DESCRIPTION

TITLE OF THE INVENTION: System and method for indirect resistance welding of a sealing plate to an anchoring plate

The present invention relates to the field of tanks for gas in a liquid state, for example liquefied natural gas (LNG), particularly for maritime or river transport or for an onshore reservoir. More specifically, the invention concerns a welding system for welding a sealing plate suitable for such a tank, and an associated welding method.

The liquid gas tanks have a capacity of several thousand cubic meters of liquid gas each, or even several tens of thousands of cubic meters of liquid gas. The vessels transporting liquefied gas have holds fitted out specifically to contain these tanks, and their holds are often divided into several tanks. A tank of this type may also be built outside a vessel for onshore storage of natural gas in a liquid state.

The gas is kept inside the tank in a liquid state, for example at -163°C (degrees Celsius) for LNG, at atmospheric pressure. The tank must therefore be watertight and thermally insulated. As a result, the internal surface of such a tank is covered by a sealing membrane, generally made from an assembly of metal sealing plates (typically stainless steel plates) welded together, each sealing plate being part of the sealing membrane of the tank.

The walls of the tank also comprise, successively underneath the sealing membrane configured to be in contact with the liquefied gas, this sealing membrane being referred to as the primary sealing membrane:

- a layer of primary insulation, for example using wooden shells filled with reinforced polyurethane foam,
- another sealing membrane, referred to as the secondary sealing membrane, for example made of thin sheet metal,
- a secondary layer of insulation, for example also made from wooden shells filled with reinforced polyurethane foam.

The primary sealing membrane is attached to the primary insulation layer by welding the sealing plates to anchoring plates, which are secured to the primary insulation layer and may be riveted to the wooden shells of the primary insulation layer. These anchoring plates form a grid around all the shells, but do not cover them completely.

Currently, as shown in Figure 1, the welds 3 attaching a sealing plate 1 to an anchoring plate 22 are made manually by a welding method using the heat of an electric arc, this method being referred to as TIG (Tungsten Inert Gas).

The welds 3 are performed by fillet welding to an edge 15 of the sealing plate 1, located between two corrugations 12, 14 of the sealing plate 1. These corrugations correspond to ribs on the sealing plate 1, which may advantageously help to form a grid and allow to absorb the deformations of the tank due to its thermal variations.

The edge 15 of the sealing plate 1 extends parallel to the direction of a first axis A1 of an orthonormal reference frame (A1, A2, A3), the corrugations 12, 14 extending orthogonally to this first axis A1 while being parallel to the direction of a second axis A2 of this orthonormal reference frame. The third axis A3 of this orthonormal reference frame extends orthogonally to the main plane of extension of the sealing plate 1.

The anchoring plate 22 is located between the two corrugations 12, 14, being attached by rivets 24 to a wooden shell, here not visible from the primary insulation layer, the shell also being located between these two corrugations 12, 14. Further anchoring plates 21 and 23 are located on either side of the anchoring plate 22, being attached to other wooden shells of the primary insulation layer by further rivets 24.

As may be seen in Figure 1, the attachment of the sealing plate 1 uses 6 welds 20 mm (millimeters) long between the two corrugations 12, 14, spaced 20 mm apart, allowing the sealing plate 1 to be attached between the two corrugations 12, 14 over at least 220 mm. As an indication, the distance d1 peak to peak between the corrugations 12 and 14 is 340 mm, which leaves a margin for their deformation.

The performance of the fillet welds 3 are operational and allow a visual verification of the welds performed. However, this performance is performed manually, which means that it takes a long time to attach the sealing plates of the tank to the anchoring plates of the primary insulation layer. A process of automatization of these welds 3 using a TIG welding method would require a very complex and expensive equipment, particularly for an automatic and precise tracking of the edge 15 of the sealing plate 1. In particular, the positioning of the rail on which an automatic TIG welding machine would be placed would require a great deal of time.

The aim of the present invention is to remedy at least part of the above-mentioned disadvantages by providing, in particular, a welding system and a welding method which

allow to accelerate the welding of the sealing plates of a tank to the anchoring plates of the tank, in a simple and inexpensive manner, while guaranteeing a good weld quality.

To this end, the invention proposes a system for the indirect resistance welding of a sealing plate of a tank configured to contain liquefied gas, to an anchoring plate arranged partly beneath the sealing plate so as to leave a free portion of the anchoring plate outside the sealing plate, an edge of the sealing plate separating the sealing plate from the free portion of the anchoring plate, the welding system comprising:

- at least one pair of electrodes and a current generator adapted to be connected to the electrodes,
- a support capable of holding the electrodes of the at least one pair of electrodes relative to each other,
- positioning means for positioning the support against the sealing plate, capable of positioning the electrodes of the at least one pair of electrodes on either side of the edge, by positioning one electrode of said at least one pair of electrodes, referred the membrane electrode, above the sealing plate and another electrode of said at least one pair of electrodes, referred to as the anchoring electrode, above the free portion of the anchoring plate, and
- at least one actuator for each pair of electrodes, capable of pressing the membrane electrode against the sealing plate and the anchoring electrode against the free portion of the anchoring plate.

By using an indirect resistance welding system, a welding point of up to 5 mm in diameter may be created under the membrane electrode between the sealing plate and the anchoring plate. This welding point is performed by applying a current of several kiloamperes between the electrodes. This change in welding technique compared to the prior art means that the sealing plate may be attached to the anchoring plate quickly, for example by welding only four welding points between two corrugations of the sealing plate, between the latter and the anchoring plate. These welding points may be performed more quickly by an operator than fillet welds, as they are spot welds and do not require very precise positioning of the welds in relation to the edge of the sealing plate.

The welding system according to the invention is able to position the membrane electrode and the anchoring electrode on either side of an edge of the sealing plate arranged on the anchoring plate, allowing the membrane electrode to be positioned on the sealing plate at a point which is also above the part of the anchoring plate located below the sealing plate,

and the anchoring electrode to be positioned on the anchoring plate, so as to allow an indirect resistance welding point between the sealing plate and the anchoring plate.

The support allows to maintain a predefined distance between the electrodes, so that when they are positioned by the positioning means, their respective distances from the edge of the sealing plate are:

- sufficiently short to allow the sealing plate to be welded to the anchoring plate by heating created by the Joule effect between these two plates, due to the resistance created by the interface between the plates in the path of the current flowing through the electrodes,
- and large enough to prevent the creation of an electric arc. Such an electric arc of this kind generates projections and visible defects that are not acceptable.

The electrode located on the sealing plate must also not be too close to the edge, otherwise the sealing plate will heat up too much at this point, causing a local deformation and damage to the welding point obtained.

For example, the electrodes are each approximately 8 mm relative to the edge of the sealing plate, their respective distances from this edge preferably being between 5 mm and 15 mm.

In an embodiment with several pairs of electrodes, the support keeps the electrodes of the different pairs of electrodes at a distance from each other.

This support is, for example, a simple electrode holder, allowing it to be moved manually to several points on the sealing plate that are not above a rivet on the anchoring plate.

The current generator of the welding system according to the invention is preferably remote from the support, so that it does not have to be moved at the same time as the support is moved in order to perform several welding points. For example, the current generator is placed on a trolley and connected to the electrodes attached to the support by metal conductors, which maitake the shape of large copper braids, given the amperage used.

The at least one actuator is secured to the support, for example. According to an optional characteristic of the invention, the support comprises at least one upright to which the stationary part of the at least one actuator is secured. This is a cylinder, for example, with the electrodes secured to the extension tube of the cylinder.

The welding system as described in the invention comprises, for example, electrode holders wherein the electrodes are held stationary, the electrode holders being secured to said at least one actuator. When said at least one actuator takes the shape of a cylinder, the electrode holders are attached to the extension tube of the cylinder, for example.

According to an optional characteristic of the welding system according to the invention, it comprises two actuators for each pair of electrodes, including a first actuator capable of pressing the membrane electrode against the sealing plate with a first pressing force, and a second actuator capable of pressing the anchoring electrode against the free portion of the anchoring plate with a second pressing force.

