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PRESSING APPARATUS, BATTERY PRODUCTION LINE, AND PRESSING METHOD

Abstract

This disclosure discloses a pressing apparatus, a battery production line, and a pressing method. The pressing apparatus is configured to press a workpiece queue. The pressing apparatus includes: a placement table, configured to support the workpiece queue, where the workpiece queue includes a plurality of workpieces arranged along a first direction; and at least one pressing assembly, where each pressing assembly includes a first presser and a stopper arranged opposite the first presser, where the first presser is configured to apply an acting force along the first direction to the workpiece queue, the stopper is configured to block the workpiece queue, and the first presser and the stopper are constructed to be capable of moving towards or away from each other along the first direction, where the pressing assembly is constructed to be capable of moving along a second direction intersecting the first direction.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This disclosure a bypass continuation application of is PCT/CN2023/134486, filed on Nov. 27, 2023, which is proposed based on and claims priority to Chinese Patent Application No. 202311310344.8, filed on Oct. 11, 2023 and entitled “PRESSING APPARATUS, BATTERY PRODUCTION LINE, AND PRESSING METHOD”, each are incorporated herein by reference in its entirety.

TECHNICAL FIELD
[0002] This disclosure relates to the field of battery production technologies, and in particular to, a pressing apparatus, a battery production line, and a pressing method.
BACKGROUND
[0003] New energy batteries are widely used in our life and industries. For example, new energy vehicles equipped with batteries have been extensively used. In addition, batteries are increasingly applied in the field of energy storage.
[0004] During the production and manufacturing of batteries, particularly in the process of grouping battery cells, it is common to perform a pressing operation on a battery cell queue. Sometimes, to manufacture battery modules of varied specifications, different pressing schemes need to be employed in the pressing process. In addition, the industry is demanding ever greater flexibility in battery production lines. Therefore, how to accommodate battery cell queues of different specifications in a single battery production line has become one of the research topics in the industry.
SUMMARY
[0005] To solve this technical problem, one intention of this disclosure is to provide a pressing apparatus, a battery production line, and a pressing method, so that battery queues can be pressed rapidly in an automated manner and high compatibility is achieved.
[0006] This disclosure is implemented using the following technical solutions.
[0007] A first aspect of this disclosure provides a pressing apparatus for pressing a workpiece queue. The pressing apparatus includes: a placement table, configured to support the workpiece queue, where the workpiece queue includes a plurality of workpieces arranged along a first direction; and at least one pressing assembly, where each pressing assembly includes a first presser and a stopper arranged opposite the first presser, where the first presser is configured to apply an acting force along the first direction to the workpiece queue, the stopper is configured to block the workpiece queue, and the first presser and the stopper are constructed to be capable of moving towards or away from each other along the first direction, where the pressing assembly is constructed to be capable of moving along a second direction intersecting the first direction.
[0008] The pressing assembly can move along the second direction intersecting the first direction. Therefore, positions of the first presser and the stopper in the second direction can be automatically adjusted for the workpiece queues of different specifications. In this way, a pressing operation can

be performed on the workpiece queues of different specifications. This improves the compatibility of the pressing apparatus, facilitating flexible production and improving the production efficiency. In addition, the pressing apparatus itself can adopt different pressing

[0009] schemes for pressing the workpiece queues of different specifications, without change of accessories. Therefore, the pressing apparatus can perform the pressing operation uninterruptedly, without a suspension for replacing accessories to accommodate the workpiece queues of different specifications. This improves the production efficiency and reduces the production cost on accessories of varied specifications and the space occupied by them.

[0010] In some embodiments, the pressing apparatus includes a fixed frame and at least one movable frame disposed on the fixed frame and capable of moving along the second direction, where each pressing assembly is disposed on each movable frame.

[0011] In this case, the movable frame can quickly bring the first presser and the stopper to a position corresponding to the workpiece queue, simplifying the structure and motion control.

[0012] In some embodiments, each movable frame is provided with a stopper bracket and a moving frame capable of reciprocating relative to the movable frame along the first direction, the stopper is mounted on the stopper bracket, and the first presser is mounted on the moving frame and is capable of moving under a driving action of the moving frame.

[0013] Therefore, the first presser and the stopper can be mounted on the movable frame. In addition, a simple structure can be used to enable the first presser to move towards or away from the stopper so as to apply or withdraw pressure.

[0014] In some embodiments, the pressing assembly includes a first pressing assembly and a second pressing assembly, where the movable frame includes a first movable frame and a second movable frame, the first pressing assembly is disposed on the first movable frame and constructed to be capable of moving along the second direction under a driving action of the first movable frame, and the second pressing assembly is disposed on the second movable frame and constructed to be capable of moving along the second direction under a driving action of the second movable frame. Two pressing assemblies are provided, and the two pressing assemblies can

[0015] be made to operate simultaneously to press a double-row workpiece queue. This improves the machining efficiency of the pressing link, thereby improving the production efficiency of the entire production line.

[0016] In some embodiments, the first pressing assembly and the second pressing assembly are constructed to be capable of switching between a first pressing mode and a second pressing mode, in the first pressing mode, one of the first pressing assembly and the second pressing assembly performs a pressing operation, in the second pressing mode, both the first pressing assembly and the second pressing assembly perform a pressing operation, and the pressing operation is performed by the first presser of each pressing assembly moving towards the stopper along the first direction.

[0017] In this way, the pressing apparatus can press two workpiece queues at the same time, further improving the production efficiency and reducing the production cost. Moreover, the pressing apparatus is designed with two pressing modes and can switch between the two pressing modes, so that the pressing apparatus can press both the single-row workpiece queue and double-row workpiece queue. This further improves the compatibility of the pressing apparatus.

[0018] In some embodiments, the pressing apparatus further includes a controller, where the controller is configured to control the first pressing assembly and the second pressing assembly to perform the pressing operation in the first pressing mode or the second pressing mode, based on preset information about an arrangement type of the workpiece queue.

[0019] In this way, the pressing apparatus can automatically switch between the pressing modes based on different situations, so that workpiece queues can be pressed using different pressing schemes based on their arrangement types. This increases the level of automation of the pressing apparatus. In addition, the pressing apparatus can press the workpiece queues uninterruptedly even if they are arranged in different types, thereby improving the production efficiency.

[0020] In some embodiments, the first presser is provided with a presser head for pushing the workpieces, and the stopper is provided with an abutting surface for abutting against the workpieces.
[0021] In this way, the workpiece queue can directly or indirectly abut against the abutting surface of the stopper, and then the workpiece queue can be pressed under the pushing force of the presser head. Moreover, that pressing is performed by the presser head can adapt to the pressed surfaces of workpiece queues of different specifications or the pressed surface of the tray holding the workpiece queues. In addition, the abutting surface allows pressure to be distributed uniformly on the workpiece queue.
[0022] In some embodiments, the pressing apparatus further includes a second presser, where the second presser is configured to apply an acting force along a third direction to the workpiece queue, and the second presser is disposed on the first movable frame and/or the second movable frame in a manner of being capable of reciprocating along the third direction, where the third direction intersects both the first direction and the second direction.
[0023] In this way, the pressing apparatus can also press a top surface of the workpiece queue, so that the workpiece queue can also be pressed in the height direction, guaranteeing the dimensional accuracy of the workpiece queue in the third direction.
[0024] In some embodiments, the second presser is disposed on the first movable frame or the second movable frame through a moving carriage, where the moving carriage includes a third-direction guide rail extending along the third direction, and the second presser is capable of moving along the third-direction guide rail.
[0025] In this way, a simple and stable structure can be used to enable the second presser to move along the third direction.
[0026] In some embodiments, the moving carriage is capable of moving along the first direction, and the moving carriage further includes at least one moving-carriage slider capable of sliding along the first direction, and the second presser includes at least one pressing plate, where the at least one pressing plate is capable of moving along with the moving-carriage slider.
[0027] In this way, the second presser can move along the first direction to an appropriate position and press the workpiece queues of different specifications along the third direction. This further improves the compatibility and flexibility of the pressing apparatus. In addition, the second presser includes at least one pressing plate, and the at least one pressing plate can move along with the moving-carriage slider. Therefore, when a plurality of pressing plates are provided, the spacing between the plurality of pressing plates can be adjusted to accommodate more specifications of workpiece queues.
[0028] In some embodiments, the intersecting includes perpendicular intersecting.
[0029] In this case, the workpiece queue can be pressed in the perpendicular direction, which is particularly suitable for pressing workpiece queues in the shape of a cuboid.
[0030] In some embodiments, the placement table is provided with a lifting mechanism for raising and lowering a tray carried by the placement table, and the tray is configured for holding the workpiece queue.
[0031] In this way, a tray can disengage from a tray conveyor line by using the lifting mechanism, so that the tray can be easily aligned and positioned.
[0032] In some embodiments, a blocking apparatus is disposed on a side of the placement table in the first direction, and the blocking apparatus is configured to block the tray.
[0033] In this way, a tray can be easily stopped on the placement table.
[0034] In some embodiments, each pressing assembly further includes a sleeve, and the sleeve is disposed at a position allowing an opening of the sleeve to be fitted over a tray lead screw, where the tray lead screw is provided in the tray carried by the placement table and extends from an end of the tray along the first direction.
[0035] In this way, the tray and the pressing apparatus can be permanently connected using the tray

lead screw and sleeve, so as to prevent the movement of the tray during pressing and facilitate the pressing of the workpiece queue. This improves the stability and reliability of the pressing operation.

[0036] A second aspect of this disclosure provides a battery production line. The battery production line includes a tray conveyor line and the pressing apparatus according to the first aspect of this disclosure. The tray conveyor line places trays on the placement table or removes trays from the placement table, and the first presser of the pressing apparatus moves towards the stopper along the first direction to perform a pressing operation on a battery queue carried by the tray on the placement table.

[0037] In this way, workpiece queues can be pressed rapidly in an automated manner, improving the pressing efficiency. In addition, the workpiece queues of varied specifications, for example, single-row workpiece queues and double-row workpiece queues, can be pressed in different pressing modes, improving the compatibility. Moreover, this also improves the flexible production of the battery production line. In some embodiments, the workpiece includes at least one of a battery and

[0038] a battery unit formed by combining at least two batteries, and the workpiece queue includes at least one of a battery queue formed by arranging a single row of batteries and a battery unit queue formed by arranging the battery units.

[0039] In this way, battery pressing is supported. In addition, battery queues of varied specifications can be accommodated, for example, a single-row battery queue formed by arranging single rows of batteries and a double-row battery queue formed by arranging double rows of batteries. This improves the compatibility (flexibility) of the pressing apparatus and even the entire battery production line, and also improves the efficiency of grouping batteries.

[0040] A third aspect of this disclosure provides a pressing method, where a pressing apparatus is configured to press a workpiece queue. The pressing apparatus includes a placement table and at least one pressing assembly, each pressing assembly includes a first presser and a stopper arranged opposite the first presser, and each pressing assembly is constructed to be capable of moving along a second direction intersecting a first direction. The pressing method includes: a placing step of placing a tray carrying the workpiece queue on the placement table and bringing the tray to a predetermined position, where the workpiece queue includes a plurality of workpieces arranged in the first direction, and the tray includes a first vertical plate and a second vertical plate for limiting positions of two ends of the workpiece queue in the first direction; a positioning step of moving at least one pressing assembly along the second direction to a preparatory pressing position, where each pressing assembly includes the first presser and the stopper, and at the preparatory pressing position, each workpiece queue is located between the first presser and the stopper of the each pressing assembly; and a pressing step of moving the first presser towards the stopper along the first direction to perform a pressing operation on the workpiece queue until the workpiece queue reaches a predetermined length.

[0041] In this way, the pressing apparatus can press the workpiece queues automatically and efficiently. In addition, workpiece queues in different sizes are accommodated, presenting good compatibility.

[0042] In some embodiments, before the positioning step, the pressing method further includes: a reading step of reading information about the workpiece queue; and

[0043] determining whether the tray contains the workpiece queue, and if the tray does not contain the workpiece queue, removing the tray from the placement table, or if the tray contains the workpiece queue, proceeding to a type determining step.

[0044] In this way, whether a tray contains a workpiece queue and information about the workpiece queue can be quickly determined, so that the workpiece queue can be pressed correctly, reducing the risk of misoperation.

[0045] In some embodiments, the pressing assembly includes a first pressing assembly and a

second pressing assembly. The first pressing assembly and the second pressing assembly are constructed to be capable of switching between a first pressing mode and a second pressing mode, in the first pressing mode, one of the first pressing assembly and the second pressing assembly performs a pressing operation, in the second pressing mode, both the first pressing assembly and the second pressing assembly perform a pressing operation, and in the type determining step, an arrangement type of the workpiece queue is determined based on the read information about the workpiece queue, where the arrangement type is used for determining that the pressing operation is performed in the first pressing mode or the second pressing mode.

