

Title of the Invention: System for connecting a plurality of wave reinforcements of a corrugated membrane of a sealed and thermally insulating tank

[0001] The invention relates to the field of sealed and thermally insulating tanks, particularly but not exclusively to tanks with corrugated membranes according to the definitions of the "IGC code," the "International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk." These sealed and thermally insulating tanks may consist of a land or sea tank ("GBS," for "Global Base Storage").

[0002] In particular, the invention relates to the field of sealed and thermally insulating tanks for the storage and/or transport of liquid at low temperature or of liquefied gas, such as tanks for the transport of Liquefied Natural Gas (LNG) or also for Liquefied Petroleum Gas (also called LPG), having a temperature between -50 °C and 0 °C, for example. These tanks can be installed on land or on a floating structure. In the case of a floating structure, the tank may be intended for the transporting of liquefied gas or for receiving liquefied gas serving as fuel for the propulsion of the floating structure.

[0003] The invention relates firstly to a punching tool and the associated punching system for use in securing a wave reinforcement connecting element of a sealed and thermally insulating vessel. It applies particularly, but not exclusively, to the repair of wave reinforcements, which includes the connection of the wave reinforcements together, once repaired.

[0004] The present invention also relates to a storage installation comprising a sealed and thermally insulating tank, it being possible for this installation to consist of a ship in which the wave reinforcements have been punched using the punching tool according to the invention so as to connect said wave reinforcements to one another by means of a connecting element.

[0005] At present, the repair of a wave reinforcement requires cutting the corrugated membrane and also cutting the wave reinforcement in order to replace the damaged or defective portion with a wave reinforcement portion that is new or capable of performing its function.

[0006] Once the operation of replacing at least a portion of the wave reinforcement has been completed, it is necessary to join the various parts of the wave reinforcements—the so-called new parts and those from the initial wave reinforcement—so that they can perform their functions in a similar or analogous manner. At the present time, there is no system for repairing all or part of damaged wave reinforcements, more precisely for replacing these wave reinforcements or portions of wave reinforcements and then reinserting them under the waves of the corrugated membrane and securing them. As will become apparent from the following, if the wave reinforcements are not well secured under the waves of the membrane, they cannot effectively perform their functions of mechanical resistance to sloshing in the tank.

[0007] The applicant intends to remedy the shortcomings of the current process for replacing damaged or defective portions of wave reinforcements of a corrugated membrane of a sealed and thermally insulating tank.

[0008] After various experiments and tests, the applicant has developed a set for repairing wave reinforcements consisting primarily of a punching tool and a connecting element for connecting the repaired wave reinforcements, which makes it possible to ensure the connection and the securement of the wave reinforcements to one another as well as in the waves or corrugations of the membrane where they are housed.

[0009] Thus, the present invention relates to a tool for punching wave reinforcements of a corrugated membrane of a sealed and thermally insulating tank that is suitable and intended for punching a wave reinforcement symmetrically relative to a vertical axis of symmetry of said reinforcement.

[0010] The punching tool according to the invention is characterized in that it comprises at least two punching heads for producing at least two punches that are symmetrically disposed in the upper part of said wave reinforcement in order to secure the position of a connecting element between a plurality of wave reinforcements so as to interconnect and secure a plurality of wave reinforcements.

[0011] The expression “corrugated membrane” is understood to refer to the fact that it is a primary membrane, i.e., that this membrane is in direct contact with the very

cold or cryogenic liquid contained in the tank, and that it has a plurality of corrugations or waves—or protuberances—that are formed by the membrane and oriented toward the interior of the tank. These corrugations or protruding waves are intended to combat the phenomena involving thermal contraction of the membrane due to contact with the very cold, or cryogenic, liquid contained in the tank.

[0012] Other advantageous characteristics of the invention are presented succinctly below:

[0013] According to a first embodiment of the invention, the punching tool consists of a striking tool that is placed on a wave reinforcement at one of its longitudinal ends matching the outer shape of at least the upper part of said reinforcement.