It should be noted that in this application, the term "pressing force", exerted by an actuator by means of an electrode, refers to the contact force resulting from the pressure exerted by the electrode on the surface of the anchoring or sealing plate to which the electrode is pressed by the actuator. The effort pick-up applied to the electrodes may be performed by an operator or by a machine that maintains the welding system.

This characteristic allows the sealing plate to be brought more securely into contact with the anchoring plate at the level of the welding point, thus ensuring a good weld quality. According to an optional characteristic of the invention, the second pressing force has a lower value than the first pressing force. The first pressing force, expressed in kilograms of force, corresponds, for example, to a force of approximately 4 kilograms, and the second pressing force corresponds, for example, to a force of approximately 2 kilograms. These values are given here by way of indication, without being restrictive of the invention. For example, much higher pressing forces may be applied, particularly if the effort pick-up is performed by a machine.

According to an optional characteristic of the welding system according to the invention, the membrane electrode comprises a contact surface with the sealing plate that is strictly smaller than a contact surface of the anchoring electrode with the free portion of the anchoring plate.

This contact surface determines the cross-section of the current between each electrode and the plate against which the electrode is pressed. For example, the membrane and anchoring electrodes are cylindrical and are pressed by one of their bases against the sealing or anchoring plate. The membrane electrode then comprises a circular cross-section of, for example, between 7 and 9 mm and preferably 8 mm, while the anchoring electrode comprises a circular cross-section of, for example, between 11 and 13 mm and preferably 12 mm.

In another example, the membrane and anchoring electrodes have a shape like a right prism with a polygonal cross-section, the polygonal cross-section of the membrane electrode being smaller than the polygonal cross-section of the anchoring electrode.

In yet another example, when the electrodes take the shape of wheels configured to roll on the plates, of the same diameter, their contact surfaces with the plates are portions of their lateral surfaces, of lengths the dimensions of the wheel orthogonal to their radii, and the length of the portion of the lateral surface of the membrane electrode is smaller than the length of the portion of the lateral surface of the anchoring electrode. In this example, the lateral surfaces of the wheels preferably comprise flats, the actuators being activated when one of the flats of each electrode is in contact with the sealing plate or the anchoring plate, so as to ensure a sufficient contact surface for the current to pass.

In one embodiment of the invention, the positioning means comprise at least one stop secured to the support and capable of being pressed against the edge of the sealing plate, or against a corrugation of the sealing plate.

When the stop is configured to bear against the edge of the sealing plate, the stop comprises, for example, a lower surface located at the same level as the end of the anchoring electrode configured to come into contact with the anchoring plate, in a direction parallel to the direction of the current in the anchoring electrode, when a welding point is produced by the welding system according to the invention. The stop may therefore be used to position the electrodes on either side of the edge of a sealing plate of any thickness.

When the stop is configured to bear against a corrugation of the sealing plate, the stop comprises, for example, a lower surface located at the same level as the end of the membrane electrode configured to come into contact with the sealing plate, in a direction parallel to the direction of the current in the membrane electrode, when a welding point is produced by the welding system according to the invention. The stop may therefore be used regardless of the height of the corrugation on the membrane, which generally comprises corrugations of different heights.

For example, the support comprises a frame delimiting an opening, the stop forming an extension of a lower portion of the support capable of being in contact with one or other of the sealing plate or the anchoring plate, without obstructing the opening in the frame.

The positioning means comprise, for example, two stops secured to the support and capable of being pressed against the edge of the sealing plate, or one or more stops capable of being pressed against a corrugation of the sealing plate, the corrugation being parallel to the edge of the sealing plate. The electrodes are then preferably arranged on the support, between the two stops.

Even more preferably, the dimension of the support parallel to the edge of the sealing plate, and comprised between two consecutive corrugations of the sealing plate, when the stop or stops are pressed against this edge, is strictly less than the distance between these two consecutive corrugations between which the support is partly installed, so as to be able to move the support slightly parallel to the edge of the sealing plate, in order to position the electrodes outside riveted locations of the anchoring plate.

The welding system may comprise several pairs of electrodes arranged between the two stops. For example, it comprises as many pairs of electrodes as there are welding points to be made between the two stops, the number of welding points to be made preferably corresponding to the number of welding points to be made between two consecutive corrugations of the anchoring plate. In this way, an operator may perform all the welding points between two consecutive corrugations without moving the support of the welding system according to the invention. The pairs of electrodes are spaced apart by a distance greater than or equal to a predetermined minimum distance to avoid the formation of parasitic current paths when a welding point is produced. This predetermined minimum distance is, for example, between 30 mm and 60 mm and is preferably equal to or approximately equal to 50 mm.

In one embodiment of the invention, the support comprises two rails capable of being positioned on either side of the edge of the sealing plate and parallel to said edge, and movement means for moving the electrodes of each pair of electrodes, mounted so as to move in translation on the two rails. By "parallel to said edge" we mean substantially parallel to said edge, i.e. within a tolerance of a few degrees. The rails of the support are able to be positioned on either side of the edge of the sealing plate and parallel to said edge, i.e. in a configuration of placing the support on the sealing and anchoring plates to weld them, the rails are positioned on either side of the edge and parallel to it.

The movement means comprise, for example, uprights attached in a sliding manner to the rails, the uprights being secured to the stationary parts of one or more actuators, which are themselves secured to the electrodes by their moving parts. The rails and the movement means allow the electrodes, for example, to move between two stops arranged at the longitudinal ends of the support and capable of pressing it against the edge of the sealing plate.

The movement means comprise, for example, at least one axle arranged orthogonally to the rails, the electrodes of each pair of electrodes taking the shape of wheels mounted on the at least one axle. This axle, for example, is attached to the moving part of the at least

one actuator, and is connected to a rotary motor, for example. Where the electrodes are each pressed with a separate pressing force, each electrode is mounted on a separate axle attached to the moving part of a separate actuator. Each axle is then connected to a rotary motor, for example. One of the axles supporting an electrode, for example, is attached to an extension tube of a cylinder secure to one of the uprights attached in a sliding manner to one of the rails, while the other of the axles supporting another electrode is attached to an extension tube of another cylinder secured to the other of the uprights attached in a sliding manner to the other of the rails.

In another example, the movement means comprise at least one axle arranged orthogonally to the rails as well as a first hub mounted on the at least one axle and on which the membrane electrode is arranged, the movement means further comprising a second hub mounted on the at least one axle and on which the anchoring electrode is arranged, each pair of electrodes being configured such that the membrane electrode is capable of being in contact with the sealing plate at the same time as the anchoring electrode is capable of being in contact with the free portion of the anchoring plate. The movement means comprise, for example, a rotary motor mechanically connected to the axle, and at least one rack cooperating with the axle, the rack being formed on one of the rails. When one axle per hub is used, the movement means comprise, for example, one rack per rail and one rotary motor per axle or the same rotary motor for both axles.

In another example, the indirect resistance welding system according to the invention comprises several pairs of electrodes and the movement means comprise at least one axle arranged orthogonally to the rails as well as a first hub mounted on the at least one axle, the membrane electrodes of the pairs of electrodes being distributed angularly around the first hub, the movement means further comprising a second hub mounted on the at least one axle, the anchoring electrodes of the electrode pairs are angularly distributed around the second hub, the pairs of electrodes being configured such that the membrane electrode of one of the pairs of electrodes is able to be in contact with the sealing plate at the same time as the anchoring electrode of said pair of electrodes is able to be in contact with the free portion of the anchoring plate. The membrane electrodes, for example, form radii angularly distributed around the first hub, and the anchoring electrodes, for example, form radii angularly distributed around the second hub.

"Orthogonal to the rails" means substantially orthogonal to the rails, i.e. within a tolerance of a few degrees.

As in the previous example, the at least one axle is attached to the moving part of the at least one actuator. In addition, where the membrane and anchoring electrodes are pressed with separate pressing forces, each hub is mounted on a separate axle attached to the moving part of a separate actuator. One of the axles supporting one of the hubs is, for example, attached to an extension tube of a cylinder secured to one of the uprights attached in a sliding manner to one of the rails, the other of the axles supporting the other of the hubs being attached to an extension tube of another cylinder secured to the other of the uprights attached in a sliding manner to the other of the rails.