[0046] In this way, after the arrangement type of the workpiece queue is determined, a pressing mode matching the arrangement type can be selected to accommodate the single-row workpiece queue and double-row workpiece queue. In addition, the pressing mode can be switched automatically, helping improve the production efficiency.

[0047] In some embodiments, the pressing apparatus further includes a second presser configured to apply an acting force along a third direction to the workpiece queue, and after the positioning step and before the pressing step, the pressing method further includes: a down-pressing step of moving the second presser along the third direction to press down on the workpiece queue.

[0048] This can further improve the dimensional accuracy of the workpiece queue in the third direction.

[0049] In some embodiments, the placing step includes: blocking, using a blocking apparatus, the tray moving along the first direction to place the tray on the placement table; and raising the placement table using a lifting mechanism of the placement table, so that the placement table disengages from a tray conveyor line that transports the tray, whereby the tray is brought to the predetermined position.

[0050] In this way, the tray can be placed in the expected position, and aligned and positioned without being affected by the tray conveyor line. In addition, the tray conveyor line cannot be easily damaged.

[0051] In some embodiments, the positioning step includes: moving the pressing assembly along the second direction to position each workpiece queue between the first presser and the stopper of each pressing assembly based on the arrangement type, where if the arrangement type is a double-row workpiece queue, one of the first pressing assembly and the second pressing assembly is moved along the second direction, and if the arrangement type is a single-row workpiece queue, both the first pressing assembly and the second pressing assembly are moved along the second direction; bringing the first vertical plate of the tray into contact with the stopper, and positioning the tray by having a sleeve of the pressing assembly fitted over a tray lead screw, where the tray lead screw is disposed in the tray and extends from an end of the tray along the first direction; and moving the first presser, which has moved to a position corresponding to the workpiece queue, along the first direction to the vicinity of the second vertical plate of the tray.

[0052] In this way, one or both of the first pressing assembly and the second pressing assembly can be made to operate based on the arrangement type of the workpiece queue, so that the pressing operation can be performed automatically. In addition, through the cooperation between the sleeve and the tray lead screw, the tray can be fixed at the preparatory pressing position, so as to stably maintain the workpiece queue at an appropriate position.

[0053] In some embodiments, the pressing step includes: moving the first presser towards the stopper along the first direction to perform a pressing operation on the workpiece queue based on the arrangement type, where if the arrangement type is a double-row workpiece queue, the first presser of one of the first pressing assembly and the second pressing assembly performs the pressing operation, and if the arrangement type is a single-row workpiece queue, the first pressers of both the first pressing assembly and the second pressing assembly perform the pressing operation; and determining whether each pressed workpiece queue has the predetermined length; and if every workpiece queue has the predetermined length, proceeding to a locking step, if any

workpiece queue is longer than the predetermined length, making the first presser corresponding to that workpiece queue continue pressing until the workpiece queue reaches the predetermined length, and if any workpiece queue is shorter than the predetermined length, determining that the workpiece queue is unqualified under pressing criteria; where in the locking step, the sleeve fitted over the tray lead screw is rotated to be locked, thereby preventing the second vertical plate from moving away from the first vertical plate along the first direction, so as to maintain the workpiece queue at the predetermined length.

[0054] In this way, pressing can be performed based on the arrangement type of the workpiece queue, so as to support pressing of both single-row workpiece queues and double-row workpiece queues. In addition, the length of a workpiece queue is checked after a pressing operation. Therefore, whether appropriate pressing is performed can be learned in a timely manner. Then, supplementary pressing is performed or the workpiece queue is considered unqualified under pressing criteria, based on actual situations. In addition, the locking step can maintain the pressed workpiece queue at a predetermined length, facilitating subsequent processes.

[0055] Beneficial effects of the embodiments of this disclosure are as follows:

[0056] This disclosure provides a pressing apparatus, a battery production line, and a pressing method, so that battery queues can be pressed rapidly in an automated manner and high compatibility is achieved.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0057] Persons of ordinary skill in the art can clearly understand various other advantages and benefits by reading the detailed description of the preferred embodiments below. The accompanying drawings are merely intended to illustrate the purposes of the preferred implementations, and should not be construed as a limitation on this disclosure. Moreover, throughout the accompanying drawings, the same reference signs represent the same parts. In the accompanying drawings:

[0058] FIG. **1** is a schematic diagram of a three-dimensional structure of a pressing apparatus according to some embodiments of this disclosure;

[0059] FIG. **2** is a schematic plan view of a pressing apparatus according to some embodiments of this disclosure;

[0060] FIG. **3** is a schematic plan view of a pressing apparatus carrying a tray and a workpiece queue according to some embodiments of this disclosure;

[0061] FIG. **4** is a cross-sectional view of FIG. **3** in the A-A direction;

[0062] FIG. **5** is an enlarged view of part B circled in FIG. **4**;

[0063] FIG. **6** is a first schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure;

[0064] FIG. **7** is a second schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure;

[0065] FIG. **8** is a third schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure;

[0066] FIG. **9** is an enlarged view of part C circled in FIG. **8**;

[0067] FIG. **10** is a fourth schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure;

[0068] FIG. **11** is an enlarged view of part D circled in FIG. **10**;

[0069] FIG. **12** is a schematic plan view of a single-row workpiece queue capable of being pressed by a pressing apparatus according to some embodiments of this disclosure;

[0070] FIG. **13** is a schematic plan view of a double-row workpiece queue capable of being pressed

by a pressing apparatus according to some embodiments of this disclosure;
[0071] FIG. **14** is a schematic flowchart of a pressing method according to some embodiments of this disclosure;
[0072] FIG. **15** is another schematic flowchart of a pressing method according to some embodiments of this disclosure;
[0073] FIG. **16** is yet another schematic flowchart of a pressing method according to some embodiments of this disclosure;
[0074] FIG. **17** is a schematic flowchart of a placing step according to some embodiments of this disclosure;
[0075] FIG. **18** is a schematic flowchart of a positioning step according to some embodiments of this disclosure; and
[0076] FIG. **19** is a schematic flowchart of a pressing step according to some embodiments of this disclosure.

REFERENCE SIGNS

[0077] **100**: pressing apparatus; **101**: placement table; **102**: lifting mechanism; **1021**: lifting plate; **1022**: lifting apparatus; **103**: blocking apparatus; **104**: universal ball; **105**: positioning apparatus; **106**: gripper; **200**: workpiece queue; **300**: tray; **301**: tray lead screw; **302**: first vertical plate; **303**: second vertical plate; **400**: tray conveyor line; **110**: pressing assembly; **113**: first presser; **1131**: presser head; **114**: stopper; **1141**: abutting surface; **115**: sleeve; **120**: fixed frame; **121**: first traverse beam; **122**: second traverse beam; **1221**: traverse guide rail; **1222**: blocking piece; **123**: longitudinal beam; **130**: movable frame; **1301**: meshing part; **1302**: first drive apparatus; **1303**: lead screw; **1304**: second drive apparatus; **1305**: movable-frame guide rail; **1306**: first slider; **131**: first movable frame; **132**: second movable frame; **140**: stopper bracket; **1401**: stopper slide rail; **1402**: stopper slide frame; **1403**: stopper side baffle; **150**: moving frame; **1501**: moving frame connecting plate; **1502**: nut; **1503**: first-presser side baffle; **160**: second presser; **161**: moving carriage; **162**: third-direction guide rail; **163**: presser connecting plate; **1631**: second slider; **1632**: third slider; **164**: moving-carriage slider; **165**: pressing plate; and **166**: carriage slide rail.

DESCRIPTION OF EMBODIMENTS

[0078] The following describes in detail the embodiments of technical solutions of this disclosure with reference to the accompanying drawings. The following embodiments are merely intended for a clearer description of the technical solutions of this disclosure and therefore are used as just examples which do not constitute any limitations on the protection scope of this disclosure.
[0079] Unless otherwise defined, all technical and scientific terms used herein shall have the same meanings as commonly understood by those skilled in the art to which this disclosure belongs. The terms used herein are intended to merely describe the specific embodiments rather than to limit this disclosure. The terms “include” and “have” and any other variations thereof in this disclosure are intended to cover non-exclusive inclusions.
[0080] In the description of the embodiments of this disclosure, the terms “first”, “second”, “third”, and the like are merely intended to distinguish between different objects, and shall not be understood as any indication or implication of relative importance or any implicit indication of the number, sequence or primary-secondary relationship of the technical features indicated. In the description of the embodiments of this disclosure, “a plurality of” means at least two unless otherwise specifically stated.
[0081] In this specification, reference to “embodiment” means that specific features, structures or characteristics described with reference to the embodiment may be incorporated in at least one embodiment of this disclosure. The word “embodiment” appearing in various places in the specification does not necessarily refer to the same embodiment, or an independent or alternative embodiment that is exclusive of other embodiments. Persons skilled in the art explicitly and implicitly understand that the embodiments described herein may be combined with other embodiments.

[0082] In the description of the embodiments of this disclosure, the term “and/or” is only an associative relationship for describing associated objects, indicating that three relationships may be present. For example, A and/or B may indicate the following three cases: presence of only A, presence of both A and B, and presence of only B. In addition, a character “/” in this specification generally indicates “or” relationship between contextually associated objects.
[0083] In the description of the embodiments of this disclosure, the orientations or positional relationships indicated by the technical terms “length”, “width”, “thickness”, “upper”, “lower”, “front”, “rear”, “left”, “right”, “vertical”, “horizontal”, “top”, “bottom”, “inside”, “outside”, and the like are based on the orientations or positional relationships as shown in the accompanying drawings. These terms are merely for ease and brevity of description of the embodiments of this disclosure rather than indicating or implying that the means or components mentioned must have specific orientations or must be constructed, manipulated, or used according to specific orientations, and therefore shall not be construed as any limitations on embodiments of this disclosure.
[0084] In the description of the embodiments of this disclosure, unless otherwise specified and defined explicitly, the technical terms “mounting”, “connection”, “join”, and “fastening” should be understood in their general senses. For example, they may refer to a fixed connection, a detachable connection, or an integral connection, may refer to a mechanical connection or electrical connection, and may refer to a direct connection, an indirect connection via an intermediate medium, or an interaction between two elements. Persons of ordinary skill in the art can understand specific meanings of these terms in this disclosure as appropriate to specific situations.
[0085] In the description of the embodiments of this disclosure, unless otherwise specified and defined explicitly, the technical term “contact” should be understood in its general sense, which may be direct contact, contact via an intermediate medium layer, contact with no acting force on each other, or contact with an acting force on each other.
[0086] The following describes in detail this disclosure.
[0087] At present, new energy batteries are used more extensively in our life and industries. They have been widely used in energy storage power supply systems such as hydroelectric power plants, thermal power plants, wind power plants, and solar power plants, as well as in many other fields including electric transportation tools such as electric bicycles, electric motorcycles, and electric vehicles, and aerospace. With continuous expansion of application fields of traction batteries, market demands for the traction batteries are also expanding.
[0088] During the production and manufacturing process of products such as batteries, grouped battery cell queues or battery unit queues need to be pressed to obtain a battery module with higher fastness and desired flatness. This facilitates subsequent operations on the battery queues or battery unit queues such as binding and attachment of a heat exchange plate, and reduces the complexity of processing devices. Moreover, pressing the battery queues or battery unit queues helps improve the compactness of the battery module, thereby improving the volume utilization of batteries.
[0089] To meet diversified product needs, battery manufacturers usually need to manufacture battery products of varied specifications. Therefore, batteries are grouped in different forms and specifications, for example, battery cells in a single row are arranged into a group (sometimes also referred to as a “single-row module”), or two or more battery cells are bonded to form a battery unit and a plurality of battery units are arranged into a group (sometimes also referred to as a “double-row module” and “multi-row module”). However, existing apparatuses for pressing battery queues or battery unit queues can generally handle only one arrangement form of the foregoing single-row module, double-row module, and multi-row module, or can press the battery queues or battery unit queues in only one specification. If it is required to press battery modules in different arrangement forms or specifications, the pressing apparatus and even the production line needs to be stopped for replacing accessories, resetting machining parameters, and the like. This is time-consuming, and is detrimental to improvement in the automation level of production and

production efficiency. Moreover, manufacturing tools and accessories need to be prepared for adapting to battery modules in varied arrangement forms and specifications. This requires a large space on the production line for storing these tools and accessories, which is not conducive to lowering production costs.

