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United States Patent	12390876
Kind Code	B2
Date of Patent	August 19, 2025
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Resistance spot welding apparatus

Abstract

One aspect of the present disclosure is a resistance spot welding apparatus for welding a workpiece made of layered metallic plates. The resistance spot welding apparatus includes a first electrode; a second electrode arranged such that the workpiece is interposed between the first electrode and the second electrode; and a pressure mechanism that applies pressure to the first electrode towards the first metallic plate by air. The pressure mechanism includes a piston coupled to the first electrode; a cylinder having an inner space that accommodates the piston; a first ventilation unit that supplies the inner space with air for applying pressure to the first electrode; and a second ventilation unit that discharges air from the inner space as pressure is applied to the first electrode. At least one of the first ventilation unit or the second ventilation unit includes two or more air passages that communicate with the inner space.

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Appl. No.:	**17/547987**
Filed:	**December 10, 2021**

Prior Publication Data

Document Identifier	Publication Date
US 20220226924 A1	Jul. 21, 2022

Foreign Application Priority Data

JP	2021-007122	Jan. 20, 2021

Publication Classification

Int. Cl.: **B23K11/30** (20060101); **B23K11/11** (20060101); **B23K11/31** (20060101)

U.S. Cl.:

CPC **B23K11/115** (20130101); **B23K11/3009** (20130101);

Field of Classification Search

CPC: B23K (11/115); B23K (11/11); B23K (11/3009)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS
(1) This application claims the benefit of Japanese Patent Application No. 2021-007122 filed on Jan. 20, 2021 with the Japan Patent Office, the entire disclosure of which is incorporated herein by reference.
BACKGROUND
(2) The present disclosure relates to a resistance spot welding apparatus.
(3) In apparatuses for performing a resistance spot welding on a workpiece made of layered metallic plates such as steel plates, a publicly known configuration is to apply pressure to an electrode, which is being welded, by air pressure produced by a pneumatic cylinder such that the electrode is pressed against the metallic plates (see, Japanese Unexamined Patent Application Publication No. 2002-059269).
(4) By thus applying pressure to the electrode towards the metallic plates, an area of contact between the electrode and the metallic plates after completion of the welding increases. As a result, a cooling speed of the metallic plates is improved, and a fracture of the metallic plate after the welding can be reduced.
(5) In addition, by using the pneumatic cylinder as a pressure mechanism, the cost of the welding apparatus can be reduced compared with a case of using a servomotor.
SUMMARY
(6) Resistance spot welding, in which air pressure is applied to an electrode, the electrode is pushed into a metallic plate as the metallic plate is softened during the welding. When this happens, the pressure applied on the metallic plate by the electrode drops due to decrease in the pressure inside a pneumatic cylinder, which causes a lack of stability in the pressure application. It consequently generates spatters that may cause welding failures.
(7) Preferably, one aspect of the present disclosure is to provide a resistance spot welding apparatus that can apply air pressure to an electrode while reducing the welding failures.
(8) One aspect of the present disclosure is a resistance spot welding apparatus configured to weld a workpiece made of layered metallic plates. The resistance spot welding apparatus includes a first electrode configured to contact a first metallic plate among the metallic plates; a second electrode configured to contact a second metallic plate among the metallic plates, the second electrode being arranged such that the workpiece is interposed between the first electrode and the second electrode; and a pressure mechanism configured to apply pressure to the first electrode towards the first metallic plate by air.
(9) The pressure mechanism includes a piston coupled to the first electrode; a cylinder having an inner space that accommodates the piston; a first ventilation unit configured to supply the inner space with air for applying pressure to the first electrode; and a second ventilation unit configured to discharge air from the inner space as pressure is applied to the first electrode. At least one of the first ventilation unit or the second ventilation unit includes two or more air passages that are