[0014] In the context of this first embodiment, the punching heads preferably consist of pins, with the striking of the striking tool with a hammer, for example, resulting in the punching of the wave reinforcement by means of said pins. Striking using a hammer, a sledgehammer, or any suitable element, for example, is performed manually by an operator.

[0015] Still in the context of this first embodiment, the pins are advantageously arranged vertically in the striking tool, i.e., along the vertical axis of symmetry. According to another variant, which is shown in Fig. 4, the pins are arranged along a horizontal axis, perpendicular to the vertical axis X'X and to the longitudinal axis Y'Y of the wave reinforcement.

[0016] According to a second embodiment, the punching tool consists of a manually operable clamp.

[0017] In the context of this second embodiment, the punching heads are advantageously embodied in the general form of a cylinder or cone. As will readily be understood, any shape that makes it possible to substantially deform the wave reinforcement can be employed for these punching heads.

[0018] Still in the context of this second embodiment, the clamp is preferably made of metal and has handles with a length of at least 20 centimeters. In doing so, the operator has a multiplied actuating force that enables him to perform the punches

without any difficulty or inconvenience, so that he can repeat this action as many times as necessary.

[0019] The present invention also relates to a use of the punching tool as presented succinctly above for the punching of wave reinforcements of a corrugated membrane of a sealed and thermally insulating tank in order to secure the position of a connecting element between a plurality of wave reinforcements.

[0020] The invention also relates to a system for connecting a plurality of wave reinforcements of a corrugated membrane of a sealed and thermally insulating tank, comprising a connecting element for the wave reinforcements that is inserted into the wave reinforcements to be interconnected and the punching tool as presented succinctly above, the position of said connecting element relative to the wave reinforcements being secured by said punching tool.

[0021] According to a preferred embodiment of the invention, the connecting element consists of a metal bar, preferably of cylindrical shape.

[0022] Advantageously, the connecting element is secured to one of the ends of a wave reinforcement.

[0023] According to one embodiment, the system for connecting a plurality of wave reinforcements of a corrugated membrane of a sealed and thermally insulating tank comprises a connecting element for connecting the wave reinforcements that is inserted into the wave reinforcements to be interconnected, and a punching tool, the punching tool being suitable and intended for punching a wave reinforcement symmetrically relative to a vertical axis of symmetry, the punching tool comprising at least two punching heads for making at least two punctures that are symmetrically arranged in the upper part of said wave reinforcement in order to secure the position of a connecting element between a plurality of wave reinforcements so as to interconnect and secure a plurality of wave reinforcements. It will be readily understood that the punching tool can be used multiple times to punch multiple wave reinforcements together.

[0024] The present invention also relates to a method for connecting a plurality of wave reinforcements of a corrugated membrane of a sealed and thermally insulating tank, comprising:

- a step of connecting a plurality of wave reinforcements with the aid of a connecting element, preferably consisting of a metal bar, that is inserted into said reinforcements;
- a step of securing the connecting element relative to the wave reinforcements using the punching tool as described succinctly above.

[0025] Finally, the invention relates to a storage installation comprising a supporting structure and a sealed and thermally insulating tank installed in an internal space of the supporting structure, said storage installation comprising at least one corrugated membrane having wave reinforcements, said wave reinforcements being interconnected by a connecting element, preferably consisting of a metal bar, that is inserted into said wave reinforcements.

[0026] The storage installation is characterized in that the connecting element is secured, for example punched, to at least part of said reinforcement using the punching tool as described succinctly above.

[0027] The invention will be better understood, and other objects, details, features, and advantages thereof will become clearer in the following description of a plurality of specific embodiments of the invention, which are non-limiting and given solely for purposes of illustration with reference to the accompanying drawings.

[0028] [Fig. 1] Fig. 1 is a schematic view illustrating the cutting of a corrugated membrane in order to replace a portion of a wave reinforcement which has been damaged or is defective.

[0029] [Fig. 2] Fig. 2 is a schematic view illustrating a plurality of large wave reinforcements intended for the large waves of a corrugated membrane, with the connecting element which will be introduced into the upper part of said large wave reinforcements as well as the same set of a plurality of small wave reinforcements intended for the small waves of the same corrugated membrane, with its associated connecting element.