[0090] In view of the foregoing problems in the related art, this disclosure proposes a pressing apparatus. The pressing apparatus is configured to press a workpiece queue, and includes a placement table and at least one pressing assembly. The placement table is configured to support the workpiece queue, where the workpiece queue includes a plurality of workpieces arranged along a first direction. Each pressing assembly includes a first presser and a stopper arranged opposite the first presser, where the first presser is configured to apply an acting force along the first direction to the workpiece queue, the stopper is configured to block the workpiece queue, and the first presser and the stopper are constructed to be capable of moving towards or away from each other along the first direction, where the pressing assembly is constructed to be capable of moving along a second direction intersecting the first direction.

[0091] The pressing apparatus according to this embodiment of this disclosure can rapidly press workpiece queues in an automated manner, reducing labor costs and improving the pressing efficiency. In addition, the pressing assembly moves along the second direction, and positions of the first presser and the stopper in the second direction can be automatically adjusted for the workpiece queues of different specifications. In this way, a pressing operation can be performed on the workpiece queues of different sizes or specifications without a suspension. This improves the compatibility of the pressing apparatus, facilitating flexible production and improving the production efficiency.

[0092] The pressing apparatus according to this embodiment of this disclosure can be used in the battery production process, for example, for pressing battery cell queues or battery unit queues. Certainly, those skilled in the art should understand that the pressing apparatus provided in this embodiment of this disclosure is configured to press not only workpieces during the battery production and manufacturing process, but also any other workpiece queues that need to be pressed.

[0093] Some embodiments of this disclosure are described in detail, with reference to FIG. **1** to FIG. **19**.

[0094] FIG. **1** is a schematic diagram of a three-dimensional structure of a pressing apparatus according to some embodiments of this disclosure. FIG. **2** is a schematic plan view of a pressing apparatus according to some embodiments of this disclosure. FIG. **3** is a schematic plan view of a pressing apparatus carrying a tray and a workpiece queue according to some embodiments of this disclosure. FIG. **4** is a cross-sectional view of FIG. **3** in the A-A direction. FIG. **5** is an enlarged view of part B circled in FIG. **4**. FIG. **6** is a first schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure. FIG. **7** is a second schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure. FIG. **8** is a third schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure. FIG. **9** is an enlarged view of part C circled in FIG. **8**. FIG. **10** is a fourth schematic diagram of a three-dimensional structure of a movable frame according to some embodiments of this disclosure. FIG. **11** is an enlarged view of part D circled in FIG. **10**. FIG. **12** is a schematic plan view of a single-row workpiece queue capable of being pressed by a pressing apparatus according to some embodiments of this disclosure. FIG. **13** is a schematic plan view of a double-row workpiece queue capable of being pressed by a pressing apparatus according to some embodiments of this disclosure. FIG. **14** is a schematic flowchart of a pressing method according to some embodiments of this disclosure. FIG. **15** is another schematic flowchart of a pressing method according to some embodiments of this disclosure. FIG. **16** is yet another schematic flowchart of a pressing method according to some embodiments of this disclosure. FIG. **17** is a schematic flowchart of a placing

step according to some embodiments of this disclosure. FIG. **18** is a schematic flowchart of a positioning step according to some embodiments of this disclosure. FIG. **19** is a schematic flowchart of a pressing step according to some embodiments of this disclosure.

[0095] In some embodiments of this disclosure, for ease of description, the first direction, second direction, and third direction are specified, and the first direction, second direction, and third direction intersect each other. In the embodiments illustrated in FIG. **1** to FIG. **13**, descriptions are provided assuming that the first direction, second direction, and third direction are perpendicular to each other. However, persons skilled in the art should understand that the embodiments of this disclosure are not limited to the case that the three directions are perpendicular to each other. For ease of description, as shown in FIG. **1** to FIG. **4**, FIG. **12**, and FIG. **13**, the direction indicated by an arrow X is the first direction, the direction indicated by an arrow Y is the second direction, and the direction indicated by an arrow Z is the third direction (also referred to as the height direction). Sometimes, the third direction indicated by the arrow Z is referred to as "top" and the opposite direction is referred to as "bottom".

[0096] As shown in FIG. **1** to FIG. **11**, a first aspect of this disclosure provides a pressing apparatus **100**, configured to press a workpiece queue **200**. The pressing apparatus **100** includes a placement table **101** and at least one pressing assembly **110**. The placement table **101** is configured to support the workpiece queue **200**, where the workpiece queue **200** includes a plurality of workpieces arranged along a first direction. Each pressing assembly **110** includes a first presser **113** and a stopper **114** arranged opposite the first presser **113**, where the first presser **113** is configured to apply an acting force along the first direction to the workpiece queue **200**, and the stopper **114** is configured to block the workpiece queue **200**. The first presser **113** and the stopper **114** are constructed to be capable of moving towards or away from each other along the first direction, and the pressing assembly **110** is constructed to be capable of moving along a second direction intersecting the first direction.

[0097] During the production and manufacturing process of products such as batteries, grouped battery cell queues or battery unit queues need to be pressed to obtain a battery module with higher fastness. This facilitates subsequent processing such as binding and packing. The "pressing" in this embodiment of this disclosure includes abutting battery cells in the grouped battery cell queue or battery units in the grouped battery unit queue against each other more tightly. The pressing apparatus **100** in this embodiment of this disclosure is an apparatus capable of performing a pressing operation.

[0098] In an embodiment of this disclosure, the workpiece queue **200** includes a plurality of workpieces arranged along the first direction, and the workpiece may be, for example, a battery or a battery unit formed by combining at least two batteries. As shown in FIG. **12** and FIG. **13**, the workpiece queue **200** may include, for example, a battery queue formed by arranging a single row of batteries or a battery cell queue formed by arranging the battery units. Certainly, in some other embodiments, the workpiece queue **200** may alternatively include a queue formed by arranging other workpieces.

[0099] In an embodiment of this disclosure, the battery may be a battery cell.

[0100] The battery cell refers to a basic unit that can implement mutual conversion between chemical energy and electric energy, and it can be used for producing a battery module or battery pack to supply electricity to an electric apparatus.

[0101] The battery cell may be a secondary battery. The secondary battery is a battery cell that can be reused, after being discharged, by activating the active material inside it through charging.

[0102] The battery cell may be a lithium-ion battery, a sodium-ion battery, a sodium-lithium-ion battery, a lithium metal battery, a sodium metal battery, a lithium-sulfur battery, a magnesium-ion battery, a nickel-hydrogen battery, a nickel-cadmium battery, a lead storage battery, or the like, which is not limited in this embodiment of this disclosure.

[0103] Although not shown, the battery cell typically includes an electrode assembly. The electrode

assembly includes a positive electrode, a negative electrode, and a separator. During charging and discharging of the battery cell, active ions (such as lithium ions) intercalate and deintercalate back and forth between the positive electrode and the negative electrode. The separator is arranged between the positive electrode and the negative electrode to prevent short circuit of the positive electrode and negative electrode and to allow the active ions to pass through.

[0104] In some embodiments, the battery cell further includes an electrolyte, and the electrolyte conducts ions between positive and negative electrodes. The electrolyte is not specifically limited to any particular type in this disclosure, and may be selected based on needs. The electrolyte may be in a liquid state, gel state, or solid state.

[0105] In some embodiments, the battery cell may include a housing. The housing is configured to encapsulate the electrode assembly, the electrolyte, and other components. The housing may be steel housing, aluminum housing, plastic housing (for example, polypropylene), composite metal housing (for example, copper-aluminum composite housing), aluminum-plastic film, or the like.

[0106] For example, the battery cell may be a cylindrical battery cell, a prismatic battery cell, a pouch battery cell, or a battery cell of another shape. The prismatic battery cell includes a square shell battery cell, a blade battery cell, or a polygonal battery such as a hexagonal battery. This is not particularly limited in this embodiment of this disclosure.

[0107] In some embodiments, the housing includes a cover and a shell, where the shell is provided with an opening, and the cover closes the opening to form a closed space for accommodating the electrode assembly and substances such as the electrolyte. The shell may be provided with one or more openings. One or more covers may be provided.

[0108] In some embodiments, the housing is provided with at least one electrode terminal, and the electrode terminal is electrically connected to a tab. The electrode terminal may be directly connected to the tab or indirectly connected to the tab through an adapter. The electrode terminal may be provided on the cover or may be provided on the shell.

[0109] In some embodiments, the housing is provided with a pressure relief mechanism. The pressure relief mechanism is configured to relieve internal pressure of the battery cell.

[0110] In an embodiment of this disclosure, the battery may alternatively be a single physical module that includes one or more battery cells for providing a higher voltage and capacity. When there are a plurality of battery cells, the plurality of battery cells are connected in series, parallel, or series-parallel through a busbar.

[0111] The pressing apparatus **100** according to an embodiment of this disclosure is described with reference to accompanying drawings. As shown in FIG. **1** and FIG. **2**, the pressing apparatus **100** includes a placement table **101** and at least one pressing assembly **110**.

[0112] The placement table **101** is configured to support a workpiece queue **200**, and provides a stable placement platform for it. Specifically, the placement table **101** is configured to carry, for example, a workpiece queue to be pressed (a workpiece queue that has not been pressed) or a pressed workpiece queue, and a workpiece queue being pressed or a workpiece queue that has completely been pressed. The placement table **101** may directly support the workpiece queue **200**, or may support the workpiece queue **200** through a tray or a similar structure. In a case that the placement table **101** directly supports the workpiece queue **200**, the workpiece queue to be pressed may be, for example, placed on the placement table **101** by a robot arm or manually, and the pressed workpiece queue may be removed from the placement table **101** by a mechanical gripper and transported to another location. In a case that the placement table **101** supports the workpiece queue **200** through a tray **300** (details are described below), for example, the workpiece queue to be pressed can be brought to the placement table **101** along with the tray **300**, and the pressed workpiece queue **200** can be transported from the placement table **101** to another location along with the tray **300**.

[0113] In an embodiment of this disclosure, a support surface of the placement table **101** is approximately in the shape of a rectangle. In some other embodiments, the support surface of the

placement table **101** may be alternatively in the shape of a square, a circle, a polygon, or in any other appropriate shapes. This embodiment of this disclosure does not particularly limit the shape of the support surface of the placement table **101** as long as the workpiece queue **200** can be stably carried.

[0114] The pressing assembly **110** is configured to press the workpiece queue **200** on the placement table **101**. In this embodiment of this disclosure, the pressing apparatus **100** includes two pressing assemblies **110**. However, in some other embodiments, the pressing apparatus **100** may alternatively include one pressing assembly **110** or more (more than two) pressing assemblies **110**. The number of pressing assemblies **110** is not particularly limited in this embodiment of this disclosure. Unless otherwise specified, any one of the two pressing assemblies **110** is used herein as an example for description, with reference to the accompanying drawings.

[0115] The pressing assembly **110** can move along a second direction intersecting the first direction, and includes a first presser **113** configured to apply an acting force along the direction to the workpiece queue **200** and a stopper **114** configured to block the workpiece queue **200** under the acting force. The stopper **114** is disposed on opposite sides of the first presser **113** in the first direction. The acting force applied by the first presser **113** to the workpiece queue **200** may be a pushing force applied along the first direction.

[0116] When a workpiece queue to be pressed is placed on the placement table **101** or brought along the first direction to the placement table **101** along with the tray **300**, a position of the workpiece queue **200** on the placement table **101** or in the tray **300** in the second direction may not be fixed, allowing for a tiny difference. In addition, the workpiece queues **200** in different sizes or specifications (for example, single-row battery modules and double-row battery modules) may be also placed at different positions on the placement table **101** or in the tray **300**. Therefore, the pressing assembly **110** needs to move along the second direction to the vicinity of the position (also referred to as a preparatory pressing position) of the workpiece queue **200** before performing the corresponding pressing operation.

[0117] In this embodiment of this disclosure, the pressing assembly **110** can move along the second direction intersecting the first direction. Therefore, positions of the first presser **113** and the stopper **114** in the second direction can be automatically adjusted according to different positions and specifications of the workpiece queues **200**. In this way, a pressing operation can be performed on the workpiece queues **200** at different positions and of different specifications. This improves the compatibility of the pressing apparatus **100**, facilitating flexible production and improving the production efficiency.

[0118] When the pressing assembly **110** moves in position along the second direction, the workpiece queue **200** to be pressed is located between the first presser **113** and the stopper **114**.