The pairs of electrodes formed by the membrane and anchoring electrodes are, for example, configured on the hubs so that each membrane electrode is angularly arranged on the first hub at the same level as an anchoring electrode on the second hub. More particularly, considering the axial direction defined by the axle, a pair of electrodes is defined with a membrane electrode and an anchoring electrode which are aligned with each other.

An optional characteristic of the indirect resistance welding system is that it comprises gripping means secured to the support. These gripping means facilitate the positioning of the support against the sealing plate, and the force to be exerted on the support by an operator, to counter the pressing force or forces exerted by the at least one actuator.

The indirect resistance welding system according to the invention may comprise a trolley on which is mounted a robotic arm capable of cooperating with the gripping means. In this way, the force to be exerted on the support is provided by the robotic arm. For example, the trolley also carries the current generator, connected by conductors to the various electrodes, and preferably also supplying the various actuators when these are electric cylinders. If these actuators are hydraulic cylinders, the trolley carries, for example, in addition to the current generator, a source of liquid for supplying the hydraulic cylinders, connected by fluid connections to the hydraulic cylinders. In addition, the trolley preferably carries means of controlling the robotic arm, the cylinders and the current generator.

The invention also relates to a method for indirect resistance welding, using an indirect resistance welding system according to the invention, and comprising the steps of:

- positioning the membrane electrode above the sealing plate and the anchoring electrode above the free portion of the anchoring plate, by pressing the positioning means against a portion of the sealing plate,

- activating the at least one actuator until the membrane electrode is pressed against the sealing plate and the anchoring electrode is pressed against the free portion of the anchoring plate, and
- sending current to the electrodes.

Sending current naturally uses the current generator.

When the indirect resistance welding system comprises two actuators, including a first actuator capable of pressing the membrane electrode against the sealing plate with a first pressing force, and a second actuator capable of pressing the anchoring electrode against the free portion of the anchoring plate with a second pressing force, the activation step preferably comprises pressing the membrane electrode against the sealing plate with the first force and pressing the anchoring electrode against the free portion of the anchoring plate with the second force, the first force being strictly greater than the second force.

When the indirect resistance welding system comprises two rails capable of being positioned on either side of the edge of the sealing plate and parallel to said edge, and movement means for moving the electrodes of the pair of electrodes, mounted so that they may move in translation on the two rails,
the positioning step comprises the positioning of the rails on either side of the edge of the sealing plate, and is followed by a plurality of steps of activating and sending current, the welding method according to the invention also comprising a step of moving the electrodes along the rails, interposed between a step of sending current and a step of activating the at least one actuator.

The displacement step allows the electrodes to be moved at least a predetermined minimum distance, for example between 30mm and 60mm, and preferably equal to or approximately equal to 50mm. This minimum distance allows to prevent the creation of parasitic current paths during a current-sending step.

Alternatively, when the indirect resistance welding system comprises a row of pairs of electrodes arranged on the support, the positioning step comprises positioning each membrane electrode of the electrode pairs above the sealing plate and each anchoring electrode of the electrode pairs above the free portion of the anchoring plate, and the welding method according to the invention comprises as many current sending steps as there are pairs of electrodes, the current sending steps each being spaced apart by a predetermined minimum duration and each supplying a single pair of electrodes. The longitudinal section of the row refers here to a section of the row along its length.

In this alternative embodiment of the invention, the welding points are preferably performed consecutively by each pair of electrodes in the row of pairs of electrodes, in one direction of travel of this row, i.e. the welding points are made one behind the other along the edge of the sealing plate. This means that the steps involved in sending current to the electrodes are less likely to cause parasitic current paths. In addition, the predetermined time between each current sending step also allows to prevent the creation of parasitic current paths. It is, for example, between 300 and 400 ms and preferably equal to or approximately equal to 350ms (milliseconds).

Furthermore, in this alternative embodiment of the invention, the actuator or actuators of each pair of electrodes are preferably activated separately from the actuators of the other pairs of electrodes, before the step of sending current to the pair of electrodes, which avoids having to apply too great a force to the support to counteract the pressing forces exerted on the electrodes.

In its various embodiments, the welding method according to the invention offers similar advantages to those of the welding system according to the invention.

Other characteristics and advantages of the invention will become apparent from the following description, on the one hand, and from a number of examples of embodiment given by way of indication and without limitation with reference to the attached schematic drawings, on the other hand, wherein:

[Fig 1], already described in relation to the prior art, shows a portion of sealing plate fillet-welded to an anchoring plate,

[Fig 2] illustrates the principle of indirect resistance welding used in the invention to weld a sealing plate to an anchoring plate,

[Fig 3] is a perspective view of an indirect resistance welding system according to the invention, in a first embodiment of the invention, the system being positioned against an edge of a sealing plate, above it and an anchoring plate,

[Fig 4] is a side view of the indirect resistance welding system shown in Figure 3,

[Fig 5] is a top view of the indirect resistance welding system shown in Figure 3,

[Fig 6] is a perspective view of an indirect resistance welding system according to the invention, in a second embodiment of the invention, the system being positioned against an edge of a sealing plate, above it and an anchoring plate,

[Fig 7] is a perspective view of an indirect resistance welding system according to the invention, in a third embodiment of the invention, the system being positioned against an edge of a sealing plate, above it and an anchoring plate,

[Fig. 8] is a perspective view of an indirect resistance welding system according to the invention, in a fourth embodiment of the invention, the system being positioned against an edge of a sealing plate, above it and an anchoring plate,

[Fig 9] is a perspective view of an indirect resistance welding system according to the invention, in a fifth embodiment of the invention, the system being positioned against an edge of a sealing plate, above it and an anchoring plate,

[Fig 10] is a perspective view of an indirect resistance welding system according to the invention, comprising the indirect resistance welding system of the second embodiment of the invention, and a robotic arm capable of pressing this indirect welding system against a sealing plate,

[Fig 11] represents steps in an indirect resistance welding method according to the invention, using the indirect resistance welding system of the first, the third or the fourth embodiment of the invention, and

[Fig 12] shows steps in an indirect resistance welding method according to the invention, using the indirect resistance welding system of the second embodiment of the invention.

Figure 2 shows schematically a welding point 30 produced by an indirect resistance welding system according to the invention. This comprises an electrode 41 referred to as membrane electrode and an electrode 42 referred to as anchoring electrode, each connected to a different terminal of a current generator (not shown).

The indirect resistance welding system according to the invention allows the membrane electrode 41 to be pressed against the sealing plate 1, in the vicinity of the edge 15 of the sealing plate separating the part of the anchoring plate 22 located under the sealing plate 1 from the free portion of the anchoring plate 22 not covered by the sealing plate. The anchoring plate 22 is riveted to a shell 40.

As a guide, the thickness of the sealing plate 1 is 1.2 mm and that of the anchoring plate 22 is 2 mm.

The indirect resistance welding system also allows the anchoring electrode 42 to be pressed against the free portion of the anchoring plate 22, in the vicinity of the edge 15 of the sealing plate.

The current generator allows to send a current I passing through the electrodes 41, 42 and between the electrodes 41, 42. The current path I between the electrodes 41, 42 passes through the sealing plate 1 and through the anchoring plate 22, passing through a point located under the sealing plate 1, in line with the membrane electrode, at the interface with the anchoring plate 22. Of course, the direction of the current between the electrodes 41, 42 is irrelevant. The electrical resistance at this point is high and, as a result of the Joule effect when the current I passes, material melts to form a welding point 30, which is therefore located under the sealing plate 1.

The electrodes 41 and 42 are each separated from the edge 15 by a distance of approximately 8 mm, for example 7.5 mm. However, it should be noted that the distance from the membrane electrode 41 to the edge 15 is not necessarily identical to the distance from the anchoring electrode 42 to the edge 15.

Alternatively, the membrane electrode 41 and the anchoring electrode 42 are each less than 8 mm, e.g. 6 mm but more than 5 mm, from the edge 15, or are each more than 8 mm, e.g. 12 mm but less than 15 mm, from the edge 15.