[0030] [Fig. 3] Fig. 3 is a schematic view illustrating the same wave reinforcement as that shown in Fig. 1 after the damaged/defective portion of the wave reinforcement has been replaced, the connecting element being almost fully inserted into the different parts forming the repaired wave reinforcement;

[0031] [Fig. 4] Fig. 4 is a schematic view illustrating the first embodiment of the punching tool.

[0032] [Fig. 5] Fig. 5 is a schematic view illustrating a variant of the first embodiment of the punching tool.

[0033] [Fig. 6] Fig. 6 is a schematic representation of a second embodiment of the punching tool.

[0034] [Fig. 7] Fig. 7 is a schematic representation illustrating two variants of punching heads in the context of the second embodiment of the punching tool.

[0035] [Fig. 8] Figs. 8a and 8b are views of a wave reinforcement end after punching of the wave reinforcement with the second embodiment of the punching tool, with both of the two punching heads shown in Fig. 7.

[0036] [Fig. 9] Fig. 9 is a schematic cutaway representation of a liquefied gas storage installation from a ship and a loading/unloading terminal of a tank of the liquefied gas storage installation.

[0037] In the following, the present invention will be illustrated using a wave reinforcement of a particular type, but it will be readily understood that the invention is not limited to this type of wave reinforcement. For instance, the punching tool and the connecting element are adapted here to the external shape of this type of wave reinforcement and to the internal geometry of said reinforcement, namely the cross members and the channels or conduits into which the connecting element must be inserted, and therefore have a suitable shape and geometry. Nevertheless, the invention provides a more global solution, regardless of the external shape and the internal geometry of the reinforcements, in that it provides a punching tool on the one hand and a connecting element on the other, one cooperating with the other in order to achieve the object of interconnecting the wave reinforcement parts and securing them together as well as to the waves, or corrugations, under which these wave reinforcements are present. As will be readily understood, the shape of the waves or corrugations are at least partially determinative of that of the wave reinforcements and, again, the present invention is not limited to corrugated membranes of the type of those illustrated in the appended figures.

[0038] A sealed and thermally insulating tank for the storage and transport of a cryogenic fluid, such as Liquefied Natural Gas (LNG), for example, comprises a plurality of tank walls, each having a multilayer structure.

[0039] From the outside toward the inside of the tank, such a tank wall comprises a thermal insulation barrier that is anchored to a supporting structure by retaining members and a sealing membrane that is supported by the thermal insulation barrier and intended to be in contact with the cryogenic fluid contained in the tank.

[0040] In particular, the supporting structure can be a self-supporting metal sheet or, more generally, any type of rigid partition having suitable mechanical properties. The supporting structure can be formed in particular by the hull or the double hull of a ship. The supporting structure has a plurality of walls that define the general shape of the tank, usually a polyhedral shape.

[0041] The tank can also include a plurality of thermal insulation barriers and sealing membranes. For example, from the outside to the inside of the tank, a tank can comprise a secondary thermal insulation barrier that is anchored to the supporting structure, a secondary sealing membrane that is supported by the secondary thermal insulation barrier, a primary thermal insulation barrier membrane resting on the secondary sealing membrane, and a primary sealing membrane resting on the primary thermal insulation barrier. The thermal insulation barrier can be made in many ways of numerous materials according to known techniques such as those described in documents WO 2017017337 or WO 2017006044, for example. The sealing membranes can be made of corrugated rectangular metal pieces having series of corrugations of different or similar sizes.

[0042] The present invention concerns itself with these sealing membranes when they are corrugated, meaning when they exhibit waves or corrugations that render them suitable for housing wave reinforcements intended to mechanically protect the corrugated membrane against the movements of the liquid in the tank, particularly due to the phenomenon known as sloshing.

[0043] As is partially visible in Figs. 1 and 3, the corrugated sealing membrane 1 conventionally has two series of perpendicular corrugations 2 and 3. Thus, the

sealing membrane 1 has a plurality of nodes 4 corresponding to the intersections between the corrugations 2 and 3 of the two series of corrugations.