[0119] For example, the stopper **114** may always remain stationary in the first direction. In this way, when the pressing assembly **110** moves in position along the second direction and presses the workpiece queue **200**, only the first presser **113** moves towards the stopper **114** along the first direction, applying a pushing force to the workpiece queue **200** along the first direction until the workpiece queue **200** reaches a predetermined length. The pressing operation is completed.

[0120] For another example, the first presser **113** and the stopper **114** can operate together, and move towards or away from each other along the first direction. In this way, when the pressing assembly **110** moves in position along the second direction and presses the workpiece queue **200**, the first presser **113** and the stopper **114** move towards each other along the first direction until being in contact with the workpiece queue **200** located therebetween. In this case, the stopper **114** may remain stationary, and the first presser **113** continues moving along the first direction, applying a pushing force to the workpiece queue **200** along the first direction until the workpiece queue **200** reaches a predetermined length. The pressing operation is completed.

[0121] After the pressing operation is completed for the workpiece queue **200** to be pressed, the first presser **113** and the stopper **114** can move away from each other along the first direction and

move along the second direction to their initial positions. In this way, the pressed workpiece queue **200** can be removed from the placement table **101** by a mechanical gripper or transported with the tray **300**, so that the next batch of workpiece queues to be pressed can be placed on the placement table **101** or brought to the placement table **101** along with the tray **300**. As a result, the pressing apparatus **100** can perform the pressing operation uninterruptedly.

[0122] In addition, a distance between the first presser **113** and the stopper **114** can be adjusted according to different sizes of workpiece queues **200** in the first direction or a size of the pressed workpiece queue **200** in the first direction. As a way of adjustment, for example, the strokes of the first presser **113** and the stopper **114** moving towards or away from each other can be adjusted according to the size of the workpiece queue **200** to be pressed in the first direction. Alternatively, the timing and position for controlling the first presser **113** and the stopper **114** to stop moving towards each other but to move away from each other can be controlled based on the distance between the first presser **113** and the stopper **114** measured by a distance meter or based on the size of the workpiece queue **200** being pressed in the first direction detected by a grating ruler sensor.

[0123] The first presser **113** and the stopper **114** can move towards or away from each other along the first direction. Therefore, the pressing apparatus **100** itself can adopt different pressing schemes for pressing the workpiece queues **200** of different specifications, without change of accessories. In this case, the pressing apparatus **100** can perform the pressing operation uninterruptedly, without a suspension for replacing accessories to accommodate the workpiece queues of different specifications. This improves the production efficiency and reduces the production cost on accessories of varied specifications and the space occupied by them.

[0124] In some embodiments of this disclosure, the pressing apparatus **100** includes a fixed frame **120** and at least one movable frame **130** disposed on the fixed frame **120** and capable of moving along the second direction, where each pressing assembly **110** is disposed on each movable frame **130**.

[0125] As shown in FIG. **1**, the fixed frame **120** is disposed on the placement table **101**. As a specific example, the fixed frame **120** includes a frame body, and the frame body includes two first traverse beams **121** extending along the first direction, two second traverse beams **122** extending along the second direction, and four longitudinal beams **123** extending along the third direction. The two first traverse beams **121** are spaced apart along the second direction, the two second traverse beams **122** are respectively attached to positions between ends of the two first traverse beams **121** along the first direction, and the longitudinal beams **123** are respectively attached to the joints of the first traverse beams **121** and the second traverse beams **122**.

[0126] In this embodiment of this disclosure, two movable frames **130** are provided, in correspondence with the number of pressing assemblies **110**. In some other embodiments, one or more (more than two) movable frames **130** may be provided. In this embodiment of this disclosure, the number of movable frames **130** is not particularly limited and may be provided based on the number of pressing assemblies **110**. Unless otherwise specified, any one of the two movable frames **130** is used herein as an example for description, with reference to the accompanying drawings.

[0127] As shown in FIG. **2**, the movable frame **130** is arranged parallel to the two first traverse beams **121** and stretches across the two second traverse beams **122**, where the second traverse beam **122** is provided with a traverse guide rail **1221** extending along the second direction. The movable frame **130** can reciprocate along the traverse guide rail **1221**. As a specific example, as shown in FIG. **6** to FIG. **10**, the movable frame **130** includes a meshing part **1301** and a first drive apparatus **1302**. The meshing part **1301** can mesh with the traverse guide rail **1221** on the second traverse beam **122** and can reciprocate on the traverse guide rail **1221** under the driving force of the first drive apparatus **1302**.

[0128] The first drive apparatus **1302** includes but is not limited to a motor. As a specific example, the first drive apparatus **1302** may be a servo motor.

[0129] For example, the meshing part **1301** may be a gear, and the traverse guide rail **1221** may be

a gear rack. As a specific example, the meshing part **1301** may be a helical gear. For another example, the meshing part **1301** may be a nut meshing with a lead screw, and the traverse guide rail **1221** may be a lead screw. For still another example, the meshing part **1301** may be a slider, and the traverse guide rail **1221** may be a linear guide rail.

[0130] In this case, merely through the cooperation between the meshing part **1301** and the traverse guide rail **1221**, the movable frame **130** can reciprocate along the second direction. Driven by the movable frame **130**, the first presser **113** and the stopper **114** can reciprocate along the second direction to quickly reach the position corresponding to the workpiece queue **200**. This features simple structure and motion control and ingenious design. In addition, the traverse guide rail **1221** can further limit the sliding track of the movable frame **130**, improving the movement stability of the movable frame **130** along the second direction.

[0131] As shown in FIG. **1**, a blocking piece **1222** is disposed on two opposite sides of the second traverse beam **122** along the second direction, where the blocking piece **1222** protrudes from a top surface of the second traverse beam **122** and is at least higher than the traverse guide rail **1221**. In this way, the blocking piece **1222** can limit the position of the movable frame **130** to some extent, preventing the movable frame **130** from falling off the traverse guide rail **1221** when moving along the second direction. This improves the reliability of the pressing apparatus **100**.

[0132] The following further describes the structure of the pressing assembly.

[0133] In some embodiments of this disclosure, as shown in FIG. **6** and FIG. **10**, each movable frame **130** is provided with a stopper bracket **140** and a moving frame **150** capable of reciprocating relative to the movable frame **130** along the first direction, the stopper **114** is mounted on the stopper bracket **140**, and the first presser **113** is mounted on the moving frame **150** and is capable of moving under a driving action of the moving frame **150**.

[0134] As shown in FIG. **6** and FIG. **10**, the movable frame **130** includes a lead screw **1303** extending along the first direction. The lead screw **1303** can be connected to an output terminal of a second drive apparatus **1304** and rotates under the driving force of the second drive apparatus **1304**. The moving frame **150** is connected to a moving frame connecting plate **1501**, and a side surface of the moving frame connecting plate **1501** back away from the moving frame **150** is permanently connected to an outer peripheral surface of a nut **1502** capable of moving on the lead screw **1303**, so that the moving frame **150** can reciprocate along the lead screw **1303** under a driving action of the nut.

[0135] Therefore, the first presser **113** and the stopper **114** can be mounted on the movable frame **130**. In addition, a simple structure can be used to enable the first presser **113** to move towards or away from the stopper **114** so as to apply or withdraw pressure.

[0136] In an embodiment of this disclosure, the movable frame **130** further includes two movable-frame guide rails **1305** extending along the first direction. The two movable-frame guide rails **1305** are parallel to the lead screw **1303** and arranged on opposite sides of the movable frame **130** along the third direction. Each movable-frame guide rail **1305** is provided with a first slider **1306** (see FIG. **10**) capable of reciprocating thereon, and the side surface of the moving frame connecting plate **1501** back away from the moving frame **150** is permanently connected to both the outer peripheral surface of the nut **1502** and an outer peripheral surface of the first slider **1306**. The disposition of two movable-frame guide rails **1305** can reduce the load of the lead screw **1303** and reduce the friction of the moving frame **150** when moving along the first direction, ensuring stable and smooth movement of the moving frame **150**. This also effectively reduces energy consumption and facilitates energy conservation and environmental protection.

[0137] Certainly, persons skilled in the art should understand that the movable frame **130** may not be disposed on the movable-frame guide rail **1305**, or one or more (more than two) movable-frame guide rails **1305** may be provided, which is not particularly limited in this embodiment of this disclosure.

[0138] In some embodiments, the moving frame **150** may be provided with a first-presser side

baffle **1503**, where the first-presser side baffle **1503** can move along the first direction independent of the first presser **113**.

[0139] In an embodiment of this disclosure, as shown in FIG. **6** and FIG. **8**, the stopper **114** is mounted on the stopper bracket **140**, and the stopper bracket **140** is permanently connected to the movable frame **130**. In other words, during the pressing operation, the stopper **114** does not move along the first direction, and the workpiece queue **200** can be pressed when the first presser **113** approaches along the first direction. However, in some other embodiments, the stopper bracket **140** can be arranged to be capable of reciprocating along the first direction relative to the movable frame **130**, and the stopper **114** can also reciprocate along the first direction under the driving action of the stopper bracket **140**. In this way, during the pressing operation, the workpiece queue **200** can be pressed when the first presser **113** and the stopper **114** move towards each other along the first direction.

[0140] In some embodiments, the stopper bracket **140** may also be provided with a stopper side baffle **1403**. Specifically, the stopper bracket **140** may be provided with a stopper slide rail **1401** extending along the first direction, and the stopper side baffle **1403** is connected to the stopper slide rail **1401** through a stopper slide frame **1402**. Driven by a drive apparatus such as a servo motor, the stopper slide frame **1402** can drive the stopper side baffle **1403** to move along the stopper slide rail **1401**, so that the stopper side baffle **1403** can move along the first direction independent of the stopper **114**.

[0141] In some embodiments of this disclosure, two pressing assemblies **110** may be provided. For ease of description, the two pressing assemblies **110** are referred to as a first pressing assembly and a second pressing assembly respectively.

[0142] As shown in FIG. **2** and FIG. **3**, the pressing assembly **110** includes the first pressing assembly and the second pressing assembly, where the movable frame **130** includes a first movable frame **131** and a second movable frame **132**, the first pressing assembly is disposed on the first movable frame **131** and constructed to be capable of moving along the second direction under a driving action of the first movable frame **131**, and the second pressing assembly is disposed on the second movable frame **132** and constructed to be capable of moving along the second direction under a driving action of the second movable frame **132**.

[0143] When in the initial positions as shown in FIG. **2**, the first movable frame **131** and the second movable frame **132** are spaced apart at the farthest ends of the opposite sides of the fixed frame **120** along the second direction. The two movable frames **130** may have the same structure and motion control mode, and each movable frame **130** is provided with the pressing assembly **110**. With two pressing assemblies **110** provided, when the workpiece queue **200** to be pressed is one double-row workpiece queue **200**, any one of the two pressing assemblies **110** can be moved to press the double-row workpiece queue **200**; when the workpiece queues **200** to be pressed are two single-row workpiece queues **200**, the two pressing assemblies **110** can be moved to press the two single-row workpiece queues **200** simultaneously. This improves the machining efficiency of the pressing link, thereby improving the production efficiency of the entire production line.

[0144] Certainly, persons skilled in the art should understand that in some other embodiments, the pressing apparatus **100** may alternatively include only one movable frame **130**, that is, only one pressing assembly **110**, and may alternatively include three, four, or more movable frames **130** and pressing assemblies **110**, which may specifically depend on a size of the pressing apparatus **100** and actual manufacturing difficulty.

