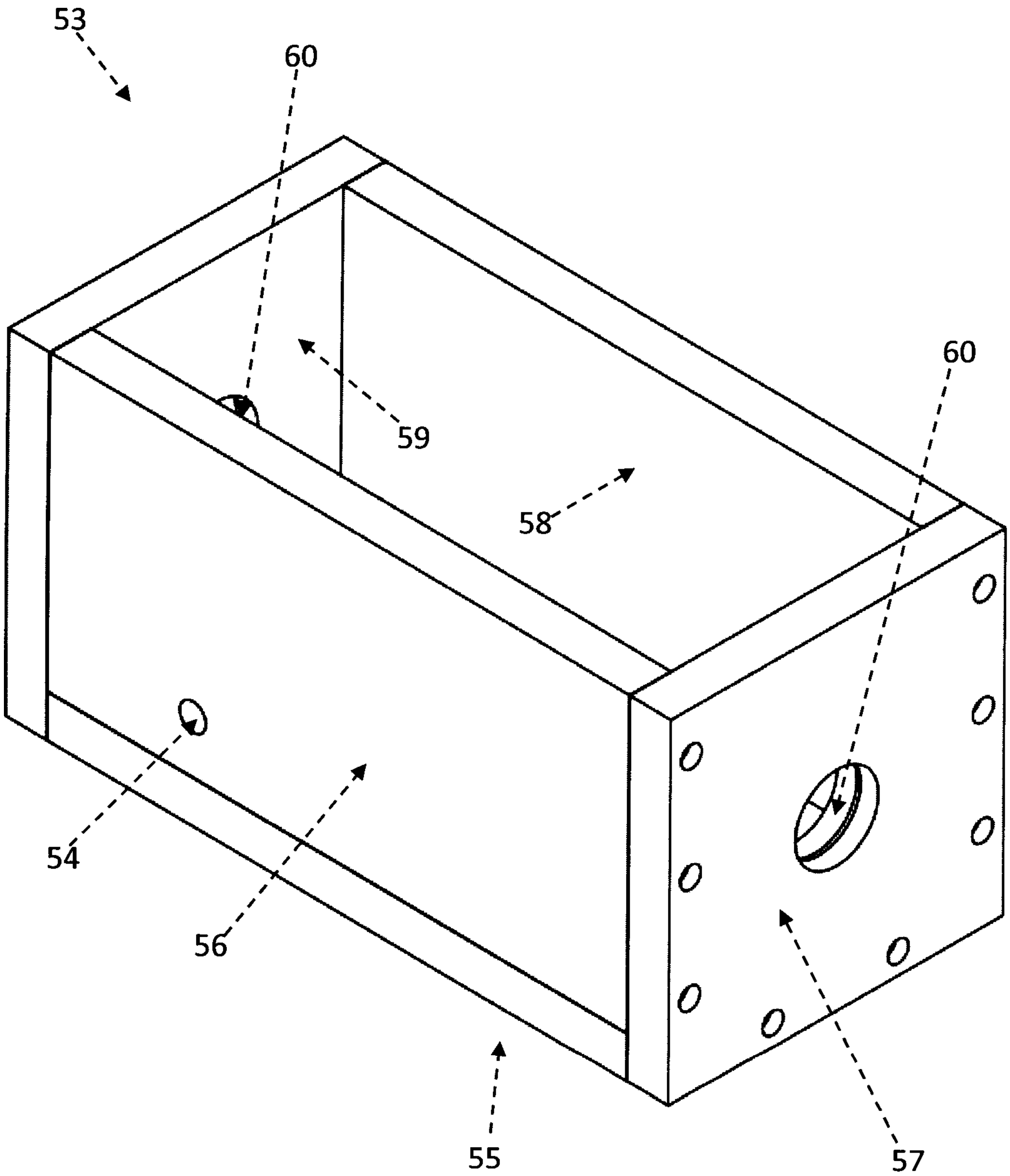



Figura 5

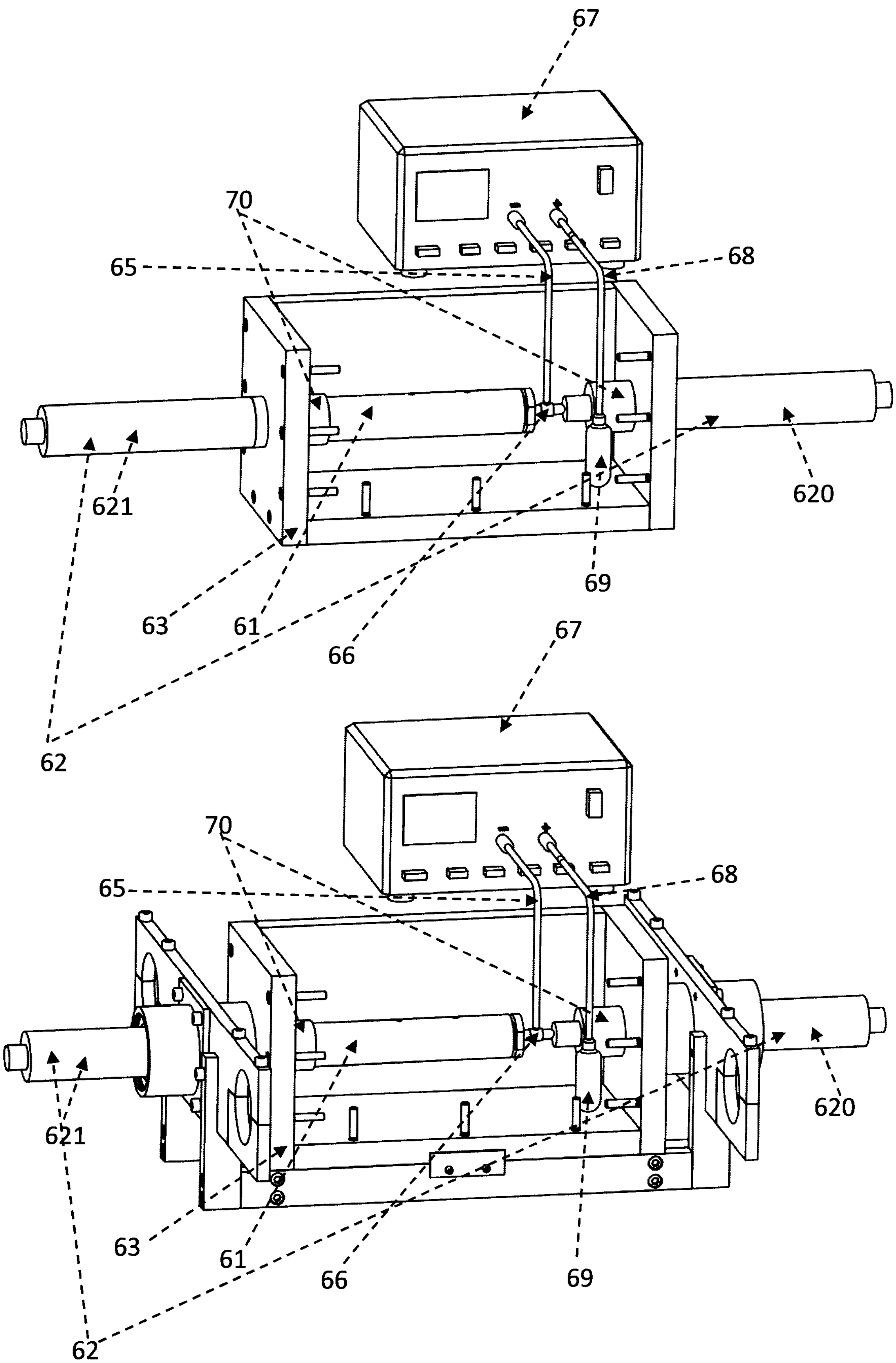



Figura 6

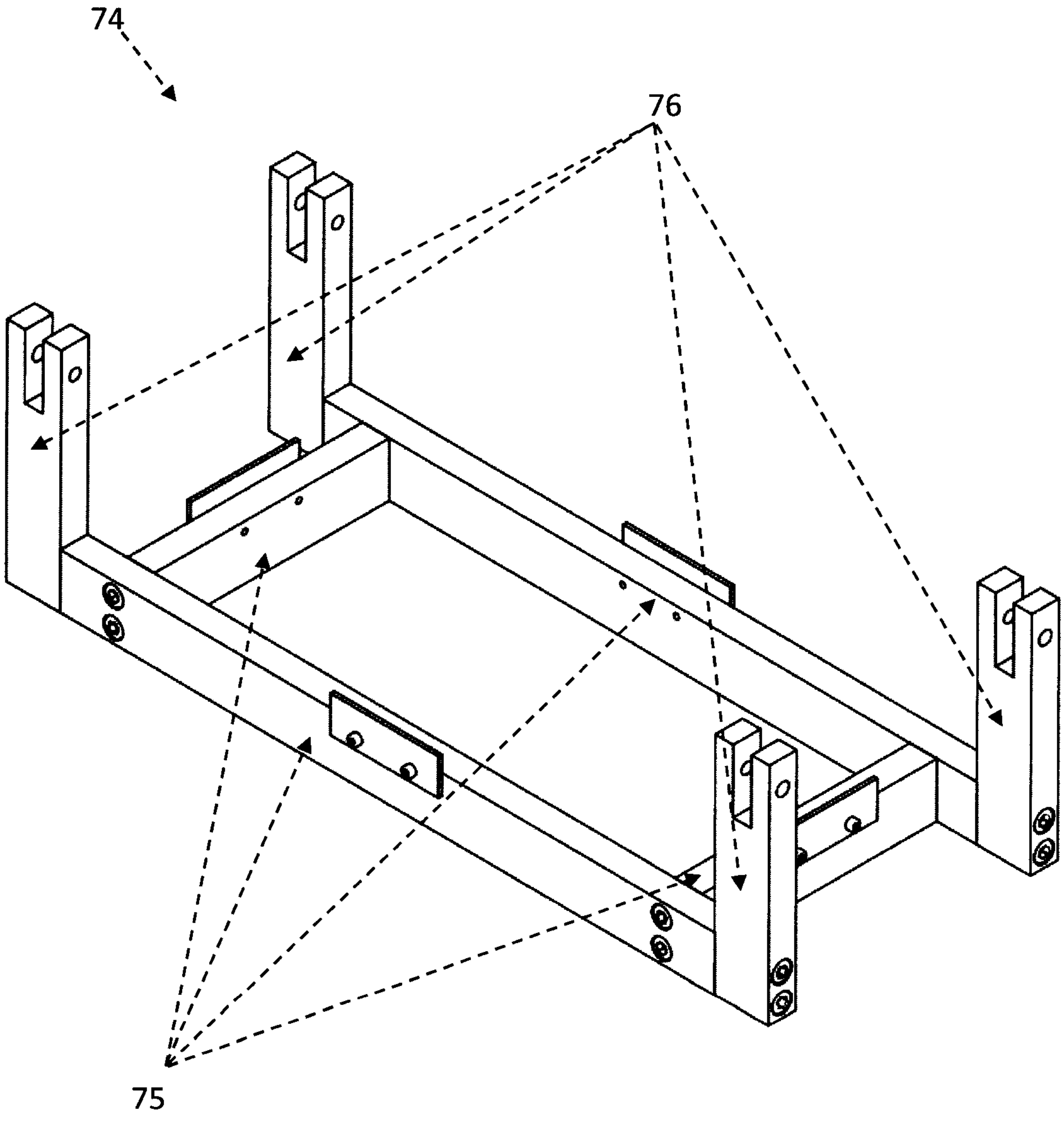



Figura 7

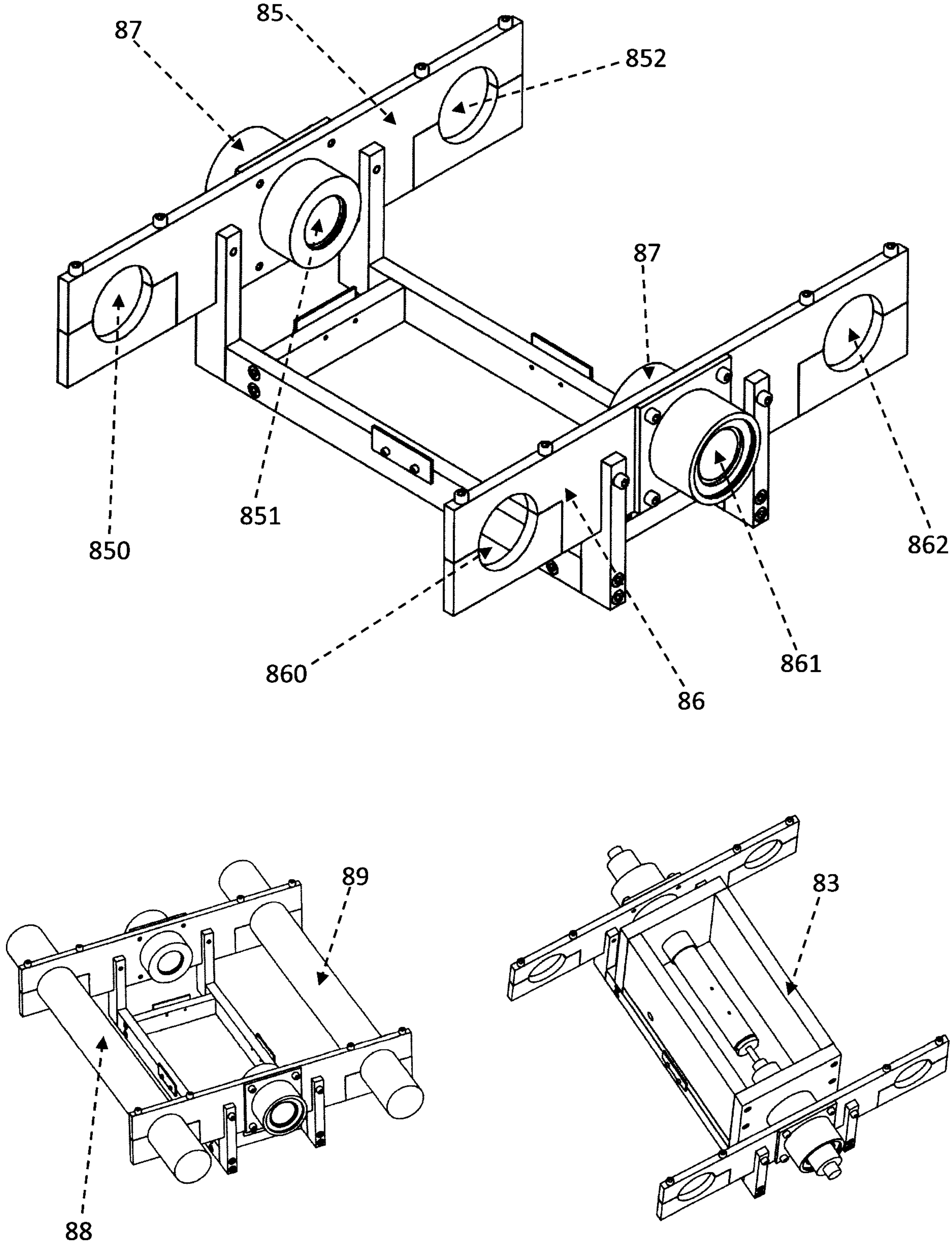



Figura 8

SPANISH OFFICE
PATENTS AND TRADEMARKS

SPAIN

(21) Application number: 201400788

(22) Date of submission of the application: 07.10.2014

(32) Priority Date:

# REPORT ON THE STATE OF THE ART

(51) **Int. Cl. :** ***G01N17/00*** (2006.01)

RELEVANT DOCUMENTS

| Category | (56) Documents cited | Affected claims |
|---|---|---|
| A | I. SERRE, J. B. VOGT. "Liquid metal embrittlement of T91 martensitic steel evidenced by small punch test". NUCLEAR ENGINEERING AND DESIGN, 20070228 AMSTERDAM, NL 28.02.2007 VOL: 237 No: 7 Pages: 677-685 ISSN 0029-5493 doi: doi:10.1016/j.nucengdes.2006.07.007 Singh Ram Kumar; Dutta Bijon K | 1-10 |
| A | CN 102042939 A (UNIV EAST CHINA SCIENCE & TECH) 04.05.2011, WPI database summary and figures. Retrieved from EPOQUE. | 1-10 |
| A | YAMAGUCHI Y et al. "Fracture and deformation properties of Ni-Fe superalloy in cryogenic high magnetic field environments". CRYOGENICS, 20030801 ELSEVIER, KIDLINGTON, GB 01.08.2003 VOL: 43 No: 8 Pages: 469-475 ISSN 0011-2275 Doi: doi:10.1016/S0011-2275(03)00123-1 Johnson Wesley Schnell Andrew | 1-10 |
| A | TANAKA K et al. "Evaluation on high temperature fracture toughness of CrMoV cast steel by small punch testing". INTERNATIONAL JOURNAL OF PRESSURE VESSELS AND PIPING, 20090901 ELSEVIER SCIENCE PUBLISHERS, BARKING, GB 01.09.2009 VOL: 86 No: 9 Pp: 643-648 ISSN 0308-0161. | 1-10 |