These minimum and maximum distances allow to prevent the formation of an electric arc with the edge 15 when a current I is sent by the current generator to the electrodes, while allowing the current I passing through the anchoring plate 22 and the sealing plate 1 at the level of the welding point 30 to be large enough to create this welding point 30.

According to a first embodiment of the invention shown in Figures 3 to 5, an indirect resistance welding system S1 according to the invention comprises a support 5 forming a rectangular frame 53 delimiting an opening 530. This indirect resistance welding system S1 comprises the same electrodes 41, 42 as in Figure 2, and comprises a current generator connected in the same way to these electrodes.

The support 5 comprises positioning means for positioning the support 5 relative to the sealing plate 1, and more particularly positioning means for positioning the support 5 against the edge 15 of the sealing plate 1. The function of these positioning means is to ensure that the support 5 and therefore the electrodes 41, 42 are reliably positioned in relation to the sealing plate 1 and the anchoring plate 22. These positioning means may in particular take the shape of at least one stop, configured to come into contact with the edge 15 of the sealing plate. In the example shown, the positioning means comprise a first stop 51 and a second stop 52.

The first stop 51 and the second stop 52 (visible in Figure 4) are attached under a median part of the two short edges of the rectangular frame 53, their stop surfaces being coplanar and parallel to the two long edges of the rectangular frame 53. The stops 51 and 52 extend on either side of the rectangular frame 53 without projecting beyond the side of the opening 530 of the rectangular frame 53.

Each long edge of the rectangular frame 53 is extended orthogonally to the rectangular frame 53 by a rail 532, 534 in the shape of a slide with a substantially U-shaped cross-section, the arms of the U extending parallel to the main plane of extension of the rectangular frame 53. The rails 532, 534 extend from a side of the rectangular frame 53 which is opposite the side of the projecting frame from which the stops 51, 52 extend.

The support 5 also comprises a first upright 55 extending orthogonally to the rectangular frame 53, being attached so as to slide in the first of the rails 532, the first upright 55 being cut out at one of its ends so as to form a slider 550 gripping one of the edges of the rail 532.

Similarly, the support 5 comprises a second upright 57 extending orthogonally to the rectangular frame 53, being attached so as to slide in the second of the rails 534, the second upright being cut out at one of its ends so as to form a slider gripping one of the edges of the rail 534.

An actuator 9 is arranged between the uprights 55 and 57 and is secured to them by its stationary part. In this embodiment of the invention, the actuator 9 is an electric or hydraulic cylinder, the outer tube of which is secured to the uprights 55, 57. Two electrode holders 61, 62 are attached to the extension tube of the actuator 9 and respectively hold one of the electrodes 41, 42 longitudinally orthogonal to the main extension plane of the rectangular frame 53. The first electrode holder 61 holds the membrane electrode 41 by being attached to the extension tube on the side of the first upright 55, while the second electrode holder 62 holds the anchoring electrode 42 by being attached to the extension tube on the side of the second upright 57. The electrodes 41, 42 are partly arranged in the opening 530 of the rectangular frame 53.

The membrane electrode 41 is cylindrical with a circular cross-section approximately 8 mm in diameter. The circular end of the membrane electrode 41, which extends on the side of the rectangular frame 53 associated with the stops 51, 52, forms a contact surface of the membrane electrode 41 with the sealing plate 1, i.e. it is configured to be in contact with the sealing plate 1.

The anchoring electrode 42 is cylindrical with a circular cross-section approximately 12 mm in diameter. The circular end of the anchoring electrode 42, which extends on the side of the rectangular frame 53 associated with the stops 51, 52, forms a contact surface of the anchoring electrode 42 with the anchoring plate 22, i.e. it is configured to be in contact with the anchoring plate 22.

The electrodes 41, 42 are here of the same height but their attachment to the actuator extension tube 9 shifts them longitudinally from one another (in the direction of the axis A3 when the support 5 is positioned on the sealing and anchoring plates), the thickness of the sealing plate 1, so that the contact surface of the membrane electrode 41 with the sealing plate 1 is closer to the opening 530 than the contact surface of the anchoring electrode 42 with the anchoring plate 22. This longitudinal offset, in a direction orthogonal to the rectangular frame 53, is therefore 1.2 mm.

A first handle 81 is attached to the ends of a first of the short edges of the rectangular frame 53 and a second handle 82 is attached to the ends of a second of the short edges of the rectangular frame 53.

These handles 81, 82 allow an operator to install the indirect resistance welding system S1 on the sealing 1 and anchoring plates 22 as shown in Figures 3 to 5, i.e. by aligning the long edges of the rectangular frame 53 along the first axis A1 parallel to the edge 15 of the sealing plate 1, so that the edge 15 is in the opening 530 of the rectangular frame 53. This alignment is performed so that the electrodes lie on either side of the edge 15 of the sealing plate, with the membrane electrode 41 lying above the sealing plate 1 and the anchoring electrode 42 lying above the anchoring plate 22.

The first and second stops 51, 52 allow the operator to press the support 5 in place:

- against the free portion of the anchoring plate 22, parallel to the third axis A3, i.e. orthogonal to the main extension planes of the plates 1, 22, and
- against the edge 15 of the sealing plate 1, parallel to the second axis A2, i.e. orthogonal to the wafer of the sealing plate 1.

As shown in Figure 4, the indirect resistance welding system S1 comprises a wedge 54 attached under the first rail 532 of the support 5 allowing to position the rectangular frame 53, and in particular the rails of the support 5, orthogonally to the third axis A3.

When the stop surfaces of the first and second stops 51, 52 are pressed against the edge 15 of the sealing plate, the membrane electrode 41 and the anchoring electrode 42 are

each located at the desired and easily reproducible distance, here approximately 8 mm, from the edge 15 of the sealing plate.

A part of the rectangular frame 53 is then located between the corrugations 12 and 14 of the sealing plate 1, without abutting against another corrugation 16 of the sealing plate 1, remote from the edge 15 and orthogonally joining the corrugations 12 and 14. This part of the rectangular frame 53 is strictly smaller than the distance between the corrugations 12 and 14, by at least the size of a rivet 24, so that the rectangular frame 53 may be moved along the edge 15 to avoid positioning the electrodes 41, 42 above such a rivet 24. It should be noted that, in an alternative embodiment, the first and second stops 51, 53 coming up against the edge 15, are replaced by one or more stops coming up against the corrugation 16 parallel to the edge 15.

The actuator 9 is then able to press the membrane electrode 41 against the sealing plate 1 and the anchoring electrode 42 against the free portion 22 of the anchoring plate, with the same pressing force corresponding, for example, to three kilograms. The electrodes may then be supplied with current to form a welding point 30 between the sealing plate 1 and the anchoring plate 22.

Once the welding point has been performed and the actuator 9 deactivated, the rails 532, 534 and the sliders of the uprights 55, 57 allow an operator to move the electrodes 41, 42 into the opening 530 of the rectangular frame 53 of the support 5, by a minimum distance of approximately 40 mm, before performing a new welding point. The opening 530 in the rectangular frame 53 extends for example longitudinally (along the length of the frame and parallel to the axis A1 when the support 5 is positioned on the sealing and anchoring plates) over at least twenty centimeters so as to allow 4 to 6 welding points 30 to be performed between the sealing plate 1 and the anchoring plate 22, without moving the rectangular frame 53.

As an alternative to this first embodiment of the invention, each electrode 41, 42 is attached to a separate actuator, which allows a greater force to be applied to the membrane electrode 41 than to the anchoring electrode 42.

A second embodiment of the invention is now described in relation to Figure 6, wherein an indirect resistance welding system S2 comprises elements common to those of the indirect resistance welding system S1 of the first embodiment of the invention, these common elements being identically referenced.

The indirect resistance welding system S2 comprises a support 5b comprising a rectangular plate 53b wherein four openings 530b are arranged at regular distances from each other along the length of the rectangular plate 53b. The indirect resistance welding system S2 also comprises four pairs p1, p2, p3, p4 of electrodes 41 and 42, these four pairs being arranged in a row in the support 5b. Each pair of electrodes p1 to p4 pass in part through a separate opening 530b in the rectangular plate 53b. The indirect resistance welding system S2 also comprises switching means capable of connecting each pair of electrodes p1 to p4 to a current generator.