[0145] In some embodiments of this disclosure, the first pressing assembly and the second pressing assembly are constructed to be capable of switching between a first pressing mode and a second pressing mode, in the first pressing mode, one of the first pressing assembly and the second pressing assembly performs a pressing operation, and in the second pressing mode, both the first pressing assembly and the second pressing assembly perform a pressing operation. The pressing operation is performed by the first presser **113** of each pressing assembly **110** moving towards the

stopper **114** along the first direction.
[0146] For example, the pressing apparatus **100** can select the first pressing mode or second pressing mode for pressing based on the size, arrangement type, or number of the workpiece queues **200** to be pressed. In addition, the first pressing mode and the second pressing mode can be switched based on a change of the arrangement type and number of the workpiece queues **200** to be pressed. It should be noted that the change of the workpiece queue **200** includes the change the size of the single-row workpiece queue **200** in the second direction and the change of the size of the workpiece queue **200** to be pressed in the second direction caused by arranging workpieces into a double-row workpiece queue **200**.
[0147] Battery pressing is used as an example for further description. For example, if the workpiece queues **200** to be pressed are two queues arranged in the same way as the battery queue shown in FIG. **12**, the two battery queues can be pressed in the second pressing mode. If each battery queue is called a single-row module, the second pressing mode can be used to press the two queues of single-row modules simultaneously. It should be noted that the extending direction of the battery queue is the same as the first direction, and the first presser **113** and the stopper **114** respectively apply a pushing force to the battery queue from two ends of the battery queue in the first direction.
[0148] For another example, if the workpiece queue **200** to be pressed is a battery queue shown in FIG. **13**, the battery queue can be pressed in the first pressing mode. If the battery queue is arranged into a double-row module, one queue of the double-row module can be pressed in the first pressing mode.
[0149] Persons skilled in the art should understand that the description herein about battery queue pressing is merely an example. The battery queue pressing scenarios are not limited thereto. For example, when the first pressing mode is used for pressing, the workpiece queue **200** may alternatively be a single-row battery queue with a larger size arranged along the second direction. When the second pressing mode is used for pressing, the workpiece queue **200** may alternatively be a double-row battery queue formed by arranging a plurality of battery units, that is, the first pressing assembly and the second pressing assembly together press one double-row battery queue.
[0150] In this way, the pressing apparatus **100** can press two workpiece queues **200** simultaneously, further improving the production efficiency and reducing the production cost. Moreover, the pressing apparatus **100** is designed with two pressing modes and can switch between the two pressing modes, so that the pressing apparatus **100** can press both the single-row workpiece queue and double-row workpiece queue. This further improves the compatibility of the pressing apparatus **100**.
[0151] In some embodiments of this disclosure, the pressing apparatus **100** further includes a controller (not shown in the figures), where the controller is configured to control the first pressing assembly and the second pressing assembly to perform the pressing operation in the first pressing mode or the second pressing mode, based on preset information about an arrangement type of the workpiece queue **200**.
[0152] For example, the controller may be implemented by a microcomputer, a programmable controller, or by other known means. The controller is not particularly limited in this embodiment of this disclosure as long as functions of the controller can be implemented.
[0153] Information such as the arrangement type of the workpiece queue **200** can be set on a host computer. In this way, the pressing apparatus **100** can automatically switch between the pressing modes based on different situations, so that workpiece queues **200** can be pressed using different pressing schemes based on their arrangement types. This increases the level of automation of the pressing apparatus **100**. In addition, identity information of the workpiece queue including the information about the size and arrangement type of the workpiece queue can be written in an electronic tag, and the electronic tag is attached to the tray **300** holding the workpiece queue **200**. When the tray **300** holding the workpiece queue **200** reaches the pressing apparatus **100**, the

pressing apparatus **100** obtains the information such as the size and arrangement type of the workpiece queue **200** by means of scanning or identification, determines that the first pressing mode or the second pressing mode is used for pressing based on the information, and then drives the corresponding movable frame and the pressing assembly on the movable frame based on the determined pressing mode. In this way, the pressing apparatus **100** can press the workpiece queues uninterruptedly even if they are arranged in different types, thereby improving the production efficiency. In some embodiments of this disclosure, as shown in FIG. **6** to FIG. **11**, the first presser **113** is provided with a presser head **1131** (see FIG. **6**) for pushing the workpieces, and the stopper **114** is provided with an abutting surface **1141** (see FIG. **7**) for abutting against the workpieces.

[0154] In this way, the workpiece queue **200** can directly or indirectly abut against the abutting surface **1141** of the stopper **114**, and then the workpiece queue **200** can be pressed under the pushing force of the presser head **1131**. Moreover, that pressing is performed by the presser head can adapt to the pressed surfaces of workpiece queues **200** of different specifications or the pressed surface of the tray **300** holding the workpiece queues **200**.

[0155] The abutting surface **1141** of the stopper **114** is flat, so that pressure applied to the workpiece queue **200** can be distributed uniformly, improving the reliability and stability of the pressing apparatus **100**.

[0156] For example, a buffer can be disposed on the presser head of the first presser **113** and the abutting surface of the stopper **114** to play a cushioning role when the pressing assembly **110** presses the workpiece queue **200**. This reduces the possibility of damage to workpieces during pressing of the workpiece queue **200**. The buffer includes but is not limited to a spring.

[0157] For another example, the presser head **1131** and the abutting surface **1141** may be made of an elastic material, so as to prevent undesirable situations such as noise or workpiece deformation caused by contact between the workpiece and the presser head and abutting surface made of rigid materials. The elastic material includes but is not limited to rubber.

[0158] In some embodiments of this disclosure, as shown in FIG. **1** and FIG. **5** to FIG. **7**, the pressing apparatus **100** further includes a second presser **160**, where the second presser **160** is configured to apply an acting force along a third direction to the workpiece queue **200**, and the second presser **160** is disposed on the first movable frame **131** and/or the second movable frame **132** in a manner of being capable of reciprocating along the third direction, where the third direction intersects both the first direction and second direction.

[0159] For example, the acting force applied by the second presser **160** along the third direction to the workpiece queue **200** may be a pushing force (for example, downward pushing force or pressure) applied along the third direction.

[0160] In this way, the pressing apparatus **100** can also press a top surface of the workpiece queue **200**, so that the workpiece queue **200** can also be pressed in the height direction, guaranteeing the dimensional accuracy of the workpiece queue **200** in the third direction.

[0161] In this embodiment of this disclosure, the second presser **160** is disposed on the first movable frame **131**. In some other embodiments, the second presser **160** may alternatively be disposed on the second movable frame **132**, or the second presser **160** may be disposed on both the first movable frame **131** and the second movable frame **132**.

[0162] Persons skilled in the art should understand that when more movable frames **130** are provided, the pressing apparatus **100** may include more second pressers **160**.

[0163] In some embodiments of this disclosure, as shown in FIG. **6** and FIG. **7**, the second presser **160** is disposed on the first movable frame **131** or the second movable frame **132** through a moving carriage **161**, where the moving carriage **161** includes a third-direction guide rail **162** extending along the third direction, and the second presser **160** is capable of moving along the third-direction guide rail **162**.

[0164] As shown in FIG. **6** and FIG. **7**, the moving carriage **161** includes a presser connecting plate **163**. The presser connecting plate **163** is connected to the first movable frame **131** or the second

movable frame **132**, and a second slider **1631** is disposed on a side surface of the presser connecting plate **163** back away from the first movable frame **131** or the second movable frame **132**. The second slider **1631** can slide along the third-direction guide rail **162**, so that the moving carriage **161** can be disposed on the presser connecting plate **163** in a manner of being capable of moving along the third direction. As a result, the second presser **160** can move along the third direction.

[0165] In this way, a simple and stable structure can be used to enable the second presser **160** to move along the third direction, so that the pressing apparatus **100** can press the workpiece queue **200** along the third direction. This guarantees the dimensional accuracy of the workpiece queue **200** in the third direction.

[0166] In some embodiments of this disclosure, the moving carriage **161** is capable of moving along the first direction, and the moving carriage **161** further includes at least one moving-carriage slider **164** capable of sliding along the first direction, and the second presser **160** includes at least one pressing plate **165**, where the at least one pressing plate **165** is capable of moving along with the moving-carriage slider **164**.

[0167] As shown in FIG. **6** and FIG. **7**, a third slider **1632** is further disposed on a side of the presser connecting plate **163** facing the movable frame **130**, and the third slider **1632** can move along the movable-frame guide rail **1305**. In this way, the presser connecting plate **163** can move along the first direction, thereby driving the moving carriage **161** and then the second presser **160** to move along the first direction. The movement of the third slider **1632** along the movable-frame guide rail **1305** can be implemented by a servo motor or the like. In addition, a gear rack rail may be disposed at the top of the movable frame **130**, and a meshing part, for example, a helical gear, is disposed below the top of the presser connecting plate **163**. The meshing part reciprocates along the gear rack rail, driving the presser connecting plate **163**, the moving carriage **161**, and then the second presser **160** to reciprocate along the first direction. It should be noted that the lead screw **1303** is not in contact with the presser connecting plate **163**, so no interference exists therebetween.

[0168] The second presser **160** can move along the first direction to an appropriate position and press the workpiece queues **200** of different specifications along the third direction. This further improves the compatibility and flexibility of the pressing apparatus **100**.

[0169] The second presser **160** includes at least one pressing plate **165**, and the pressing plate **165** includes a pressing surface, where the pressing surface is used for abutting against the top surface of the workpiece queue **200**. The pressing surface is approximately flat, so that pressure applied to the workpiece queue **200** can be distributed uniformly, improving the reliability and stability of the pressing apparatus **100**. A buffer layer may be disposed on the pressing surface of the pressing plate **165**, so as to prevent undesirable situations such as noise and deformation of the workpiece queue **200** caused by collision between the rigid pressing plate **165** and the top surface of the workpiece queue **200**.

[0170] In the example shown in FIG. **6** and FIG. **7**, the second presser **160** includes three pressing plates **165**. These three pressing plates **165** may be close as shown in FIG. **6** and FIG. **7** or apart from each other with a specific spacing.

[0171] The moving carriage **161** further includes a carriage slide rail **166** extending along the first direction and at least one moving-carriage slider **164** capable of sliding along the carriage slide rail **166**, and the pressing plate **165** can move along the first direction along with the moving-carriage slider **164**.

[0172] Therefore, when a plurality of pressing plates **165** are provided, the spacing between the plurality of pressing plates **165** can be adjusted to accommodate more specifications of workpiece queues.

[0173] The number of pressing plates **165** and the number of moving-carriage sliders **164** are not particularly limited in this embodiment of this disclosure, which may be one, two, three, or more.

[0174] In some embodiments of this disclosure, the intersecting includes perpendicular

intersecting.
[0175] As mentioned above, the first direction, the second direction, and the third direction intersect, and the intersecting herein includes perpendicular intersecting. In this case, the workpiece queue **200** can be pressed in the perpendicular direction, which is particularly suitable for pressing workpiece queues **200** in the shape of a cuboid.
[0176] However, persons skilled in the art should understand that the embodiments of this disclosure are not limited to the case that the three directions are perpendicular to each other.
[0177] In some embodiments of this disclosure, the placement table **101** is provided with a lifting mechanism **102** for raising and lowering a tray **300** carried by the placement table **101**, and the tray **300** is configured for holding the workpiece queue **200**.
[0178] As shown in FIG. **1**, FIG. **4**, and FIG. **5**, the lifting mechanism **102** includes a lifting plate **1021** and a lifting apparatus **1022**. The lifting plate **1021** is provided with a plurality of universal balls **104** arranged evenly in a spaced-apart manner. When the lifting mechanism **102** is in a lowered state, the tray **300** transported by the tray conveyor line **400** can be smoothly located above the universal ball **104** and carried by the universal ball **104**. In this way, the tray **300** can be brought to a predetermined position on the placement table **101** more smoothly and quickly.
[0179] When the tray **300** is at the predetermined position on the placement table **101**, the lifting plate **1021** rises along the third direction under the driving force of the lifting apparatus **1022**, and the tray **300** disengages from the tray conveyor line **400** by using the lifting mechanism **102**. In this way, the tray **300** can be easily aligned and positioned.
[0180] For example, the lifting apparatus **1022** may be implemented by a lifting cylinder. To be specific, a cylinder body of the lifting cylinder is fixed below the placement table **101**, and a cylinder rod, which is retractable relative to the cylinder body, is connected below the lifting plate **1021**, and the lifting plate **1021** ascends or descends with the extension and retraction of the cylinder rod. One, two, or more lifting apparatuses **1022** may be provided. In this embodiment of this disclosure, two lifting apparatuses **1022** are provided.
[0181] As shown in FIG. **2**, the lifting plate **1021** is further provided with a positioning apparatus **105** for positioning the tray **300**. When the tray **300** is being brought to the placement table **101** along a guide rail of the tray conveyor line **400**, the positioning apparatus **105** is in a sunk position and does not interfere with the movement of the tray **300**. When the tray **300** stops under an action of the blocking apparatus **103** (described in detail later), the positioning apparatus **105** rises and meshes with a positioning recess at the bottom of the tray **300**, so as to position the tray **300** reliably and protect the tray **300** against accidents such as falling during the rising process. This helps improve the stability of the pressing assembly **110** when pressing the workpiece queue **200**.
[0182] For example, the positioning apparatus **105** may be a positioning post or positioning pin, or any other suitable positioning apparatus. In this embodiment of this disclosure, two positioning apparatuses **105** are provided, and the two positioning apparatuses **105** are diagonally opposite and spaced apart on the lifting plate **1021**. In some other embodiments, one, two, or more positioning apparatuses **105** may be provided, and the number and structure of the positioning apparatuses **105** are not particularly limited in this embodiment of this disclosure.
[0183] For example, the lifting mechanism **102** may further include a synchronous lifter. The synchronous lifter may be a commercially available synchronous lifter. In this way, the tray **300** can be smoothly moved up and down, reducing undesirable situations such as movement and deformation of the workpiece queue caused by the inclination of the tray **300**.
[0184] As shown in FIG. **1** to FIG. **3**, the placement table **101** is further provided with at least one gripper assembly. The gripper assembly includes two grippers **106**, and the two grippers **106** are spaced apart on opposite sides of the lifting plate **1021** along the second direction and can move towards or away from each other along the second direction. The gripper **106** is provided with a contact surface for contact with the tray **300**, and in the third direction, the contact surface is slightly higher than the lifting plate **1021** in a risen state and is approximately flush with the tray

300 in a risen state. In this way, when the tray **300** reaches the predetermined position on the placement table **101** and is raised, the two grippers **106** move towards each other along the second direction until the contact surface touches the tray **300**, so that the gripper assembly can grip the tray **300**, limiting the position of the tray **300**. This further improves the reliability of positioning the tray **300**, and further reduces undesirable situations such as accidental falling of the tray **300** during the lifting process.