independent from one another and communicate with the inner space.
(10) This configuration increases amount of air supply or air discharge into or from the cylinder of the pressure mechanism when applying pressure to the first electrode with two or more air passages. As a result, time to apply pressure to the first electrode is reduced.
(11) In other words, this configuration reduces a time to recover the pressure the first electrode applying to the first metallic plate after the first electrode is pushed into the softened first metallic plate. As a result, the welding failures caused by generation of spatters can be reduced.
(12) In one aspect of the present disclosure, tensile strength of at least one of the first metallic plate or the second metallic plate may be 1800 MPa or more. This configuration can precisely reduce the welding failures caused by generation of spatters on a high tension metallic plate, which requires a high-pressure push with the electrode when welding and thus is prone to have spatters generated due to decrease in pressure.
(13) In one aspect of the present disclosure, the first ventilation unit may include two or more air passages that are independent from one another and communicate with the inner space. This configuration can precisely reduce the time to apply pressure to the first electrode.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) An example embodiment of the present disclosure will be described hereinafter by way of example with reference to the accompanying drawings, in which:
(2) FIG. **1** is a schematic drawing of a resistance spot welding apparatus of an embodiment;
(3) FIG. **2** is a schematic cross-sectional view of electrodes and a pressure mechanism of the resistance spot welding apparatus of FIG. **1**;
(4) FIG. **3**A is a schematic cross-sectional view of the electrodes and metallic plates during welding;
(5) FIG. **3**B is a schematic cross-sectional view of the electrodes and the metallic plates during welding;
(6) FIG. **3**C is a schematic cross-sectional view of the electrodes and the metallic plates during welding;
(7) FIG. **3**D is a schematic cross-sectional view of the electrodes and the metallic plates during welding;
(8) FIG. **3**E is a graph showing one example of changes in pressure applied to the first electrode during welding;
(9) FIG. **4**A is a schematic cross-sectional view of a pressure mechanism of an embodiment different from the embodiment of FIG. **2**; and
(10) FIG. **4**B is a schematic cross-sectional view of a pressure mechanism of an embodiment different from the embodiment of FIG. **2**.
DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS
1. First Embodiment
(11) [1-1. Configuration]
(12) A resistance spot welding apparatus **1** shown in FIG. **1** is configured to weld a workpiece W made of layering a first metallic plate P**1** and a second metallic plate P**2**.
(13) In the present embodiment, the first metallic plate P**1** is placed over the second metallic plate P**2**. Materials for the first metallic plate P**1** and the second metallic plate P**2** are not limited to particular materials and are, for example, steel plates such as stainless aluminum-plated steel plates. At least one of the first metallic plate P**1** or the second metallic plate P**2** has a tensile strength of 1800 MPa or more and 3000 MPa or less.
(14) The resistance spot welding apparatus **1** performs a resistance sport welding on the first

metallic plate P**1** and the second metallic plate P**2**, arranged as the workpiece W, in a thickness direction. The resistance spot welding apparatus **1** includes a first electrode **2**, a second electrode **3**, a pressure mechanism **4**, and a main body **5**.

(15) <Electrode>

(16) The first electrode **2** is arranged above the workpiece W and is configured to contact a surface of the first metallic plate P**1**.

(17) The second electrode **3** is arranged below the workpiece W and is configured to contact a surface of the second metallic plate P**2**. The second electrode **3** is also configured to have the workpiece W interposed between the first electrode **2** and the second electrode **3** and to apply a pressure to the workpiece W in the thickness direction.

(18) The first electrode **2** is movable relative to the second electrode **3** in a vertical direction. In the present embodiment, a direction the workpiece W is interposed between the first electrode **2** and the second electrode **3** (that is, a moving direction of the first electrode **2** and/or the second electrode **3**) is parallel to the vertical direction.

(19) A welding current flows between the first electrode **2** and the second electrode **3**, where the workpiece is interposed, via the workpiece W. The first electrode **2** and the second electrode **3** weld the first metallic plate P**1** with the second metallic plate P**2** while interposing the workpiece W and applying pressure to the interposed workpiece W in the thickness direction.