In this second embodiment of the invention, each membrane electrode 41 or anchoring electrode 42 of a pair of electrodes p1 to p4 is actuated by a separate first actuator 91 or respectively a separate second actuator 92, which in this second embodiment are hydraulic or electric cylinders. In particular, the membrane electrode 41 of each pair of electrodes p1 to p4 is attached by its electrode holder 61 to the extension tube of a first actuator 91, this first actuator 91 being secured by its outer tube to a first upright 55b attached to the rectangular plate 53b of the support 5b and extending orthogonally thereto.

Similarly, the anchoring electrode 42 of each pair of electrodes p1 to p4 is attached by its electrode holder 62 to the extension tube 920 of a second actuator 92, this second actuator 92 being secured by its outer tube to a second upright 57b attached to the rectangular plate 53b of the support 5b and extending orthogonally thereto.

The electrode holders 61 and 62 hold the respective electrodes 41 and 42 longitudinally, orthogonally to the main plane of extension of the rectangular plate 53b of the support 5b.

The arrangement of the electrodes 41, 42 in the support 5b is such that a longitudinal section of the rectangular plate 53b separates each membrane electrode 41 from each anchoring electrode 42. This longitudinal section corresponds to a median cut along the length of the rectangular plate 53b. In other words, all the membrane electrodes 41 are on the same side of the rectangular plate 53b along the length of this rectangular plate 53b, and all the anchoring electrodes 42 are on the other side of the rectangular plate 53b with respect to this same side.

In a similar way to the first embodiment, the support 5b comprises positioning means for positioning the support against the edge 15 of the sealing plate. The positioning means comprise a first stop 51b and a second stop 52b arranged under a median part of two short edges of the rectangular plate 53b, the stop surfaces of the stops 51b, 52b being coplanar and parallel to the long edges of the rectangular plate 53b. The stops 51b and 52b extend

on either side of the rectangular plate 53b without obstructing the openings 530b in the rectangular plate 53b.

In addition, a first handle 81b is attached to the ends of a first of the short edges of the rectangular plate 53b and a second handle 82b is attached to the ends of a second of the short edges of the rectangular plate 53b.

The first and second stops 51b, 52b, which form the positioning means mentioned above, allow the support 5b to be pressed against the edge 15 of the sealing plate 1 and the free portion of the anchoring plate 22 in a similar way to the pressing of the support 5 by the first and second stops 51, 52 of the first embodiment.

The support 5b also comprises a wedge, not shown, allowing to hold the rectangular plate 53b orthogonally to the direction of the axis A3.

This positioning allows each membrane electrode 41 to be positioned above the sealing plate 1 and each anchoring electrode 42 above the anchoring plate 22, so that they are each positioned at a desired and easily reproducible distance of approximately 8 mm from the edge 15 of the sealing plate 1.

In contrast to the first embodiment of the invention, in this second embodiment the electrodes 41, 42 may not be moved along part of the length of the rectangular plate 53b of the support 5b. In addition, their respective contact surfaces with the sealing plate 1 or the anchoring plate 22 may be attached to the extension tubes of the actuators 91, 92, at the same level orthogonally to the main plane of extension of the rectangular plate 53b, when the extension tubes are retracted, since these extension tubes may move independently of each other.

The actuators 91 and 92 of each pair p1 to p4 of electrodes are capable of pressing the membrane electrode 41 against the sealing plate 1 and the anchoring electrode 42 against the free portion 22 of the anchoring plate, with a pressing force of approximately 4 kilograms for the membrane electrode 41 and a pressing force of approximately 2 kilograms for the anchoring electrode 42. These values are given for information only. This pressing is performed pair by pair of electrodes, as the welding points are produced. The current I is also sent successively to each pair of electrodes p1 to p4 so as not to generate current leaks, a poor current distribution or require too high a current.

In other words, when a pair of electrodes is pressed against the plates to produce a welding point, the other pairs of electrodes are raised, i.e. placed at a distance from the plates, and

the current I is sent successively to each pair of electrodes only when it is pressed against the plates.

The openings 530b are spaced 50 mm apart, for example, so that four welding points 30 are performed, distributed over a substantial length along the edge 15 of the sealing plate 1.

As an alternative to this second embodiment of the invention, the support 5b comprises more or less than four pairs of electrodes, for example only one pair of electrodes or six pairs of electrodes.

According to a third embodiment of the invention now described in relation to Figure 7, an indirect resistance welding system S3 comprises a support 5c forming a rectangular frame 53c delimiting an opening 530c.

In a similar way to the first embodiment, the support 5c comprises positioning means for positioning the support against the edge 15 of the sealing plate. The positioning means comprise a first stop 51c and a second stop 52c.

One end of a first of the two short edges of the rectangular frame 53c comprises a foot forming the first stop 51c, and one end of a second of the two short edges of the rectangular frame 53c comprises a foot forming the second stop 52c, the stops 51c and 52c being arranged on the same side of a long edge of the rectangular frame 53c. The stop surfaces of the first and second stops 51c, 52c are coplanar and parallel to the two long edges of the rectangular frame 53c. The stops 51c and 52c extend under the rectangular frame 53c without obstructing the opening 530c of the rectangular frame 53c.

Each long edge of the rectangular frame 53c is extended orthogonally to the rectangular frame 53c by a first rail 532c or a second rail 534c identical to the rails 532 and 534 of the first embodiment of the invention.

The support 5c also comprises a first upright 55c extending orthogonally to the rectangular frame 53c, being attached so as to slide in the first of the rails 532c, the first upright 55c being cut out at one of its ends so as to form a slider 550c gripping one of the edges of the first rail 532c.

Similarly, the support 5c comprises a second upright 57c extending orthogonally to the rectangular frame 53c, being attached so as to slide in the second of the rails 534c, the second upright 57c being cut out at one of its ends so as to form a slider gripping one of the edges of the second rail 534c. The uprights 55c and 57c are held at a distance from each

other and in the first and second rails 532c, 534c, by a crossbar 56 connecting the ends of the uprights 55c, 57c opposite the ends of the uprights forming sliders.

Unlike the first embodiment of the invention, in this third embodiment of the invention, the indirect resistance welding system S3 comprises a first actuator 91c and a second actuator 92c, secured by their stationary parts to the respective uprights 55c, 57c. In this example, the actuators 91c, 92c are in this example of embodiments hydraulic or electric cylinders.

The first actuator 91c is secured by its extension tube to a first axle on which a first hub 63 is mounted in rotation, and the second actuator 92c is secured by its extension tube to a second axle on which a second hub 64 is mounted in rotation. The first hub 63 and the second hub 64 are therefore electrode holders.

Membrane electrodes 41c, of the same shape as the electrodes 41 of the first embodiment, are secured to the first hub so as to form radii, or radial branches, regularly and angularly distributed around the first hub.

Similarly, anchoring electrodes 42c, of the same shape as the electrodes 42 of the first embodiment, are secured to the second hub so as to form radii, or radial branches, regularly and angularly distributed around the second hub.

In addition, a first handle 81c is attached to the ends of the first short edge of the rectangular frame 53c, and a second handle 82c is attached to the ends of the second short edge of the rectangular frame 53c.

These handles 81c, 82c allow an operator to install the indirect resistance welding system S3 on the sealing 1 and anchoring plates 22 as shown in Figure 7, i.e. by aligning the long edges of the rectangular frame 53c parallel to the edge 15 of the sealing plate 1, so that the edge 15 is in the opening 530c of the rectangular frame 53c. This alignment is performed so that the membrane electrodes 41c are above the sealing plate 1 and the anchoring electrodes 42c are above the anchoring plate 22.

The first and second stops 51c, 52c allow the operator to press the support 5c on the one hand:

- against the free portion of the anchoring plate 22, orthogonally to the main extension planes of the plates 1, 22, and
- against the edge 15 of the sealing plate 1, orthogonally to the wafer of the sealing plate 1.