[0185] For example, a gripping cylinder may be used to enable the two grippers **106** to move towards or away from each other.

[0186] In this embodiment of this disclosure, two gripper assemblies are provided and spaced apart on the placement table **101** along the first direction. In some other embodiments, one or more (more than two) gripper assemblies may be provided.

[0187] As an apparatus holding the workpiece queue, the tray **300** at least includes a bottom plate. The tray **300** holds the workpiece queue **200**. After being pressed, the workpiece queue **200** can be directly moved out of the pressing apparatus **100** through the tray **300** to the next process. In this way, the pressed workpiece queue **200** can be directly moved out of the pressing apparatus **100** through the tray **300** instead of a robot arm. This simplifies production line equipment, reduces control steps, and helps improve the production efficiency. In addition, the workpiece queue **200** is directly moved out with the tray **300** after being pressed, helping maintain the shape of the workpiece queue **200**.

[0188] In some embodiments of this disclosure, a blocking apparatus **103** is disposed on a side of the placement table **101** in the first direction, and the blocking apparatus **103** is configured to block the tray **300**.

[0189] As shown in FIG. **2** and FIG. **3**, two blocking apparatuses **103** are provided, but the number of blocking apparatuses **103** is not limited thereto and may be one or more. For example, the blocking apparatus **103** may be implemented by a blocking cylinder or in other forms such as a blocking piece. The blocking apparatus **103** may be controlled by a controller so as to block the tray **300** at the right time.

[0190] In this way, the tray **300** can be easily stopped at the predetermined position on the placement table **101** by the blocking apparatus **103**.

[0191] The placement table **101** may further be provided with an information reading apparatus for reading identity information of the tray **300**. As a specific example, an electronic tag is disposed on the tray **300** and can be read by the information reading apparatus. By reading the electronic tag, the information reading apparatus can obtain information related to the tray **300**, where the information related to the tray **300** includes information about the workpiece queue **200** held by the tray **300**. In a case that the workpiece queue **200** is a battery queue, the information related to the tray **300** includes the specification of the battery queue, the arrangement type of the battery queue (for example, a single-row module or a double-row module), and the like. In addition, the placement table **101** may be further provided with a position

[0192] detection apparatus for detecting whether the tray **300** is in position, including whether being in position in the first direction and/or whether being horizontal. For example, the position detection apparatus may be a commercially available position switch.

[0193] In some embodiments of this disclosure, as shown in FIG. **4**, FIG. **5**, and FIG. **11**, each pressing assembly **110** further includes a sleeve **115**, and the sleeve **115** is disposed at a position allowing an opening of the sleeve **115** to be fitted over a tray lead screw **301**, where the tray lead screw **301** is provided in the tray **300** carried by the placement table **101** and extends from an end of the tray **300** along the first direction.

[0194] When the pressing apparatus **100** is pressing the workpiece queue **200**, the tray **300** holding the workpiece queue **200** cannot move to ensure the accuracy and stability of the pressing operation. Therefore, after the tray **300** holding the workpiece queue **200** is brought to the placement table **101** and raised to be disengaged from the tray conveyor line **400**, the tray **300**

needs to be fixed before the pressing operation.
[0195] As mentioned above, the tray **300** is positioned using the positioning apparatus **105** and the gripper assembly. However, this can only ensure that the tray **300** does not move relative to the lifting plate **1021**. During pressing of the workpiece queue **200**, the pressing assembly **110** applies a great force to the workpiece queue **200**. Therefore, it is necessary to further ensure that the tray **300** does not move, so as to prevent pressing failure.
[0196] In this embodiment of this disclosure, the tray **300** is provided with a tray lead screw **301**, and the tray lead screw **301** extends from an end of the tray **300** along the first direction, so that the tray **300** can be permanently connected to the pressing apparatus **100** by fitting the sleeve **115** over the tray lead screw **301**. This prevents the tray **300** from moving during the pressing process and ensures proper processing of the workpiece queue **200**, improving the stability and reliability of the pressing operation.
[0197] For example, the sleeve **115** may be fitted over or detached from the tray lead screw **301** under the control of a telescopic cylinder.
[0198] In an embodiment of this disclosure, as shown in FIG. **5**, except for the bottom plate, the tray **300** further includes a first vertical plate **302** and a second vertical plate **303** for limiting positions of two ends of the workpiece queue **200** in the first direction. When the pressing assembly **110** presses the workpiece queue **200** held in the tray **300**, the abutting surface **1141** of the stopper **114** abuts against the first vertical plate **302**, and the presser head **1131** of the first presser **113** presses the second vertical plate **303**.
[0199] A meshing part is disposed below the second vertical plate **303** and connected to the tray lead screw **301**. The meshing part may be integrated with the second vertical plate **303**, or may be separated from the second vertical plate **303** but assembled together. The meshing part may be, for example, a nut capable of meshing with the tray lead screw **301**. In this way, when the presser head of the first presser **113** applies a pushing force along the first direction to the second vertical plate **303** for indirect pressing of the workpiece queue **200**, the second vertical plate **303** moves along the first direction. The tray lead screw **301** may be, for example, a self-locking lead screw, that is, the tray lead screw **301** and the meshing part of the second vertical plate **303** can be mutually locked. When the pressing operation is completed, the sleeve **115** still drives the tray lead screw **301** to rotate to some extent, so that the tray lead screw **301** and the meshing part are self-locked. In other words, when the second vertical plate **303** stops moving, it is left stationary at the current stop position. In this way, after the pressing is completed, even if the sleeve **115** is detached from the tray lead screw **301** later, the second vertical plate **303** does not move due to self-locking of the meshing part and the tray lead screw **301**, so that the workpiece queue **200** can be maintained at the predetermined length after the pressing. This improves the reliability of the pressing apparatus **100**.
[0200] For example, the pressing apparatus **100** further includes a detection apparatus for detecting the length of the workpiece queue **200** in the first direction, and the detection apparatus may be disposed on the placement table **101**. The detection apparatus may be arranged to ascend and descend along the third direction relative to the lifting plate **1021**. In this case, when the tray **300** is being brought to the placement table **101**, the detection apparatus descends to a position not interfering with the movement of the tray **300**, and when the tray **300** is in position and raised by the lifting mechanism **102** to be in a state of being disengaged from the tray conveyor line **400**, the detection apparatus is also raised to a position to detect the length of the workpiece queue **200** in the tray **300**. For example, the detection apparatus may be a distance meter.
[0201] In this way, the length of the workpiece queue **200** can be detected, so as to learn about the current pressing status, and then accurate control can be performed based on the current pressing status, for example, whether to end pressing or continue pressing.
[0202] The following describes the action of the pressing apparatus **100**.
[0203] For example, the pressing apparatus **100** can carry the workpiece queue **200** through the tray **300**. For example, the tray **300** can be brought by the tray conveyor line **400** from a previous

process to the placement table **101** of the pressing apparatus **100**. The tray **300** on the placement table **101** is raised by the lifting plate **1021** driven by the lifting apparatus **1022**, so that the tray **300** disengages from the conveyor line of the production line.

[0204] When the tray **300** is raised to a position, the pressing assembly **110** moves to the preparatory pressing position along the second direction, and the sleeve **115** is fitted over the tray lead screw **301** of the tray **300** to fix the tray **300**. The workpiece queue **200** is pressed by the first presser **113** moving towards the stopper **114** along the first direction. After the pressing is completed, the sleeve **115** still drives the tray lead screw **301** to rotate to some extent to lock the tray lead screw **301** and leave it distant so that they are no longer in a sleeved connection. The lifting plate **1021** is driven by the lifting apparatus **1022** to lower the tray **300** to a position allowing the tray **300** to be smoothly brought onto the tray conveyor line **400**. Driven by a pressing motor, the pressed workpiece queue **200** is transported to the next process along with the tray **300** for subsequent operations.

[0205] A second aspect of this disclosure provides a battery production line. As shown in FIG. **3** and FIG. **4**, the battery production line includes a tray conveyor line **400** and the pressing apparatus **100** according to any one of the foregoing embodiments. The tray conveyor line **400** places trays **300** on the placement table **101** or removes them from the placement table **101**, and the first presser **113** of the pressing apparatus **100** moves towards the stopper **114** along the first direction to perform a pressing operation on a battery queue carried by the tray **300** on the placement table **101**.

[0206] In the battery production line provided in this embodiment of this disclosure, the workpiece queue to be pressed is brought to the placement table **101** along with the tray **300**, and the pressed workpiece queue is transported to a next machining position still along with the tray **300**. Therefore, when the pressing apparatus **100** is used to press the workpiece queue **200**, the workpiece queue to be pressed is placed in the tray **300** on the placement table **101**.

[0207] The battery production line includes the tray conveyor line **400**, where the tray conveyor line **400** is configured to transport the tray **300**. The tray conveyor line **400** can be connected to the placement table **101** of the pressing apparatus **100**, so that the tray **300** can be brought to the placement table **101** from the tray conveyor line **400**, and the tray can be removed from the placement table **101** via the tray conveyor line **400** after the pressing is completed.

[0208] For example, the tray conveyor line **400** may be a conveyor belt such as a strap, a plurality of rollers arranged side by side, or a plurality of chains or speed chains.

[0209] In this way, workpiece queues **200** can be pressed rapidly in an automated manner, improving the pressing efficiency. In addition, the workpiece queues of varied specifications, for example, single-row workpiece queues and double-row workpiece queues, can be pressed in different pressing modes, improving the compatibility. Moreover, this also improves the flexible production of the battery production line.

[0210] In some embodiments of this disclosure, the workpiece includes at least one of a battery and a battery unit formed by combining at least two batteries. The workpiece queue **200** includes at least one of a battery queue formed by arranging a single row of batteries and a battery unit queue formed by arranging the battery units.

[0211] In this way, battery pressing is supported. In addition, battery queues of varied specifications can be accommodated, for example, a single-row battery queue formed by arranging single rows of batteries and a double-row battery queue formed by arranging double rows of batteries. This improves the compatibility (flexibility) of the pressing apparatus **100** and even the entire battery production line, and also improves the efficiency of grouping batteries.

[0212] A third aspect of this disclosure provides a pressing method, where a pressing apparatus **100** is configured to press a workpiece queue **200**, the pressing apparatus **100** includes a placement table **101** and at least one pressing assembly **110**, each pressing assembly **110** includes a first presser **113** and a stopper **114** arranged opposite the first presser **113**, and each pressing assembly **110** is constructed to be capable of moving along a second direction intersecting a first direction.

