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TITLE OF THE INVENTION: SUBSTRATE ASSEMBLING APPARATUS

BACKGROUND OF THE INVENTION:

Field of the Invention

5 This invention relates to a substrate assembling apparatus and particularly to the substrate assembling apparatus suitable for assembling of a liquid crystal display panel where substrates to be bonded to each other in the vacuum chamber are held in a face-to-face position and are bonded to each other with reduced space between
10 them.

Prior Art

 The production of a liquid crystal display panel contains a step wherein two glass substrates provided with
15 a transparent electrode and thin film transistor array are bonded to each other at a position very close to each other about several microns apart using the adhesive (also called "sealing material") on the periphery of the substrate (the substrates subsequent to assembling is hereinafter
20 referred to as a "cell"). Then the empty space formed thereby is filled with liquid crystal.

 One of the examples of said step of sealing liquid crystal is disclosed in the Official Gazette of Japanese Patent Laid-Open NO.26763/1998. According to this disclosure,
25 liquid crystal is dripped on one of the substrates where

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sealing material is formed into a closed pattern in order not to provide a filling port. The other substrate is placed on that substrate in a vacuum chamber, and the upper and lower substrates are brought close to each other to make assembling.

According to said prior arts, the lower substrate is placed on a flat stage when the substrate is held in vacuum. The upper one has an appropriate position on the periphery supported by a pin-shaped member. Then after having been positioned, the upper and lower substrates are placed closer to each other and are bonded with each other. At the time of positioning, the central portion of the upper substrate is bent down by specific gravity, making it difficult to provide accurate positioning of upper and lower substrate. The greater the size of a substrate, the greater the amount of bend. The display panel tends to increase and accurate substrate assembling is getting more and more difficult according to the above prior art.

Further, the upper and lower substrates are transferred directly in the vacuum chamber. After transfer, much time is required to discharge gas from the chamber to reach the state of vacuum from the atmospheric pressure. This gives rise to a problem that productivity cannot be improved.

SUMMARY OF THE INVENTION:

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The object of the present invention is to provide a substrate assembling apparatus which allows high precision assembling of substrates under vacuum. Another object of the present invention is to provide a substrate assembling
5 apparatus which ensures a high precision and high speed in assembling despite the increasing size of a substrate. The present invention achieving said objects is characterized in that

a substrate assembling apparatus wherein upper and
10 lower substrates to be bonded are held face to face with each other and are positioned, and the distance between them is reduced so that the upper and lower substrates are bonded with each other under vacuum by the adhesive provided in at least one of said substrates;

15 said substrate assembling apparatus further characterized in that

a first table where any one of the two substrates can be removably fixed on the upper or lower surface thereof and

20 a second table where the other of the two substrates can be removably fixed on the lower or upper surface thereof are provided in a vacuum chamber such that the upper and lower surfaces of said substrates are placed face to face with each other,

25 one of the two tables is movably connected with said

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vacuum chamber through an elastic body hermetically,

the one tables has a drive means for traveling at least
in the horizontal direction with respect to said vacuum
chamber on the atmosphere side of the vacuum chamber
5 partitioned by said elastic body, and

one of two tables has a drive means for reducing the
distance between substances located face to face with each
other.

Further, the present invention is characterized in that
10 said drive means of the one of tables moves the one of tables
with respect to the vacuum chamber through a linear guide,
and is provided with an elastic body between the vacuum
chamber and linear guide, and a vacuum seal and bearing
on the atmospheric side partitioned by said elastic body.
15 Said elastic body refers to a bellows shaped member
comprising the bellows and multiple annular dish shaped
diaphragms with their outer and inner peripheries connected
alternately to each other hermetically.

The present invention is further characterized in that
20 one of the tables is a lower table in the vacuum chamber.

The present invention is still further characterized
in that the other of tables has a vertical drive means for
reducing the distance between two substrates, while the
one of tables has a drive means which is specialized in
25 driving in the horizontal direction.

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Furthermore, the present invention is still further characterized in that a load lock chamber and atmosphere release chamber are provided on the front and rear of said vacuum chamber, and each chamber is partitioned with the
5 other by a gate valve, and connection between chambers or with atmosphere is provided by opening of said gate valve, thereby permitting substrates to be transported.