As shown in Figure 7, the indirect resistance welding system S3 also comprises a wedge 54c attached under the first rail 532c of the support 5c allowing to hold the rectangular frame 53c orthogonally to the third axis A3.

When the stop surfaces of the first and second stops 51c, 52c are pressed against the edge 15 of the sealing plate, the membrane electrodes 41c and the anchoring electrodes 42c are each located at a desired and easily reproducible distance, in this case approximately 8 mm, from the edge 15 of the sealing plate 1.

When the uprights 55c, 57c slide along the rails 532c and 534c, the synchronous movement of the first and second hubs 63, 64 allows each membrane electrode 41c to be brought successively opposite the sealing 1 and anchoring plate 22, at the same time as an anchoring electrode 42c. The actuators 91c, 92c then press this membrane electrode 41c against the sealing plate 1 at the same time as they press the anchoring electrode 42c against the anchoring plate 22. These two electrodes 41c, 42c pressed at the same time form a pair of electrodes capable of performing a welding point 30, by sending the current I to this pair of electrodes 41c, 42c thus pressed.

The hubs 63, 64 comprise the same number of membrane electrodes 41c and anchoring electrodes 42c respectively, which in this case is six, forming six pairs of electrodes 41c, 42c. The indirect resistance welding system S3 also comprises switching means capable of successively connecting each of the pairs of electrodes 41c, 42c to a current generator. Alternatively, however, the hubs comprise only two, three, four or five pairs of electrodes.

The actuators 91c, 92c are able to exert pressing forces of 4 kilograms and 2 kilograms respectively on the electrodes 41c, 42c, when their respective contact surfaces are placed against the sealing plate 1 and against the anchoring plate 22 respectively. Of course, these values are given as a guide only, as other values may be used.

This third embodiment therefore allows to perform six welding points in the opening 530c of the rectangular frame 53c of the support 5c, without moving the rectangular frame 53c.

According to a fourth embodiment of the invention now described in relation to Figure 8, an indirect resistance welding system S4 comprises many elements in common with the indirect resistance welding system S3 of the third embodiment of the invention, referenced in the same way.

In particular, the indirect resistance welding system S4 comprises the same support 5c of the third embodiment, comprising the stops 51c, 52c, the wedge 54c, the rails 532c, 534c

and the uprights 55c, 57c to which the stationary parts of the first actuator 91c and of the second actuator 92c respectively are secured.

In contrast to the third embodiment of the invention, in the indirect resistance welding system S4, the first actuator 91c is secured by its extension tube to a first axle on which a membrane electrode 41d shaped like a wheel is directly mounted so as to rotate, and the second actuator 92c is secured by its extension tube to a second axle on which an anchoring electrode 42d shaped like a wheel is directly mounted so as to rotate. The first actuator 91c is able to exert a first pressing force of approximately 4 kilograms on the membrane electrode 41d, and the second actuator 92c is able to exert a second pressing force of approximately 2 kilograms on the anchoring electrode 42d. Once again, these values are given for guidance only.

The membrane and anchoring electrodes 41d, 42d have the same diameter, but the membrane electrode 41d is thinner than the anchoring electrode 42d, for example the membrane electrode 41d is 8 mm thick and the anchoring electrode 42d is 12 mm thick. The wheels formed by the membrane and anchoring electrodes 41d, 42d have flats which provide a sufficiently large contact surface for a high current to pass between each electrode and the sealing plate 1 or anchoring plate 22 to which it is applied.

When the stop surfaces of the first and second stops 51c, 52c are pressed against the edge 15 of the sealing plate 1, the membrane electrode 41d and the anchoring electrode 42d are each located at the desired and easily reproducible distance, here approximately 8 mm, from the edge 15 of the sealing plate 1. The rails 532c, 534c are also arranged on either side of the edge 15 of the sealing plate 1, parallel to it.

So when the actuators 91c, 92c press the electrodes 41d, 42d with the first and second pressing force respectively against the sealing plate 1 or the anchoring plate 22, and when the uprights 55c, 57c are moved along the rail, welding points 30 may be produced by sending current I to the electrodes 41d, 42d at regular intervals along the sealing plate 1. To speed up the welding method, the height of the actuators 91c, 92c relative to the sealing plates 1 or anchoring plates 22 between two activations is smaller than their default height just after the positioning of the support 5c.

According to a fifth embodiment of the invention now described in relation to Figure 9, an indirect resistance welding system S2b comprises many elements in common with the indirect resistance welding system S2 of the second embodiment of the invention, and referenced in the same way.

In particular, the indirect resistance welding system S2b comprises a pair of electrodes 41, 42 of the same shapes as those of one of the pairs of electrodes p1 to p4 of the second embodiment. These electrodes (41, 42) are attached by electrode holders (61, 62) identical to those used in the second embodiment, to actuators (91, 92) identical to those used in the second embodiment.

This fifth embodiment differs from that previously described in that the actuators 91, 92 are attached to a support 5d allowing ab indirect resistance welding of the sealing plate 1 to the anchoring plate 22, at the level of a circular edge 15b of the sealing plate 1, this circular edge 15b being formed, for example, by a circular cutout in the sealing plate 1.

The support 5d comprises a plate 53d comprising an opening 530d into which the extension tubes 920 of the actuators 91, 92 extend. The plate 53d is configured to be positioned substantially parallel to the sealing 1 and anchoring plates 22, i.e. parallel to within a tolerance of a few degrees, while being kept at a distance from these plates by means of a stop 51d forming a first foot of the plate 53d, and a wedge 54d forming a second foot of the plate 53d. The stop 51d and the wedge 54d are attached to separate ends of the plate 53d.

The stop 51d forms a portion of a hollow cylinder extending orthogonally to the plate 53d, the free end of which comprises a semi-circular stop surface complementary to at least a first part of the circular edge 15b of the sealing plate 1. The stop 51d is therefore able to position the support 5d against the circular edge 15b of a circular cut-out in the sealing plate 1.

The opening 530d in the plate 53d allows to separate the stationary parts of the actuators 91, 92 from their moving parts, to which the electrode holders 61, 62 are attached. The moving parts of the actuators 91, 92, the electrode holders 61, 62 and the electrodes 41, 42 are therefore arranged in the space delimited by the plate 53d, the stop 51d and the wedge 54d, while the stationary parts of the actuators 91, 92 are located on the other side of the plate relative to the stop 51d and to the wedge 54d. The stationary parts of the actuators 91, 92 rest on either side of the opening 530d and are able to slide towards each other, their extension tubes being able to follow this movement through the opening 530d, and are therefore able to adjust their respective positions on the plate 53d. This arrangement allows the distance between the electrodes 41, 42 to be adjusted. It is understood that the welding system S2b comprises a single pair of electrodes, and means for adjusting the distance between the membrane electrode 41 and the anchoring electrode 22.

Finally, handles 81d and 82d are secured to the support 5d on either side to make it easier to grip the welding system S2b.

When the welding system S2b is in position on the sealing plate 1 and the anchoring plate 22, the stop 51d is positioned against the first part of the circular edge 15b of the sealing plate 1 by being placed in the circular cut-out of the sealing plate 1, therefore on the anchoring plate 22, while the wedge 54d is placed on the sealing plate 1. The anchoring electrode 42 is then positioned above the anchoring plate 22, in the circular cut-out of the sealing plate 1, while the membrane electrode 41 is positioned above the sealing plate 1, opposite the membrane electrode 41 with respect to a second part of the circular edge 15b which is not in contact with the stop 51d. This second part of the circular edge 15b is diametrically opposed to the first part of the circular edge 15b. The membrane electrode 41 and the anchoring electrode 42 are then each located at the desired and easily reproducible distance, in this case approximately 8 mm, from the second part of the circular edge 15b of the sealing plate 1.

The first actuator 91 is then able to exert a first pressing force on the membrane electrode 41, and the second actuator 92 is able to exert a second pressing force on the anchoring electrode 42. In accordance with the examples given above, the first pressing force may be of the order of 4 kilograms, while the second pressing force is of the order of 2 kilograms, these values being to be considered as indicative and non-limiting.