[0044] The reinforcing pieces, also called wave reinforcements 5, are conventionally hollow and allow gas—typically dinitrogen—to circulate between the corrugations 2, 3 and the support 6 by passing through the reinforcing pieces 5, particularly in order to inert the insulating barrier or detect leaks. These wave reinforcements 5 are arranged under the corrugations 2, 3 between two successive nodes 4 and are thus interrupted at said nodes 4.

[0045] However, these wave reinforcements 5 undergo joint displacements with the portion of wave 2 or 3, corrugation, or undulation in which they are housed when said wave 2 or 3 is subjected to asymmetrical stresses. This joint displacement of the wave reinforcement 5 and of the corrugation 2, 3 can produce a torsion of the corrugated membrane 1 at the level of the nodes 4, which is why rails 7 extending from the node 4 have been provided in the four wave directions which may themselves comprise connecting elements 8. Such rail assemblies 7 and connecting elements 8 are intended to prevent any twisting of the wave reinforcements 5 on either side of a node 4. Such a structure of a “rail 7 - connecting element 8” assembly is known and described in greater detail in document FR 3084347, which was filed in the applicant’s name.

[0046] Moreover, in the continuity of what has just been explained above, it is absolutely essential to ensure the continuity and perfect alignment of the wave reinforcements 5 that are arranged in a wave 2, 3 or corrugation, either with the wave reinforcements 5 that were initially arranged under the waves 2, 3 or with the wave reinforcements 5 replacing part of a defective or damaged wave reinforcement 5. The invention has as its most specific object to repair or replace at least a portion of a wave reinforcement 5 even if it is not limited exclusively to this application.

[0047] As can be seen in Fig. 1, the wave reinforcements 5 are hollow and have a lower part 10 into which at least a portion of the rail 7 is inserted, whereas they also comprise a hollow upper part 22 that is intended for receiving the connecting element 20, whose function is to interconnect the wave reinforcements 5 or the wave reinforcing parts 11, 12, 13.

[0048] In the example of Fig. 1, a damaged portion 9 of a wave reinforcement 5 may have a length of at least 50 millimeters (mm), without this length posing a limitation in the context of the present invention. Prior to cutting the portion 9 of the wave reinforcement 5 to be replaced, it is of course necessary to cut the corrugated membrane 1 to appropriate dimensions—Fig. 1 illustrates such a cut having already been made—particularly so as to allow the introduction of the connecting element 20 in order to connect the different parts 11, 12, 13 for wave reinforcement 5—typically three in the example of Fig. 1—being used to replace the single wave reinforcement 5 that was initially positioned under the wave or corrugation 2.

[0049] Once the initial wave reinforcement 5 has been cut, the latter 5 is presented in three parts 11, 12, and 13 as shown in Fig. 2. Fig. 2 illustrates two sets 14, 14', each of three parts 11, 12, 13 for wave reinforcement 5, as well as a connecting element 20 between these wave reinforcement parts 11, 12, 13, consisting here of a bar having a substantially cylindrical shape. These two sets 14 and 14' are intended to show in particular that the invention is understood to be applicable regardless of the size or dimensions of the wave reinforcement 5, and hence of the waves 2, 3. Typically, these two sets 14, 14' of parts 11, 12, 13 for wave reinforcement 5 illustrate large wave reinforcements 3 and small wave reinforcements 2, respectively, for a MARK III®-type primary sealing membrane; it will be readily understood, however, that the invention is not limited to this type of corrugated membrane 1 and can be applied any time the sealed and thermally insulating tank comprises a corrugated membrane, or wavy or undulated membrane, that enables wave reinforcements 5 to be accommodated therein.

[0050] After cutting, the initially positioned wave reinforcement 5 is replaced as illustrated in Fig. 2 by three parts 11, 12, 13 for wave reinforcement 5—i.e., two end parts 11 and 13 and one central part 12 which, in the example shown in Fig. 1, is the portion 9 of the replaced wave reinforcement 5. Furthermore, in order to connect these three parts 11, 12, 13 for wave reinforcement 5, a cylindrical bar 20 is used here, namely the connecting element for said parts 11, 12, and 13 that is inserted into the hollow upper part 22 of the different parts 11, 12, 13 for wave reinforcement 5.