As shown in FIG. **14**, the pressing method includes the following steps.
[0213] S**100**. Placing step. Place a tray carrying a workpiece queue on a placement table and bring the tray to a predetermined position.
[0214] The workpiece queue **200** includes a plurality of workpieces arranged in the first direction, and the tray **300** includes a first vertical plate **302** and a second vertical plate **303** for limiting positions of two ends of the workpiece queue **200** in the first direction.
[0215] S**200**. Positioning step. Move at least one pressing assembly along a second direction to a preparatory pressing position.
[0216] Each pressing assembly **110** includes the first presser **113** and the stopper **114**, and at the preparatory pressing position, each workpiece queue **200** is located between the first presser **113** and the stopper **114** of each pressing assembly **110**.
[0217] S**300**. Pressing step. Move a first presser towards a stopper along a first direction to perform a pressing operation on the workpiece queue until the workpiece queue reaches a predetermined length.
[0218] In this way, the pressing apparatus **100** can press the workpiece queues **200** automatically and efficiently. In addition, workpiece queues **200** in different sizes are accommodated, presenting good compatibility.
[0219] In some embodiments of this disclosure, as shown in FIG. **15**, before the positioning step, the pressing method further includes the following steps. [0220] S**008**. Reading step. Read information about the workpiece queue. [0221] S**009**. Determine whether the tray contains the workpiece queue.
[0222] If the tray **300** does not contain the workpiece queue **200**, remove the tray **300** from the placement table **101**, or if the tray **300** contains the workpiece queue **200**, proceed to a type determining step.
[0223] In step S**008**, an information reading apparatus can be used to read an electronic tag of the tray **300** to obtain information related to the tray **300**, for example, the size and arrangement type of the workpiece queue **200** and whether a first pressing mode or a second pressing mode is used for pressing.
[0224] In a case that the workpiece queue **200** is a battery queue, the information related to the tray **300** includes the specification of the battery queue, the arrangement type of the battery queue (for example, a single-row module or a double-row module), and the like.
[0225] In this way, whether a tray **300** contains a workpiece queue **200** and information about the workpiece queue **200** can be quickly determined, so that the workpiece queue **200** can be pressed correctly, reducing the risk of misoperation.
[0226] In some embodiments of this disclosure, the pressing assembly **110** includes a first pressing assembly and a second pressing assembly. The first pressing assembly and the second pressing assembly are constructed to be capable of switching between a first pressing mode and a second pressing mode, in the first pressing mode, one of the first pressing assembly and the second pressing assembly performs a pressing operation, in the second pressing mode, both the first pressing assembly and the second pressing assembly perform a pressing operation, and in the type determining step, an arrangement type of the workpiece queue **200** is determined based on the read information about the workpiece queue **200**, where the arrangement type is used for determining that the pressing operation is performed in the first pressing mode or the second pressing mode.
[0227] In this way, after the arrangement type of the workpiece queue **200** is determined, a pressing mode matching the arrangement type can be selected to accommodate the single-row workpiece queue and double-row workpiece queue. In addition, the pressing mode can be switched automatically, helping improve the production efficiency.
[0228] In some embodiments of this disclosure, the pressing apparatus **100** further includes a second presser **160** configured to apply an acting force along a third direction to the workpiece queue **200**. As shown in FIG. **16**, after the positioning step and before the pressing step, the

pressing method further includes the following step.
[0229] S**299**. Down-pressing step. Move a second presser along a third direction to press down on the workpiece queue.
[0230] This can further improve the dimensional accuracy of the workpiece queue **200** in the third direction.
[0231] In some embodiments of this disclosure, as shown in FIG. **17**, the placing step includes the following steps.
[0232] S**101**. Block, using a blocking apparatus, the tray moving along a first direction to place the tray on the placement table.
[0233] S**102**. Raise the placement table using a lifting mechanism of the placement table, so that the placement table disengages from a tray conveyor line that transports the tray, whereby the tray is brought to the predetermined position.
[0234] In this way, the tray **300** can be placed in the expected position, and aligned and positioned without being affected by the tray conveyor line **400**. In addition, the tray conveyor line **400** cannot be easily damaged.
[0235] In some embodiments of this disclosure, as shown in FIG. **18**, the positioning step includes the following steps.
[0236] S**201**: Move the pressing assembly along the second direction to position each workpiece queue between a first presser and a stopper of each pressing assembly, based on an arrangement type.
[0237] If the arrangement type is a double-row workpiece queue, one of the first pressing assembly and the second pressing assembly is moved along the second direction, and if the arrangement type is a single-row workpiece queue, both the first pressing assembly and the second pressing assembly are moved along the second direction.
[0238] S**202**. Bring a first vertical plate of the tray into contact with the stopper, and
[0239] position the tray by having a sleeve of the pressing assembly fitted over a tray lead screw, where the tray lead screw is disposed in the tray and extends from an end of the tray along the first direction.
[0240] S**203**. Move the first presser, which has moved to a position corresponding to the workpiece queue, along the first direction to the vicinity of a second vertical plate of the tray.
[0241] In this way, one or both of the first pressing assembly and the second pressing assembly can be made to operate based on the arrangement type of the workpiece queue **200**, so that the pressing operation can be performed automatically. In addition, through the cooperation between the sleeve **115** and the tray lead screw **301**, the tray **300** can be fixed at the preparatory pressing position, so as to stably maintain the workpiece queue **200** at an appropriate position.
[0242] In steps S**202** and S**203**, the tray lead screw **301** is a self-locking screw, and can be mutually locked together with the meshing part of the second vertical plate **303** of the tray **300** after the pressing is completed, so that the second vertical plate **303** can be maintained at the position where the pressing is completed. In this way, the length of the workpiece queue **200** in the first direction remains unchanged after the pressing is completed, so that the workpiece queue **200** can be maintained at a predetermined length.
[0243] In some embodiments of this disclosure, as shown in FIG. **19**, the pressing step includes the following steps.
[0244] S**301**. Based on the arrangement type, move the first presser towards the stopper along the first direction to perform a pressing operation on the workpiece queue.
[0245] If the arrangement type is a double-row workpiece queue, the first presser of one of the first pressing assembly and the second pressing assembly performs the pressing operation, and if the arrangement type is a single-row workpiece queue, the first pressers of both the first pressing assembly and the second pressing assembly perform the pressing operation.
[0246] S**302**. Determine whether each pressed workpiece queue has the predetermined length.

[0247] If every workpiece queue **200** has the predetermined length, proceed to a locking step, if any workpiece queue **200** is longer than the predetermined length, make the first presser **113** corresponding to that workpiece queue **200** continue pressing until the workpiece queue **200** reaches the predetermined length, and if any workpiece queue **200** is shorter than the predetermined length, determine that the workpiece queue **200** is unqualified under pressing criteria. In the locking step, the sleeve **115** fitted over the tray lead screw **301** is rotated to be locked, thereby preventing the second vertical plate **303** from moving away from the first vertical plate **302** along the first direction, so as to maintain the workpiece queue **200** at the predetermined length.

[0248] In step S**302**, a detection apparatus, for example, may be used to detect whether the current workpiece queue **200** has the predetermined length.

[0249] For example, the detection apparatus is used to detect the length (a distance between two large end surfaces of the queue) of the current workpiece queue **200** in the first direction. Whether the length is the same as the predetermined length is determined, for example, whether the difference from the predetermined length is within a specified range of tolerance. For example, a difference of 5 mm from the predetermined length is considered with the range of tolerance. If the measured length is greater than the predetermined length (beyond the range of tolerance), the pressing assembly **110** can be controlled to perform supplementary pressing until the workpiece queue **200** has a length with the difference falling within the specified range of tolerance. If the measured length is less than the predetermined length (beyond the range of tolerance), the workpiece queue **200** is considered unqualified and may be moved to a specified place.

[0250] In this way, pressing can be performed based on the arrangement type of the workpiece queue **200**, so as to support pressing of both single-row workpiece queues and double-row workpiece queues. In addition, the length of a workpiece queue **200** is checked after a pressing operation. Therefore, whether appropriate pressing is performed can be learned in a timely manner. Then, supplementary pressing is performed or the workpiece queue **200** is considered unqualified under pressing criteria, based on actual situations. In addition, the locking step can maintain the pressed workpiece queue **200** at a predetermined length, facilitating subsequent processes.

[0251] The following describes specific examples of some embodiments of this disclosure, with reference to the accompanying drawings.

[0252] As a specific example, two single-row battery unit queues need to be pressed. The pressing apparatus **100** includes the placement table **101** and a rack frame (the movable frame **130**), where the rack frame includes a first rack frame (the first movable frame **131**) and a second rack frame (the second movable frame **132**) arranged on two opposite sides of the pressing apparatus **100** in the second direction, respectively. The first rack frame is provided with a first presser head and a first positioning stop (the first pressing assembly), where the first presser head and the first positioning stop are arranged on opposite sides of the first rack frame in the first direction, respectively. The second rack frame is provided with a second presser head and a second positioning stop (the second pressing assembly), where the second presser head and the second positioning stop are arranged on opposite sides of the second rack frame in the first direction, respectively. The first presser head and the second presser head are configured to apply a pushing force along the first direction to a battery cell queue. The first rack frame and the second rack frame are further provided with a third presser head (the second presser **160**), and the third presser head is configured to apply a pushing force along the third direction to the battery cell queue.

[0253] After the tray **300** is brought to the predetermined position on the placement table **101**, the tray **300** is raised by the lifting mechanism **102** and disengaged from the production line. When determining that the tray **300** contains two single-row battery cell queues, the controller controls the pressing apparatus **100** to use the second pressing mode. In this case, both the first rack frame and the second rack frame move along the second direction to the vicinity of the two single-row battery queues, so that the two single-row battery queues are located between the first presser head

and the first positioning stop and between the second presser head and the second positioning stop, respectively. Then, the third presser head moves along the third direction to push top surfaces of the two battery cell queues. Finally, the two single-row battery queues are pressed simultaneously along the first direction by the first presser head moving towards the first positioning stop and the second presser head moving towards the second positioning stop.

[0254] Through cooperation between two sets of presser heads and positioning stops, the two battery cell queues can be pressed simultaneously in a simple and automated manner, so that pressing can be performed quickly. This greatly improves the working efficiency of the pressing apparatus **100**.

[0255] After the pressing operation is completed, the two presser heads move away from the two positioning stops along the first direction, respectively, the first rack frame and the second rack frame return to their initial positions under the control of the controller, and the tray **300** is lowered by the lifting mechanism **102** and moves automatically to the next process.

[0256] The pressing apparatus **100** in the specific embodiment of this disclosure can achieve automatic feeding, automatic pressing, and automatic discharging, and quick pressing of battery cell queues, thereby increasing the level of automation and effectively reducing the labor cost. In addition, two battery cell queues can be pressed simultaneously, which improves the production efficiency, reduces the production cost, and facilitates flexible production.

[0257] Furthermore, the controller can automatically adjust the distance between each presser head and the positioning stop during pressing based on the actual desired size of the battery cell queue. Therefore, the pressing apparatus **100** can accommodate battery cell queues of varied sizes, improving the compatibility.

[0258] The specific operation process of pressing a battery queue is described below as an example.

[0259] First, the controller determines whether the placement table **101** carries the tray **300**. If the tray **300** is detected, it is determined that the tray **300** is in position and information about the tray **300** is read.

[0260] If the controller determines that no tray **300** is detected at the predetermined position, the controller proceeds with the following process: waiting for the tray **300** on the tray conveyor line **400** to be brought to the predetermined position on the placement table **101**. That is, the controller determines whether there is a tray **300** at the pressing front-end of the tray conveyor line **400**. If there is a tray **300** at the pressing front-end of the production line, the controller starts the pressing motor, allowing the tray **300** to be placed on the tray conveyor line **400**, and stops the pressing motor when the tray **300** reaches the predetermined position on the placement table **101**.

[0261] If there is no tray **300** on the tray conveyor line **400**, the tray **300** will not be placed on the placement table **101**. Wait for a while, generally at least one production cycle, for example, several seconds. As the wait begins, the controller starts the pressing motor, and then stops the pressing motor when the tray **300** on the tray conveyor line **400** arrives.

[0262] During operation, the pressing motor provides a driving force for the tray conveyor line **400**, so that the tray **300** on the tray conveyor line **400** is brought to the predetermined position on the placement table **101**. If there is a tray **300** at the predetermined position on the placement table **101**, the controller stops the pressing motor, so that the tray **300** on the tray conveyor line **400** is not transported to the predetermined position on the placement table **101**.

[0263] The placement table **101** is further provided with two blocking apparatuses **103** and a distance meter used as a detection apparatus. The blocking apparatus **103** is configured to prevent extra movement of the tray **300**, and the distance meter is configured to detect the length of a battery queue in the tray **300**. The distance meter periodically or aperiodically measures the length of the battery queue and reports the length to the controller. Then, the controller determines whether the battery queue reaches the predetermined length based on the length.

[0264] During implementation, an industrial in-position sensor (also referred to as a position

sensor) as a position detection apparatus may be disposed to detect whether the tray **300** reaches the predetermined position. If the in-position sensor detects that the tray **300** reaches the predetermined position, the in-position sensor sends tray arrival information to the controller, and the controller determines that the tray **300** has reached the predetermined position based on the tray arrival information from the in-position sensor. Usually, the in-position sensor can detect the position of an object, relative position change, or continuous position change.

[0265] After the tray **300** reaches the predetermined position on the placement table **101**, the controller starts a lifting cylinder used as the lifting apparatus **1022** on the placement table **101**, and the lifting cylinder drives the lifting plate **1021** on the placement table **101** to raise the tray **300** and disengage the tray **300** from the tray conveyor line **400**.