So when the actuators 91, 92 press the electrodes 41, 42 with the first and second pressing force against the sealing plate 1 or the anchoring plate 22 respectively, a welding point 30 may be produced by sending current I to the electrodes 41, 42. Other welding points 30 may then be produced on the sealing plate 1 along the periphery of its circular cut-out, by first moving the electrodes 41, 42 away from the sealing plate 1 and anchoring plate 22 respectively, then repositioning the support 5d, the latter being guided in rotation by the stop 51d moving against the circular edge 15b of the sealing plate 1.

Alternatively, in this fifth embodiment, the stop 51d is of a different shape, and comprises a stop surface capable of cooperating with other types of cut-out in the sealing plate 1.

Figure 10 now illustrates an indirect resistance welding system S5 according to the invention, comprising the indirect resistance welding system S2 according to the invention, as well as a robotic arm 83 capable of exerting a pressing force on the support 5b of the indirect resistance welding system S2, allowing to counteract the reverse bearing reactions of the pressing forces exerted by the actuators 91, 92 during the production of a welding point.

In an alternative embodiment, the indirect resistance welding system S5 comprises not the indirect resistance welding system S2 according to the invention, but the indirect resistance welding system S1, S2b, S3 or S4 according to the invention.

The robotic arm 83 is attached to a casing 84 comprising a number of items of equipment, the casing 84 being transported on the mobile trolley of the indirect resistance welding system S5. The casing 84 comprises, for example, the current generator supplying the electrodes 41, 42, the means for controlling the robotic arm 83, the current generator and the actuators 91, 92, and possibly a source of liquid for supplying the actuators when these are hydraulic cylinders.

Referring now to Figure 11, an indirect resistance welding method 100 is described, using the indirect resistance welding system S1, S3 or S4, possibly in combination with the trolley and the robotic arm 83 of the indirect resistance welding system S5.

A first step 102 of the indirect resistance welding method 100 is to position the rails 532, 534 or 532c, 534c on either side of the edge 15 of the sealing plate 1, by pressing the support positioning means 5, 5c, i.e. the first and second stops 51, 52 or 51c, 52c, against the edge 15 of the sealing plate 1, and the wedge 54 or 54c against the sealing plate 1. After this positioning 102, the first electrode or the electrodes 41, 41c, 41d are positioned above the sealing plate 1 and the second electrode or electrodes 42, 42c, 42d are positioned above the free portion of the anchoring plate 22, each at the desired distance from the edge 15 of the sealing plate 1.

During this first step 102, the position of the support 5, 5c may be adjusted along the edge 15, by holding the stops 51, 52 or 51c, 52c against this edge 15, if the electrodes 41, 41c, 41d, 42, 42c, 42d are opposite a rivet.

The next step 104 of the indirect resistance welding method 100 is the activation of the actuator or actuators 9, 91c, 92c. For the indirect resistance welding system S3, only the electrodes 41c, 42c are considered here, whose contact surface is opposite the sealing plate 1 and the anchoring plate 22 respectively. In this step 104, the actuators 9, 91c, 92c are activated until a first pressing force is exerted to press the membrane electrode 41, 41c, 41d against the sealing plate 1 and a second pressing force is exerted to press the anchoring electrode 42, 42c, 42d against the anchoring plate 22.

When the actuator 9 of the indirect resistance welding system S1 is used, the first pressing force is equal to the second pressing force and corresponds, for example, to 3 kilograms.

Other values may of course be used, depending in particular on the mechanism of force pick-up on the support.

On the other hand, the first actuator 91 of the indirect resistance welding system S3 or S4 exerts a first pressing force equal to approximately 4 kilograms on the membrane electrode 41c or the membrane electrode 41d, and the second actuator 92 of the indirect resistance welding system S3 or S4 exerts a second pressing force equal to approximately 2 kilograms on the anchoring electrode 42c or the anchoring electrode 42d. These values are given as a guide only, as other values may be used for the pressing forces.

The next step 106 in the indirect resistance welding method 100 is to send a current I of several kiloamperes through the electrodes 41, 42, 41c, 42c, 41d, 42d, so as to form a welding point 30 between the sealing plate 1 and the anchoring plate 22. For the indirect resistance welding system S3, only the electrodes 41c, 42c are considered here, whose contact surface is opposite the sealing plate 1 and the anchoring plate 22 respectively. At the end of the current sending step 106, the current I is cut off and the actuators 9, 91, 92 deactivated so that the electrodes 41, 42, 41c, 42c, 41d, 42d are no longer pressed against the sealing plate 1 or the anchoring plate 22.

Then the next step 108 is a test to check whether all the welding points 30 to be performed along the rails 532, 534, 532c, 534c have been made. This test may be visual or supervised by a program if the movement of the uprights 55, 57, 55c, 57c, the activation of the actuators 9, 91, 92 and the sending of the current I are controlled by computer. If, at the end of the test 108, it is confirmed that all the welding points 30 to be performed have been completed (branch Y), then the indirect resistance welding method 100 is terminated.

If, on the other hand, at the end of the test 108, it is found that not all the welding points 30 to be performed have been made (branch N), then the next step is a step 110 of moving the electrodes 41, 42, 41c, 42c, 41d, 42d along the rails 532, 534, 532c, 534c until they are in a position to perform a new welding point 30, separated from the previous welding point 30 by at least a predetermined distance, for example equal to 40 mm.

At the end of the step 110 of displacement, allowing a minimum time between two welding points 30 of at least 350ms, the indirect resistance welding method 100 continues by returning to the step 104 of activating the actuators 9, 91, 92, until the test at step 108 becomes positive.

Referring now to Figure 12, an indirect resistance welding method 200 is described, using the indirect resistance welding system S2, possibly in combination with the trolley and the robotic arm 83 of the indirect resistance welding system S5.

A first step 202 of the indirect resistance welding method 200 is the positioning of each membrane electrode 41 of the electrode pairs p1 to p4 above the sealing plate 1 and of each anchoring electrode 42 of the electrode pairs p1 to p4 above the free portion of the anchoring plate 22, by pressing the first and second stops 51b, 52b against the edge 15 of the sealing plate 1, and the wedge of the support 5b against the sealing plate 1. After this positioning 202, the electrodes 41, 42 of each pair p1 to p4 are each positioned at the desired distance from the edge 15 of the sealing plate 1. When the successive production of the welding points is carried out by a computer program, during this first step 202, this program initializes an electrode pair number to 1 to designate the first electrode pair p1.

The next step 204 in the indirect resistance welding method 200 is to activate the actuators 91, 92 to which the electrodes 41, 42 of the first pair p1 of electrodes are attached. In this step 204, these actuators 91, 92 are activated until a first pressing force of approximately 4 kilograms is exerted by the membrane electrode 41 on the sealing plate 1 and a second pressing force of approximately 2 kilograms is exerted by the anchoring electrode 42 on the anchoring plate 22, these values being given for information only.

The next step 206 in the indirect resistance welding method 200 is to send a current I of several kiloamperes through the electrodes 41, 42 of the first pair p1 of electrodes, so as to form a first welding point 30 between the sealing plate 1 and the anchoring plate 22. At the end of this step 206 of sending current, the current I is cut off and the actuators 91, 92 deactivated so that the electrodes 41, 42 of the first pair of electrodes p1 are no longer pressed against the sealing plate 1 or the anchoring plate 22.

Then the next step 208 is a test to check whether all the welding points 30 to be performed without moving the support 5b have been completed. This test may be visual or supervised by a program if the activation of the actuators 9, 91, 92 and the sending of the current I are controlled by a computer. If, at the end of the test 208, it is confirmed that all the welding points 30 to be performed have been completed (branch Y), then the indirect resistance welding method 200 ends.

If, on the other hand, at the end of the test 208, it is found that not all the welding points 30 to be performed have been made (branch N), then the next step is a step 210 of waiting for a predetermined duration, set at 350ms in this embodiment of the invention, then of incrementing the electrode pair number, when the successive making of the welding points

is carried out by a computer program. During the first passage through the waiting step 210 of a predetermined duration, this number is incremented to two, designating the second pair of electrodes p2 to be considered for the following steps.