Category of documents cited
X: of particular relevance
And: of particular relevance combined with others of the same category
A: reflects the state of the art
Or: referred to unwritten disclosure
P: published between the priority date and the filing date
E: previous document, but published after the date of submission of the application

**This report has been prepared**

■ for all claims

■ for claims no:

| Date of preparation of the report | Examiner | Page |
|---|---|---|
| 17.04.2015 | B. Tejedor Miralles | 1/4 |

Minimum documentation searched (classification system followed by classification symbols) G01N

Electronic databases queried during the search (name of the database and, if possible, search terms used)

INVENES, EPODOC, WPI, full-text patent databases, non-patent literature databases

Date of Written Opinion: 17.04.2015

**Statement**

| | | |
|---|---|---|
| **Novelty (Art. 6.1 LP 11/1986)** | Claims 1-10<br>Demands | **YES**<br>**NO** |
| **Inventive step (Art. 8.1 LP11/1986)** | Claims 1-10<br>Demands | **YES**<br>**NO** |

The application is considered to meet the requirement of industrial application. This requirement was assessed during the formal and technical examination phase of the application (Article 31.2 of Law 11/1986).

**Basis of the Opinion.-**

This opinion has been made on the basis of the patent application as published.

**1. Documents considered.-**

The following is a list of the documents pertaining to the state of the art taken into consideration for the realization of this opinion.

| Document | Publication or Identification Number | Publication Date |
|---|---|---|
| D01 | I. SERRE, J. B. VOGT. | 28.02.2007 |
| D02 | CN 102042939 A (UNIV EAST CHINA SCIENCE & TECH) | 04.05.2011 |
| D03 | YAMAGUCHI Y et al. | 01.08.2003 |
| D04 | TANAKA K et al. | 01.09.2009 |

**2. Reasoned declaration in accordance with Articles 29.6 and 29.7 of the Implementing Regulations of Law 11/1986 of 20 March 1986 on Patents on novelty and inventive step; Quotes and explanations in support of this statement**

The document is considered to be the state of the art closest to the object of the invention.

This document discloses a device for carrying out a miniature punching test, characterised by having a test device that includes: the specimen under test located between a pressure matrix and a support matrix; a hemispherical head punch configured to transmit the test force on the specimen; the pressure matrix that presents, in the direction of force, an opening configured to serve as a guide for the punch to come into contact with the specimen; the support matrix that presents, in the direction of force and aligned with the opening of the pressure matrix, an opening configured to allow the deformation of the specimen on the opposite side where the punch is located; and at least one tightening element configured to, together with the dies, press and immobilize the specimen in its entire contour; being the punch, the pressure matrix and the support matrix of a rigid material considering the force to which they are subjected; a stress transmitter system comprising two sections configured to transfer the force generated by the testing machine to each of the two ends of the testing device, such that each end of the testing device is in contact with a different section (D01: Figure 1, paragraph 2.2).

It differs from the first claim in that it does not have a container configured to house a liquid inside which to completely immerse the specimen, but only the upper surface of the specimen is in contact with the liquid. The technical effect achieved is to subject the entire sample to corrosion. The technical problem to be solved is how to characterize a material under corrosion conditions.

None of the cited documents, which reflect the prior art closest to the subject matter of the application, have all the technical characteristics defined in claim 1 of the application been present. Likewise, it is considered that the differential characteristic does not seem to derive in an obvious way from any of the documents cited: neither individually nor through a combination of them. For all the above, it is concluded that claim 1 and the dependent claims would satisfy the requirements of novelty and inventive step according to articles 6.1 and 8.1 of the Patent Law 11/1986.

Other documents:

Documents D02-D04 disclose devices suitable for performing a miniature punching test, however they differ in that the specimen is not completely immersed in a liquid in order to characterize it under corrosion conditions.