Moreover, the present invention is still further characterized in that said drive means located on the
10 atmosphere side outside said vacuum chamber to move the one of tables at least in the horizontal direction with respect to the vacuum chamber is linked to the one of tables by means of multiple shafts each penetrating through multiple openings which are provided separately from each
15 other in the vacuum chamber; and each opening of the vacuum chamber has an elastic body which maintains a vacuum chamber and each shaft hermetic.

BRIEF DESCRIPTION OF THE DRAWINGS:

20 Fig. 1 is a drawing representing the configuration of a substrate assembling apparatus as one embodiment of the present invention;

Fig. 2 is a cross sectional view representing the internal structure of the load lock chamber of a substrate
25 assembling apparatus in Fig. 1;

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Fig. 3 is a cross sectional view representing the internal structure of the vacuum assembling chamber of a substrate assembling apparatus in Fig. 1;

5 Fig. 4 is a cross sectional view representing the internal structure of the atmosphere release chamber of a substrate assembling apparatus in Fig. 1;

Fig. 5 is a drawing illustrating the substrate assembling process in the load lock chamber shown in Fig. 2;

10 Fig. 6 is a drawing illustrating the substrate assembling process in the vacuum assembling chamber shown in Fig. 3;

Fig. 7 is a drawing illustrating the substrate assembling process in the vacuum assembling chamber shown
15 in Fig. 3;

Fig. 8 is a drawing representing the configuration of the substrate assembling apparatus in another embodiment of the present invention;

Fig. 9 is a drawing illustrating how the lower substrate
20 is inserted in the vacuum chamber by a robot hand in the substrate assembling apparatus shown in Fig. 8;

Fig. 10 is a drawing illustrating how the lower substrate is transferred to the lower table in the substrate assembling apparatus shown in Fig. 8;

25 Fig. 11 is a drawing illustrating how upper and lower

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substrates are positioned and assembled in the substrate assembling apparatus shown in Fig. 8, and

Fig. 12 is a drawing illustrating how a magnetic seal and shaft are moved in the positioning of the upper and lower substrates in the substrate assembling apparatus
5 shown in Fig. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

The following describes one embodiment according to
10 the present invention with reference to drawings:

In Fig. 1, numeral 1 denotes a substrate assembling apparatus according to the present invention comprising a load lock chamber R1, vacuum assembling chamber (vacuum chamber) R2 and atmosphere release chamber R3. Numerals
15 2 to 5 denote gate valves provided at the inlets and outlets of chambers R1 to R3. In the structure illustration, when the terms, load lock chamber R1, vacuum assembling chamber R2 and atmosphere release chamber R3 indicate the housings constituting the chambers. The present embodiment
20 comprises multiple vacuum chambers, and the vacuum chamber for assembling of the substrates is called a vacuum assembling chamber.

In the chambers R1 to R3, a transfer path located on the same horizontal position. Through this transfer path
25 the substrates to be bonded are transferred from left to

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right in the drawing. A specific configuration will be described with respect to Fig. 2 and later.

As will be discussed later, the vacuum assembling chamber R2 except for the load lock chamber R1 and atmosphere
5 release chamber R3 is a substrate assembling apparatus in the narrow sense of the word.

Fig. 2 shows the internal structure of the load lock chamber R1.

Numeral 11 denotes multiple feed rollers provided
10 inside the load lock chamber R1, and makes forward and reverse rotation so that the transfer (or feed) jig carrying the substrates to be bonded to be discussed later is fed to the right and left directions in the drawing.

Outside air can be vacuum-separated from the inside
15 of the load lock chamber R1 by closing of the gate valve 2. Numeral 6 denotes a gate valve provided on the base of the load lock chamber R1. When it opens, the inside of the load lock chamber R1 by the vacuum pump 12 is vacuum-exhausted. Numeral 7 is an atmosphere release valve. When it opens,
20 the inside of the load lock chamber R1 is purged by atmosphere or gas with the result that the pressure gets back to the atmospheric pressure.

A gate valve 3 is located between the load lock chamber R1 and vacuum assembling chamber R2 to allow pressure in
25 each chamber to be change independently.

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Fig. 3 shows the internal structure of the vacuum assembling chamber R2.

Although not illustrated in this drawing, a valve similar to the gate valve 6 of the load lock chamber is located on the lower side of the vacuum assembling chamber R2 so that the interior of the chamber can be vacuum-exhausted by a vacuum pump (not illustrated).