[0051] It should be noted that the term “wave reinforcement parts” is used to refer to the elements 11, 12, and 13, each of which constitutes, independently or in themselves, a wave reinforcement 5.

[0052] Fig. 3 thus illustrates the insertion of this connecting element 20 into each hollow upper part 22 of each of the three parts 11, 12, 13 forming the initial wave reinforcement 5. Once the connecting element 20 is inserted into the upper parts 22 of the wave reinforcement parts 11, 12, 13 for wave reinforcement 5, the length of said element 20 corresponding to that of said parts 11, 12, 13 for wave reinforcement 5, its end 25 arrives at the level of the end 26 of each end part 11, 13 of the wave reinforcement 5. The end 25, or the end portion, of the connecting element 20 may be set back slightly from the edge or the end 26 of the end portion 11, or 13, of the wave reinforcement 5 or slightly protruding from this same edge 26.

[0053] Once the operation of connecting the different parts 11, 12, 13 for wave reinforcement 5 has been carried out using the connecting element 20, the punching tool is used, the function of which is to mechanically join, by punching or crimping, a portion of the outer wall of the end wave reinforcements 11, and/or 13, with an end portion 25 of the connecting element 20, i.e., with at least one of the two ends 25 of the element 20 for connecting to the wave reinforcement 5. Of course, it is preferable that the end portion 13 undergo the same punching as the other end portion 11 so that the connecting element 20 is well secured at its two ends, and once one of its ends has been secured, the wave reinforcement can be introduced under the dedicated wave.

[0054] According to the first embodiment of the punching tool, which is shown in Figs. 4 and 5, it consists of a striking tool 30; in other words, in order to perform the punching, an operator will have to strike said tool 30 using a hammer or a small sledgehammer, for example. This striking tool 30 comprises a main body 31 having a shape that is complementary or adapted to that of the upper contour of the part 11, or 13, of the wave reinforcement 5 so as enable this main body 31 to be placed or positioned directly on the wave reinforcement 5, more exactly on the outer walls of this wave reinforcement 5. Thus, the striking tool 30 has a profile that is substantially in the form of an inverted U, with a central recess being intended to

follow the contours of the wave reinforcement 5 when placed thereon. The main body 31 accommodates two punching heads 32 and 33— pins in this case—each intended to produce a lateral punch 50 on the wave reinforcement 5. A complementary part 35 of the main body 31 closes the striking tool 30 so that the pins 32, 33 are firmly held in their respective housing.

[0055] In the variant of Fig. 4, the pins, or punching heads 32 and 33, extend horizontally along an axis perpendicular to the longitudinal axis Y'Y of the wave reinforcement 5, whereas in the variant of Fig. 5, the pins 32, 33 extend vertically along the axis X'X. In the two variants shown in Figs. 4 and 5, the two pins 32, 33 are intended to punch a substantially identical location of the wave reinforcement 5 when the punching tool 30 is struck, namely, according to a preferred embodiment, symmetrically relative to the vertical axis X'X at the upper end, and laterally offset, from the wave reinforcement 5, close to the top thereof so as to block the connecting element 20, the cylindrical bar, in the slot or upper introduction part 22 of the wave reinforcement 11, 13 or 5.

[0056] In the variant shown in Figs. 6 and 7, the punching tool consists of a clamp 40 having, like the first embodiment, two punching heads 41, 42 that can be actuated directly using the handles or levers 43, 44, which are ideally of sufficient length—at least 20 centimeters (cm), or even at least 25/30 cm—so as to reduce the force required for punching by the strong action (moment of force) of a lever arm. This clamp 40 can be made of steel, more precisely of stainless steel, or even of aluminum or of a plastic or composite material so as to reduce its weight.

[0057] The punching heads 41, 42 are preferably metallic, made of stainless steel, in order to make them suitable for their functions of punching the wave reinforcement 5 without the punching heads 41, 42 being damaged. As can be seen in Fig. 7, these punching heads 41, 42 can have different profiles or sections. For instance, it is possible to provide a section or a conical profile 45 or a substantially/generally cylindrical profile 46 for the punching heads 41, 42, the latter 41, 42 preferably having a conical section or profile 45.