[0266] In practice, the tray **300** is further provided with a sensor (hereinafter referred to as a leveling sensor) for checking whether the tray **300** is placed stably. For example, the level sensor is implemented using a proximity switch sensor. A pair of proximity switch sensors are arranged on opposite sides of the tray bottom respectively, for example, at two corners of one side or at two diagonal corners.

[0267] When the tray is in position, the controller starts a gripping cylinder, and the gripper assembly grips the tray **300** under the driving force of the gripping cylinder. In addition, the controller receives a leveling signal sent by the leveling sensor. If the leveling signal indicates that the tray is stable, the controller uses a barcode scanner functioning as an information reading apparatus to read the electronic tag on the tray (such as battery-related information stored by RFID), and determines, based on the read battery-related information, whether the battery queue to be pressed in the tray is a single-row battery queue or a double-row battery queue.

[0268] The controller controls the pressing apparatus **100** to use the first pressing mode or the second pressing mode, based on the read battery-related information. If the read battery-related information indicates that the battery queue is a single-row battery queue, the second pressing mode is used. Then, the controller controls both the first pressing assembly and the second pressing assembly to perform the pressing operation. If the read battery-related information indicates that the battery queue is a double-row battery queue, the first pressing mode is used. Then, the controller controls one of the first pressing assembly and the second pressing assembly to perform the pressing operation. After the pressing mode is determined, the controller controls the corresponding pressing assembly **110** to move to the vicinity of the battery queue along the second direction. At this time, the controller starts the telescopic cylinder of the sleeve, and the sleeve **115** is fitted over the tray lead screw **301** of the tray **300** under the driving force of the telescopic cylinder, so as to fix the tray **300**. Then, the controller controls the first presser **113** to move towards the stopper **114** along the first direction to press the battery queue until the distance meter detects that the battery queue reaches the predetermined length. Next, the controller controls the sleeve **115** to still drive the tray lead screw **301** of the tray **300** to rotate to some extent, so that the second vertical plate **303** can be locked with the tray lead screw **301**, thereby maintaining the battery queue at the predetermined length.

[0269] After the pressing is completed, the controller further determines whether the battery queue is a single-row battery queue or a double-row battery queue based on product information. For the single-row battery queue, the single-row battery queue information, task number, and other related information are bound and stored. For the double-row battery queue, the double-row battery queue information, task number, and other related information are bound and stored, and the stored information is written in the electronic tag of the module tray.

[0270] After determining that the pressing is completed for the tray **300**, the controller resets all electrical mechanical parts (such as the servo motor and cylinders). After the information is written in the electronic tag of the tray **300**, the controller controls the pressing motor to continue working, so that the pressed module tray is removed and the next tray **300** is brought to the predetermined position on the placement table **101**.

[0271] After the pressing is completed for the current tray **300**, the controller determines whether the work order is completed. If the work order is completed, it is determined that the pressing is completed. The controller records the number of completed modules and writes the current station number in the tray **300** for recording. Then, a new work order is used. When a work order is not completed, the controller records the number of completed modules and the number of uncompleted modules. If one module is pressed, the number of uncompleted modules becomes less by one. The pressing process is repeated until the work order is completed.
[0272] The foregoing embodiments are merely intended for describing the technical solutions of this disclosure but not for limiting this disclosure. Although this disclosure is described in detail with reference to the foregoing embodiments, persons of ordinary skill in the art should understand that they may still make modifications to the technical solutions described in the foregoing embodiments or make equivalent replacements to some or all technical features thereof without departing from the scope of the technical solutions of the embodiments of this disclosure. They should all be covered in the scope of this disclosure. In particular, in absence of structural conflict, the various technical features mentioned in the embodiments can be combined in any manner.

INDUSTRIAL PRACTICABILITY

[0273] This disclosure provides a pressing apparatus, a battery production line, and a pressing method, so that battery queues can be pressed rapidly in an automated manner and high compatibility is achieved.

Claims

1. A pressing apparatus for pressing a workpiece queue, comprising: a placement table, configured to support the workpiece queue, wherein the workpiece queue comprises a plurality of workpieces arranged along a first direction; and at least one pressing assembly, wherein each pressing assembly comprises a first presser and a stopper arranged opposite the first presser, wherein the first presser is configured to apply an acting force along the first direction to the workpiece queue, the stopper is configured to block the workpiece queue, and the first presser and the stopper are constructed to be capable of moving towards or away from each other along the first direction, wherein the pressing assembly is constructed to be capable of moving along a second direction intersecting the first direction.

2. The pressing apparatus according to claim 1, wherein the pressing apparatus comprises a fixed frame and at least one movable frame disposed on the fixed frame and capable of moving along the second direction, wherein each pressing assembly is disposed on each movable frame.

3. The pressing apparatus according to claim 2, wherein each movable frame is provided with a stopper bracket and a moving frame capable of reciprocating relative to the movable frame along the first direction, the stopper is mounted on the stopper bracket, and the first presser is mounted on the moving frame and is capable of moving under a driving action of the moving frame.

4. The pressing apparatus according to claim 2, wherein the pressing assembly comprises a first pressing assembly and a second pressing assembly, the movable frame comprises a first movable frame and a second movable frame, the first pressing assembly is disposed on the first movable frame and constructed to be capable of moving along the second direction under a driving action of the first movable frame, and the second pressing assembly is disposed on the second movable frame and constructed to be capable of moving along the second direction under a driving action of the second movable frame.

5. The pressing apparatus according to claim 4, wherein the first pressing assembly and the second pressing assembly are constructed to be capable of switching between a first pressing mode and a second pressing mode, in the first pressing mode, one of the first pressing assembly and the second pressing assembly performs a pressing operation, and in the second pressing mode, both the first pressing assembly and the second pressing assembly perform a pressing operation; wherein the

pressing operation is performed by the first presser of each pressing assembly moving towards the stopper along the first direction.

6. The pressing apparatus according to claim 5, wherein the pressing apparatus further comprises a controller, wherein the controller is configured to control the first pressing assembly and the second pressing assembly to perform the pressing operation in the first pressing mode or the second pressing mode, based on preset information about an arrangement type of the workpiece queue.

7. The pressing apparatus according to claim 1, wherein the first presser is provided with a presser head for pushing the workpieces, and the stopper is provided with an abutting surface for abutting against the workpieces.

8. The pressing apparatus according to claim 4, wherein the pressing apparatus further comprises a second presser, wherein the second presser is configured to apply an acting force along a third direction to the workpiece queue, and the second presser is disposed on the first movable frame and/or the second movable frame in a manner of being capable of reciprocating along the third direction, wherein the third direction intersects both the first direction and the second direction.

9. The pressing apparatus according to claim 8, wherein the second presser is disposed on the first movable frame or the second movable frame through a moving carriage, wherein the moving carriage comprises a third-direction guide rail extending along the third direction, and the second presser is capable of moving along the third-direction guide rail.

10. The pressing apparatus according to claim 9, wherein the moving carriage is capable of moving along the first direction, and the moving carriage further comprises at least one moving-carriage slider capable of sliding along the first direction, and the second presser comprises at least one pressing plate, wherein the at least one pressing plate is capable of moving together with the moving-carriage slider.

11. The pressing apparatus according to claim 1, wherein, the intersecting comprises perpendicular intersecting.

12. The pressing apparatus according to claim 1, wherein the placement table is provided with a lifting mechanism for raising and lowering a tray carried by the placement table, and the tray is configured for holding the workpiece queue.

13. The pressing apparatus according to claim 1, wherein a blocking apparatus is disposed on a side of the placement table in the first direction, and the blocking apparatus is configured to block the tray.

14. The pressing apparatus according to claim 1, wherein each pressing assembly further comprises a sleeve, and the sleeve is disposed at a position allowing an opening of the sleeve to be fitted over a tray lead screw, wherein the tray lead screw is provided in the tray carried by the placement table and extends from an end of the tray along the first direction.

15. A battery production line comprising a tray conveyor line and the pressing apparatus according to claim 1, wherein the tray conveyor line places trays on the placement table or removes trays from the placement table, and the first presser of the pressing apparatus moves towards the stopper along the first direction to perform a pressing operation on a battery queue carried by the tray on the placement table.

16. The battery production line according to claim 15, wherein the workpiece comprises at least one of a battery and a battery unit formed by combining at least two batteries, and the workpiece queue comprises at least one of a battery queue formed by arranging a single row of batteries and a battery unit queue formed by arranging the battery units.

17. A pressing method, wherein a pressing apparatus is configured to press a workpiece queue, the pressing apparatus comprises a placement table and at least one pressing assembly, each pressing assembly comprises a first presser and a stopper arranged opposite the first presser, and each pressing assembly is constructed to be capable of moving along a second direction intersecting a first direction, wherein the pressing method comprises: a placing step of placing a tray carrying the workpiece queue on the placement table and bringing the tray to a predetermined position, wherein

the workpiece queue comprises a plurality of workpieces arranged in the first direction, and the tray comprises a first vertical plate and a second vertical plate for limiting positions of two ends of the workpiece queue in the first direction; a positioning step of moving at least one pressing assembly along the second direction to a preparatory pressing position, wherein each pressing assembly comprises the first presser and the stopper, and at the preparatory pressing position, each workpiece queue is located between the first presser and the stopper of the each pressing assembly; and a pressing step of moving the first presser towards the stopper along the first direction to perform a pressing operation on the workpiece queue until the workpiece queue reaches a predetermined length.

18. The pressing method according to claim 17, wherein before the positioning step, the pressing method further comprises: a reading step of reading information about the workpiece queue; and determining whether the tray contains the workpiece queue, and if the tray does not contain the workpiece queue, removing the tray from the placement table, or if the tray contains the workpiece queue, proceeding to a type determining step, wherein the pressing assembly comprises a first pressing assembly and a second pressing assembly, and the first pressing assembly and the second pressing assembly are constructed to be capable of switching between a first pressing mode and a second pressing mode, in the first pressing mode, one of the first pressing assembly and the second pressing assembly performs a pressing operation, in the second pressing mode, both the first pressing assembly and the second pressing assembly perform a pressing operation, and in the type determining step, an arrangement type of the workpiece queue is determined based on the read information about the workpiece queue, wherein the arrangement type is used for determining that the pressing operation is performed in the first pressing mode or the second pressing mode.

19. The pressing method according to claim 17, wherein the pressing apparatus further comprises a second presser configured to apply an acting force along a third direction to the workpiece queue, wherein the third direction intersects the first direction and the second direction, and after the positioning step and before the pressing step, the pressing method further comprises: a down-pressing step of moving the second presser along the third direction to press down on the workpiece queue.

20. The pressing method according to claim 18, wherein the placing step comprises: blocking, using a blocking apparatus, the tray moving along the first direction to place the tray on the placement table; and raising the placement table using a lifting mechanism of the placement table, so that the placement table disengages from a tray conveyor line that transports the tray, whereby the tray is brought to the predetermined position, wherein the positioning step comprises: moving the pressing assembly along the second direction to position each workpiece queue between the first presser and the stopper of each pressing assembly based on the arrangement type, wherein if the arrangement type is a double-row workpiece queue, one of the first pressing assembly and the second pressing assembly is moved along the second direction, and if the arrangement type is a single-row workpiece queue, both the first pressing assembly and the second pressing assembly are moved along the second direction; bringing the first vertical plate of the tray into contact with the stopper, and positioning the tray by having a sleeve of the pressing assembly fitted over a tray lead screw, wherein the tray lead screw is disposed in the tray and extends from an end of the tray along the first direction; and moving the first presser, which has moved to a position corresponding to the workpiece queue, along the first direction to the vicinity of the second vertical plate of the tray, and wherein the pressing step comprises: moving the first presser towards the stopper along the first direction to perform a pressing operation on the workpiece queue based on the arrangement type, wherein if the arrangement type is a double-row workpiece queue, the first presser of one of the first pressing assembly and the second pressing assembly performs the pressing operation, and if the arrangement type is a single-row workpiece queue, the first pressers of both the first pressing assembly and the second pressing assembly perform the pressing operation; and determining whether each pressed workpiece queue has the predetermined length; and if every workpiece queue

has the predetermined length, proceeding to a locking step, if any workpiece queue is longer than the predetermined length, making the first presser corresponding to that workpiece queue continue pressing until the workpiece queue reaches the predetermined length, and if any workpiece queue is shorter than the predetermined length, determining that the workpiece queue is unqualified under pressing criteria; wherein in the locking step, the sleeve fitted over the tray lead screw is rotated to be locked, thereby preventing the second vertical plate from moving away from the first vertical plate along the first direction, so as to maintain the workpiece queue at the predetermined length.