(20) <Pressure Mechanism>

(21) The pressure mechanism **4** is configured to apply pressure to the first electrode **2** towards the first metallic plate P**1** by air. As shown in FIG. **2**, the pressure mechanism **4** includes a piston **41**, a rod **42**, a cylinder **43**, a first ventilation unit **44**, and a second ventilation unit **45**.

(22) The piston **41** is coupled to the first electrode **2** via the rod **42**. The piston **41** is accommodated inside the inner space of the cylinder **43** so as to be reciprocable in an axial direction of the cylinder **43**.

(23) The rod **42** is coupled to the piston **41** and reciprocates with the piston **41** in the axial direction of the cylinder **43**. An end portion of the rod **42** opposite the piston **41** penetrates a bottom wall at a lower end of the cylinder **43** and is coupled to the first electrode **2**.

(24) The cylinder **43** includes the inner space in which the piston **41** is accommodated. The axial direction of the cylinder **43** is parallel to the vertical direction (that is, the thickness direction of the workpiece W). The cylinder **43** includes a first aperture **43**A, a second aperture **43**B, and a third aperture **43**C for communicating the inner space with an exterior of the cylinder **43**.

(25) The inner space of the cylinder **43** is divided into a first region A**1** and a second region A**2** by the piston **41**. The first aperture **43**A and the second aperture **43**B are arranged in a vicinity of an upper end of the cylinder **43** and is communicated with the first region A**1**. The third aperture **43**C is arranged in a vicinity of the lower end of the cylinder **43** and is communicated with the second region A**2**.

(26) The first region A**1** is positioned above the piston **41**. When air is supplied from the first aperture **43**A and the second aperture **43**B into the first region A**1**, the first region A**1** is inflated, which causes the piston **41** to move towards the lower end of the cylinder **43**, increasing an extent of protrusion of the rod **42** from the cylinder **43**. As a result, a pressure is applied to the first electrode **2**.

(27) The second region A**2** is positioned below the piston **41**. When air is supplied from the third aperture **43**C into the second region A**2**, the second region A**2** is inflated, which causes the piston **41** to move away from the lower end of the cylinder **43**, decreasing the extent of protrusion of the rod **42** from the cylinder **43**. As a result, the pressure applied to the first electrode **2** is reduced.

(28) When the first region A**1** is inflated, air is discharged from the second region A**2** to deflate the second region A**2** and to move the piston **41** downwardly. Reversely, when the second region A**2** is inflated, air is discharged from the first region A**1**, and the second region A**2** is inflated to move the piston **41** upwardly.