[0058] In Figs. 8a and 8b, one can see the action of the punching tool, in this case the clamp 40, on the wave reinforcements 5, blocking or securing the position of the connecting element 20 in its slot or insert 22. Fig. 8a shows the punching 50 as

performed by the clamp 40 with a punching head 41, 42 having a conical section or profile 45, while Fig. 8b shows the punching 50 as performed by the clamp 40 with a punching head 41, 42 having a substantially/generally cylindrical section or profile 46.

[0059] The expression “substantially/generally cylindrical” is understood to indicate that the punching head 41, 42 fits into a cylinder of radius r and that at least 50% of the height h of this conical punching head 46 has this same radius $r \pm 10\%$. Thus, as can be seen in Fig. 7, the punching head 41, 42 having a substantially/generally cylindrical section or profile 46 has a shape or appearance which, starting from a cylindrical configuration, bulges slightly at its center, at mid-height $h/2$.

[0060] It should be noted that the wave reinforcements 5 and the connecting element 20 can be made of many materials, including materials such as, for example, metals, particularly aluminum; metal alloys; plastics, particularly polyethylene, polycarbonate, polyether imide; or composite materials comprising fibers, particularly glass fibers, bound by a plastic resin. Preferably, these wave reinforcements 5 as well as the connecting element 20 are made of aluminum.

[0061] The wave reinforcements 5 and the connecting element 20 can be manufactured in many ways. Preferably, these wave reinforcements 5 and the connecting element 20 are produced by extrusion.

[0062] Referring to Fig. 9, a cutaway view of a ship 70 shows a sealed and insulated tank 71 having a generally prismatic shape mounted in the double hull 72 of the ship 70. Such a tank 71 conventionally has at least one corrugated membrane 1, not visible in Fig. 9, that serves as a first sealed and thermally insulating barrier. Such a corrugated membrane 1 has wave reinforcements and a connecting element for connecting said wave reinforcements, so that the punching tool 30, 40 according to the invention serves to secure this connecting element. The tank 71 comprises a primary sealed barrier 1 that is intended to be in contact with the LPG contained in the tank, a secondary sealed barrier (not visible in this figure) that is arranged between the primary sealed barrier 1 and the double hull 72 of the vessel, and two insulating barriers that are arranged between the primary sealed barrier and the secondary sealed barrier and between the secondary sealed barrier and the double hull 72, respectively.

[0063] In an inherently known manner, loading/unloading pipes 73 that are arranged on the upper deck of the ship can be connected by means of suitable connectors to a maritime or port terminal in order to transfer an LPG cargo from or to the tank 71.

[0064] Fig. 9 also shows an example of a maritime terminal comprising a loading and/or unloading station 75, an underwater pipe 76, and an onshore installation 77. The loading and/or unloading station 75 is a secured offshore installation comprising a moving arm 74 and a tower 78 that supports the moving arm 74. The moving arm 74 carries a bundle of insulated flexible pipes 79 that can be connected to the loading/unloading lines 73. The adjustable moving arm 74 adapts to all vessel sizes. A connecting pipe, not shown, extends inside the tower 78. The loading and unloading station 75 allows the loading and/or unloading of the vessel 70 from or to the onshore installation 77. The latter comprises liquefied gas storage tanks 80 and connecting pipes 81 that are connected by the underwater pipe 76 to the loading and unloading station 75. The underwater pipe 76 enables the liquefied gas to be transferred between the loading and unloading station 75 and the onshore installation 77 over a great distance—e.g., 5 km—which makes it possible to keep the vessel 70 at a great distance from the coast during loading and/or unloading operations.

[0065] In order to generate the pressure necessary for the transfer of the liquefied gas, pumps on board the ship 70 and/or pumps fitted to the shore installation 77 and/or pumps fitted to the loading and unloading station 75 are used.

[0066] As will be readily understood, even though the invention has been described in connection with a plurality of specific embodiments, it is not limited thereto, but rather comprises all of the technical equivalents of the means described and combinations thereof insofar as they are within the scope of the invention.