At the end of this waiting step 210 of a predetermined duration, the indirect resistance welding method 200 continues by returning to a step 204 of activating the actuators 91, 92 applied to the second pair of electrodes p2, followed by a new step 206 of sending current to this second pair of electrodes p2, then a new test step 208, and so on until current is sent to the pair of electrodes p4 and the end of the indirect resistance welding method 200 is established in a final test step 208.

Of course, the invention is not limited to the examples just described and many adjustments may be made to these examples without departing from the scope of the invention. In particular, the characteristics of different variants or different embodiments of the invention may be combined to achieve the invention, insofar as these variants or these embodiments are not mutually incompatible.

CLAIMS

1- A system (S1, S2, S3, S4, S5) for the indirect resistance welding of a sealing plate (1) of a tank configured to contain liquefied gas, to an anchoring plate (22) arranged partly beneath the sealing plate (1) so as to leave a free portion of the anchoring plate (22) outside the sealing plate (1), an edge (15) of the sealing plate (1) separating the sealing plate (1) from the free portion of the anchoring plate (22), the welding system (S1, S2, S3, S4, S5) comprising:

- at least one pair of electrodes and a current generator adapted to be connected to the electrodes (41, 42, 41c, 42c, 41d, 42d),
- a support (5, 5b, 5c) capable of holding the electrodes of the at least one pair of electrodes relative to each other,
- positioning means for positioning the support (5, 5b, 5c) against the sealing plate (1), capable of positioning the electrodes of the at least one pair of electrodes on either side of the edge (15), by positioning one electrode of said at least one pair of electrodes, referred to as membrane electrode (41, 41c, 41d) above the sealing plate (1) and another electrode of said at least one pair of electrodes, referred to as anchoring electrode (42, 42c, 42d), above the free portion of the anchoring plate (22), and
- at least one actuator (9, 91, 92, 91c, 92c) for each pair of electrodes, capable of pressing the membrane electrode (41, 41c, 41d) against the sealing plate (1) and the anchoring electrode (42, 42c, 42d) against the free portion of the anchoring plate (22).

2- The indirect resistance welding system (S2, S3, S4, S5) as claimed in claim 1, comprising two actuators (91, 92, 91c, 92c) for each pair of electrodes, including a first actuator (91, 91c) capable of pressing the membrane electrode (41, 41c, 41d) against the sealing plate (1) with a first pressing force, and a second actuator (92, 92c) capable of pressing the anchoring electrode (42, 42c, 42d) against the free portion of the anchoring plate (22) with a second pressing force.

3- The indirect resistance welding system (S1, S2, S3, S4, S5) according to claim 1 or 2, wherein the membrane electrode (41, 41c, 41d) comprises a contact surface with the sealing plate (1) strictly smaller than a contact surface of the anchoring electrode (42, 42c, 42d) with the free portion of the anchoring plate (22).

4- The indirect resistance welding system (S1, S2, S3, S4, S5) according to any one of claims 1 to 3, wherein the positioning means comprise at least one stop (51, 51b, 51c, 52, 52b, 52c) secured to the support (5, 5b, 5c) and capable of being pressed against the edge (15) of the sealing plate (1), or against a corrugation (12, 14, 16) of the sealing plate (1).

5- The indirect resistance welding system (S1, S2, S3, S4, S5) according to claim 4, wherein the support (5, 5b, 5c) comprises a frame (53, 53b, 53c, 53d) delimiting an opening (530, 530b, 530c, 530d), the stop (51, 51b, 51c, 52, 52b, 52c) forming an extension of a lower portion of the support (5, 5b, 5c) capable of being in contact with one or other of the sealing plate (1) or the anchoring plate (22), without obstructing the opening in the frame (53, 53b, 53c, 53d).

6- The indirect resistance welding system (S1, S3, S4) according to any one of claims 1 to 5, wherein the support (5, 5b, 5c) comprises two rails (532, 532c, 534, 534c) capable of being positioned on either side of the edge (15) of the sealing plate (1) and parallel to said edge, and movement means for moving the electrodes (41, 42, 41c, 42c, 41d, 42d) of each pair of electrodes, mounted so as to move in translation on the two rails (532, 532c, 534, 534c).

7- The indirect resistance welding system (S4) according to claim 6, wherein the movement means comprise at least one axle arranged orthogonally to the rails (532c, 534c), the electrodes (41d, 42d) of each pair of electrodes taking the shape of wheels mounted on the at least one axle.

8- The indirect resistance welding system (S3) according to claim 6, wherein the movement means comprise at least one axle arranged orthogonally to the rails (532c, 534c) as well as a first hub (63) mounted on the at least one axle and on which the membrane electrode (41c) is arranged, the movement means further comprising a second hub (64) mounted on the at least one axle and on which the anchoring electrode (42c) is arranged, each pair of electrodes being configured such that the membrane electrode (41c) is capable

of being in contact with the sealing plate (1) at the same time as the anchoring electrode (42c) is capable of being in contact with the free portion of the anchoring plate (22).

9- The indirect resistance welding system (S3) according to claim 6, comprising several pairs of electrodes and wherein the movement means comprise at least one axle arranged orthogonally to the rails (532c, 534c) as well as a first hub (63) mounted on the at least one axle and wherein the membrane electrodes (41c) of the pairs of electrodes are distributed angularly around the first hub (63), the movement means further comprising a second hub (64) mounted on the at least one axle and wherein the anchoring electrodes (42c) of the electrode pairs are angularly distributed around the second hub (64), the pairs of electrodes being configured such that the membrane electrode (41c) of one of the pairs of electrodes is able to be in contact with the sealing plate (1) at the same time as the anchoring electrode (42c) of said pair of electrodes is able to be in contact with the free portion of the anchoring plate (22).

10- A method for indirect resistance welding (100, 200), using an indirect resistance welding system (S1, S2, S3, S4, S5) according to any one of claims 1 to 9, comprising the steps of:

- positioning (102, 202) the membrane electrode (41, 41c, 41d) above the sealing plate (1) and the anchoring electrode (42, 42c, 42d) above the free portion of the anchoring plate (22), by pressing the positioning means against a portion of the sealing plate (1),
- activating (104, 204) the at least one actuator (9, 91, 92, 91c, 92c) until the membrane electrode (41, 41c, 41d) is pressed against the sealing plate (1) and the anchoring electrode (42, 42c, 42d) is pressed against the free portion of the anchoring plate (22), and
- sending current (106, 206) to the electrodes (41, 41c, 41d, 42, 42c, 42d).

11- The indirect resistance welding method (100, 200) according to claim 10 in combination with claim 2, wherein the activation step (104, 204) comprises pressing the membrane electrode (41, 41c, 41d) against the sealing plate (1) with the first force and pressing the anchoring electrode (42, 42c, 42d) against the free portion of the anchoring plate (22) with the second force, the first force being strictly greater than the second force.

12- The indirect resistance welding method (100) according to claim 10 or 11, in combination with claim 6, wherein the positioning step (102) comprises the positioning of the rails (532, 532c, 534, 534c) on either side of the edge (15) of the sealing plate (1), and is followed by a plurality of steps of activating (104) and sending current (106), the welding method (100) further comprising a step (110) of moving the electrodes along the rails (532, 532c, 534, 534c), interposed between a step of sending current (106) and a step (104) of activating the at least one actuator (9, 91, 92, 91c, 92c).

13- The indirect resistance welding method (200) according to claim 10 or 11, wherein the indirect resistance welding system (S2, S5) comprises a row of pairs of electrodes (p1, p2, p3, p4) arranged on the support (5b),
the positioning step (202) comprises positioning each membrane electrode (41) of the electrode pairs (p1, p2, p3, p4) above the sealing plate (1) and each anchoring electrode (42) of the electrode pairs (p1, p2, p3, p4) above the free portion of the anchoring plate (22), and the welding method (200) comprises as many current sending steps (206) as there are pairs of electrodes (p1, p2, p3, p4), the current sending steps (206) each being spaced apart by a predetermined minimum duration and each supplying a single pair of electrodes (p1, p2, p3, p4).