(29) The first aperture **43**A and the second aperture **43**B are positioned above the uppermost part of the piston **41**. The third aperture **43**C is positioned below the lowermost part of the piston **41**.
(30) The first ventilation unit **44** is configured to supply the inner space of the cylinder **43** with air that is used for applying pressure to the first electrode **2**. The first ventilation unit **44** includes a first air passage **44**A and a second air passage **44**B.
(31) The first air passage **44**A is coupled to the first aperture **43**A of the cylinder **43**. The second air passage **44**B is coupled to the second aperture **43**B of the cylinder **43**. The first air passage **44**A and the second air passage **44**B are each coupled to both an air supply system and an air discharge system. The first air passage **44**A and the second air passage **44**B supply air and discharge air to and from the first region A**1** of the inner space of the cylinder **43** via the first aperture **43**A or the second aperture **43**B. The first air passage **44**A and the second air passage **44**B are independent from one another. More specifically, the first air passage **44**A and the second air passage **44**B are not directly coupled to each other.
(32) In the present embodiment, the first air passage **44**A and the second air passage **44**B are arranged such that their air-supply directions face each other in a radial direction of the cylinder **43**. In other words, the first aperture **43**A and the second aperture **43**B are situated to face each other.
(33) However, the air-supply directions of the first air passage **44**A and the second air passage **44**B do not always have to face each other. Furthermore, the first air passage **44**A and the second air passage **44**B may be misaligned in the axial direction of the cylinder **43**.
(34) The second ventilation unit **45** is configured to discharge air from the inner space of the cylinder **43** as pressure is applied to the first electrode **2** (that is, along with supply of air into the first region A**1**). The second ventilation unit **45** includes a third air passage **45**A.
(35) The third air passage **45**A is coupled to the third aperture **43**C of the cylinder **43**. The third air passage **45**A is coupled to both the air supply system and the air discharge system. The third air passage **45**A supplies air and discharges air to and from the second region A**2** of the inner space of the cylinder **43** via the third aperture **43**C.
(36) <Main Body>
(37) The main body **5** has functions such as, to supply the welding current to the first electrode **2** and the second electrode **3**, and to adjust pressure between the first electrode **2** and the second electrode **3** applied by the pressure mechanism **4**.
(38) [1-2. Method of Manufacturing]
(39) Explained next is a method of resistance spot welding using the resistance spot welding apparatus **1** shown in FIG. **1**. The method of resistance spot welding includes an arrangement step and a welding step.
(40) <Arrangement Step>
(41) In this step, the work piece W, made by layering the first metallic plate P**1** and the second metallic plate P**2** in the thickness direction, is arranged between the first electrode **2** and the second electrode **3** of the resistance spot welding apparatus **1**.
(42) <Welding Step>
(43) In this step, the first metallic plate P**1** and the second metallic plate P**2** layered on one another are welded by the resistance spot welding apparatus **1**. In this step, pressure is applied to the first electrode **2** towards the first metallic plate P**1** (that is, towards the second electrode **3**) by the pressure mechanism **4** during welding.
(44) As shown in FIG. **3**A, the metallic plate is not softened immediately after the welding is initiated; thus, the first electrode **2** touches the surface of the first metallic plate P**1**. As the welding progresses, as shown in FIG. **3**B, a nugget N is formed at a boundary of the first metallic plate P**1** and the second metallic plate P**2**.
(45) As the welding further progresses, as shown in FIG. **3**C, the nugget N grows and the first metallic plate P**1** is softened. Accordingly, a leading end of the first electrode **2**, applied with pressure by the pressure mechanism **4**, thrusts into the first metallic plate P**1**. As shown in FIG. **3**D,

the welding is completed when the nugget N has grown sufficiently. Application of pressure to the first electrode **2** continues until the completion of the welding.
(46) FIG. **3**E shows one example of changes in pressure applied to the first electrode **2** from the beginning to the completion of the welding. The graph in FIG. **3**E shows time T on its horizontal axis and pressure P on its vertical axis. Times T**1**, T**2**, T**3**, and T**4** in the graph respectively show when the conditions of FIGS. **3**A, **3**B, **3**C, and **3**D occur.
(47) The welding of the workpiece W starts at a time T**0** when the pressure has risen to a set pressure P**1**. Then, after the time T**3**, the piston **41** in the cylinder **43** moves downwardly as the first electrode **2** thrusts into the first metallic plate P**1**. This causes a decrease in the pressure inside the inner space of the cylinder **43**; and thus the pressure applied to the first electrode **2** is also decreased.
(48) Meanwhile, in response to the decrease in the pressure inside the inner space of the cylinder **43**, air is supplied to the first region A**1** through the first air passage **44**A and the second air passage **44**B of the first ventilation unit **44**. Consequently, the pressure in the first region A**1** is immediately recovered back to the set pressure P**1**.
(49) [1-3. Effects]
(50) The embodiment described above in detail renders the following effects.
(51) (1a) In the cylinder **43** of the pressure mechanism **4**, the amount of air supply or air discharge increases when applying pressure to the first electrode **2** through the first air passage **44**A and the second air passage **44**B. This shortens the time for applying pressure to the first electrode **2**.
(52) In other words, this shortens the time for recovering the pressure applied to the first electrode **2** towards the first metallic plate P**1** after the first electrode **2** is pressed into the softened first metallic plate P**1**. Accordingly, welding failures caused by generation of spatters can be reduced.
(53) (1b) When using a high tension metallic plate, which requires high pressure to press the electrode during welding and thus is likely to generate spatters due to pressure decrease, the welding failures caused by generation of spatters can be precisely reduced.
(54) (1c) By having the first ventilation unit **44** formed of the first air passage **44**A and the second air passage **44**B that communicate with the inner space of the cylinder **43**, the time for applying pressure to the first electrode **2** can be precisely shortened.
2. Other Embodiments
(55) An embodiment of the present disclosure has been explained above.
(56) Nevertheless, the present disclosure can be carried out in various modifications without being limited to the aforementioned embodiment.
(57) (2a) In the resistance spot welding apparatus of the aforementioned embodiment, the first ventilation unit may include three or more air passages. And, the second ventilation unit may include two or more air passages that are independent from one another. For example, as shown in FIG. **4**A, the cylinder **43** may further include a fourth aperture **43**D, and the second ventilation unit **45** may further include a fourth air passage **45**B communicated with the fourth aperture **43**D.
(58) Furthermore, when the second ventilation unit includes two or more air passages, the first ventilation unit is not always required to include two or more air passages. For example, as shown in FIG. **4**B, while the second ventilation unit **45** includes the third air passage **45**A and the fourth air passage **45**B, the first ventilation unit **44** may include only the first air passage **44**A.
(59) (2b) In the resistance spot welding apparatus of the aforementioned embodiment, pressure may be applied to both of the first electrode and the second electrode by air. In other words, the resistance spot welding apparatus may also include a pressure mechanism that applies pressure to the second electrode towards the second metallic plate.
(60) (2c) In the resistance spot welding apparatus of the aforementioned embodiment, a workpiece made by layering three or more metallic plates may be used. In other words, one or more metallic plates may be placed between the first metallic plate and the second metallic plate.
(61) (2d) In the resistance spot welding apparatus of the aforementioned embodiment, the direction