[0067] The use of the verb "to have," "to comprise," or "to include" and conjugated forms thereof does not exclude the presence of other elements or steps other than those set out in a claim.

In the claims, any reference symbol in parentheses shall not be interpreted as a limitation of the claim.

Claims

- [Claim 1] A system for connecting a plurality of wave reinforcements (5, 11, 12, 13) of a corrugated membrane (1) of a sealed and thermally insulating tank (71), comprising a connecting element (20) for connecting the wave reinforcements (5, 11, 12, 13) that is inserted into the wave reinforcements (5, 11, 12, 13) to be interconnected, and a punching tool (30, 40), the punching tool (30, 40) being suitable and intended for punching a wave reinforcement (5, 11, 12, 13) of said reinforcement (5, 11, 12, 13) symmetrically relative to a vertical axis (X'X) of symmetry, characterized in that the punching tool (30, 40) comprises at least two punching heads (32, 33 and 41, 42) for producing at least two punches (50) that are symmetrically arranged in the upper part of said wave reinforcement (5, 11, 12, 13) in order to secure the position of a connecting element (20) between a plurality of wave reinforcements (5, 11, 12, 13) so as to interconnect and secure a plurality of wave reinforcements (5, 11, 12, 13).
- [Claim 2] The system for connecting a plurality of wave reinforcements according to claim 1, wherein the punching tool consists of a striking tool (30) that is placed on a wave reinforcement (5, 11, 12, 13) at one of its longitudinal ends (26) matching the outer shape of at least the upper part of said reinforcement (5, 11, 12, 13).
- [Claim 3] The system for connecting a plurality of wave reinforcements according to claim 1 or 2, wherein the punching heads consist of pins (32, 33), with the striking of the striking tool (30) with a hammer, for example, resulting in the punching of the wave reinforcement (5, 11, 12, 13) by means of said pins (32, 33).
- [Claim 4] The system for connecting a plurality of wave reinforcements according to claim 3, wherein the pins (32, 33) are arranged vertically, or along the vertical axis of symmetry, in the striking tool (30).
- [Claim 5] The system for connecting a plurality of wave reinforcements according to claim 1, wherein the punching tool consists of a manually operable clamp (40).

[Claim 6] The system for connecting a plurality of wave reinforcements according to claim 5, wherein the punching heads (41, 42) have the general shape of a cylinder (46) or cone (45).

[Claim 7] The system for connecting a plurality of wave reinforcements according to claim 5 or 6, wherein the clamp (40) is made of metal and has handles (43, 44) that are at least 20 centimeters long.

[Claim 8] The system for connecting a plurality of wave reinforcements according to any one of the preceding claims, wherein the connecting element (20) consists of a metal bar that is preferably cylindrical in shape.

[Claim 9] The system for connecting a plurality of wave reinforcements according to any one of the preceding claims, wherein the connecting element (20) is secured to one end of a wave reinforcement (5, 11, 12, 13).

[Claim 10] A method for connecting a plurality of wave reinforcements (5, 11, 12, 13) of a corrugated membrane (1) of a sealed and thermally insulating tank (71), the method comprising:

- a step of connecting a plurality of wave reinforcements (5, 11, 12, 13) with the aid of a connecting element (20), preferably consisting of a metal bar, that is inserted into said reinforcements (5, 11, 12, 13);
- a step of securing the connecting element (20) relative to the wave reinforcements (5, 11, 12, 13) using the system for connecting a plurality of wave reinforcements according to one of the preceding claims.

[Claim 11] A storage installation, comprising a supporting structure and a sealed and thermally insulating tank (71) installed in an internal space of the supporting structure (72), said storage installation comprising at least one corrugated membrane (1) having wave reinforcements (5, 11, 12, 13), said wave reinforcements (5, 11, 12, 13) being interconnected by a connecting element (20), preferably consisting of a metal bar, that is inserted into said wave reinforcements (5, 11, 12, 13),

characterized in that the connecting element (20) is punched on at least a part (26) of said reinforcement (5, 11, 12, 13) using the system for connecting a plurality of wave reinforcements according to one of claims 1 to 9.