to interpose the workpiece between the first electrode and the second electrode is not always required to be the vertical direction. The direction to interpose the workpiece may be a horizontal direction, or a direction that crosses both the vertical direction and the horizontal direction.
(62) (2e) In the resistance spot welding apparatus of the aforementioned embodiment, the tensile strength of both of the first metallic plate and the second metallic plate may be less than 1800 MPa.
(63) (2f) Functions of one element in the aforementioned embodiments may be achieved by two or more elements. Functions of two or more elements may be integrated into one element. A part of the configuration in the aforementioned embodiments may be omitted. At least a part of the configuration in the aforementioned embodiments may be added to or replaced with other part of the configuration in the aforementioned embodiments. It should be noted that any and all modes included in the technical ideas that are identified by the languages recited in the claims are embodiments of the present disclosure.

Claims

1. A resistance spot welding apparatus configured to weld a workpiece made of layered metallic plates, the resistance spot welding apparatus comprising: a first electrode configured to contact a first metallic plate among the metallic plates; a second electrode configured to contact a second metallic plate among the metallic plates, the second electrode being arranged such that the workpiece is interposed between the first electrode and the second electrode; and a pressure mechanism configured to apply air pressure to the first electrode towards the first metallic plate, wherein the pressure mechanism comprises: a piston coupled to the first electrode; a cylinder having an inner space that accommodates the piston; a first ventilation unit configured to supply the inner space with air for applying air pressure to the first electrode; a second ventilation unit configured to discharge air from the inner space as air pressure is applied to the first electrode; and an air supply system configured to supply air to the first ventilation unit and permit discharge of air from the second ventilation unit, wherein the first ventilation unit comprises first and second air passages independent from each other, communicating with the inner space, and respectively coupled to first and second apertures that are provided in the cylinder and face each other in a radial direction of the cylinder, and wherein the second ventilation unit comprises third and fourth air passages independent from each other, communicating with the inner space, and respectively coupled to third and fourth apertures that are provided in the cylinder and face each other in a radial direction of the cylinder.
2. The resistance spot welding apparatus according to claim 1, wherein tensile strength of at least one of the first metallic plate or the second metallic plate is 1800 MPa or more.
3. The resistance spot welding apparatus according to claim 1, wherein the first ventilation unit comprises three or more air passages that are independent from each other.