Numeral 21 indicates a lower table. The support structure will be described later. Numeral 22 represents multiple feed rollers provided inside the vacuum assembling chamber R2 so that the lower table is sandwiched on the front and back in the drawing. When they make a forward and reverse rotation, the feed (or transfer) jig loaded with the substrates to be bonded (described later) is fed in the right and left directions in the drawing.

The lower table 21 has a the pedestal 21a penetrating through the opening R2A in the lower portion of the vacuum assembling chamber R2, and is supported by XY θ stage 23 in the pedestal 21a. The XY θ stage 23 comprises the XY stage 23a and θ stage 23b.

The XY stage 23a supports the lower table 21 movably in the X- and Y-axis directions by means of cross linear guides in two upper and lower steps crossing in the X- and Y-axis directions.

Namely, 25 denotes a cross linear guide which moves

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a drive block 24 by means of a drive motor 26 and drive motor (not illustrated) in the X-axis direction as right/left direction in the drawing, and in the Y-axis direction as the front/back direction in the drawing, with
5 respect to the vacuum assembling chamber R2. Numeral 27 indicates a linear guide which ensures that the drive block 24 is pushed and moved in the X-axis direction by means of a drive motor 26, even when the drive block 24 moves in the Y-axis direction.

10 The θ stage 23b is located inside the XY stage 23a, and can be rotated with respect to the XY stage 23a through a rotary bearing 28 and vacuum seal 29 by means of a drive motor 30. Furthermore, the θ stage 23b is fixed with the lower table 21 which loads the substrate on the θ stage
15 23b. When a drive motor 30 has started, the lower table 21 rotates with respect to the XY stage 23a and vacuum assembling chamber R2 through the rotary bearing 28 and vacuum seal 29.

Numeral 31 is a bellows (elastic body) between the vacuum
20 assembling chamber R2 and drive block 24 in the opening R2A, and maintains airtightness in vacuum assembling chamber R2 with respect to atmosphere, even if the drive block 24 is moved by the cross linear guide in each of the X- and Y-axis directions to move the lower table 21.

25 Incidentally, the vacuum seal 29 maintains airtightness

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in vacuum assembling chamber R2 for rotation of the pedestal 21a.

Numeral 32 denotes a substrate elevation pin built in the lower table 21. The lower end of the pin contacts the upper end of the drive shaft of the pneumatic cylinder 33 located on the lower portion of the vacuum assembling chamber R2. Therefore, even if the lower table 21 moves in each of the X- and Y-axis directions (front/back and right/left), the pin 32 only slides in the horizontal direction on the pin receiver on the top end of the drive shaft of the pneumatic cylinder 33. For the reason of feed jig configuration to be discussed below, there are a total of three pins 32; one at the center of the left end of the lower table 21, and one on each of both sides across the width vertical to rightward feed direction.

Numeral 35 indicates a frame located on the external top portion of the vacuum assembling chamber R2. A servo motor 36 with its rotary shaft extending downward is fixed on the frame 35. The rotary shaft of the servo motor 36 is engaged with the nut 39 fixed to the arm 39 of the shaft 37 penetrating through the vacuum assembling chamber R2. Numeral 40 indicates a guide ensuring the airtightness between said shaft 37 and vacuum assembling chamber R2. The upper table 42 is fixed on the lower end of the shaft 37 through a pressure board 41 so that it is located in

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face-to-face relation to the lower table 21. The upper table 42 is moved in the vertical direction by the operation of the servo motor 36 through the shaft 37.

As will be discussed below, to fix a substrate on each of the tables 21 and 42 and to perform positioning, a sight glass 43 is provided hermetically on the opening penetrating through the vacuum assembling chamber R2. An image recognition camera 44 is located on the frame 35 over this sight glass 43. An opening is also provided on the upper table 42 immediate below the sight glass 43 to read out the positioning marks between the upper substrate fixed on the lower surface of the upper table 42 and the lower substrate fixed on the upper surface of the lower table 21.

Each of the tables 21 and 42 is provided with an electrostatic suction electrode to ensure that the substrate is sucked by static electricity. In the following description, both of the tables 21 and 42 may be called suction table.

The lower table 21 is elastically supported by the bellows 31 hermetically for the following reason: When the vacuum assembling chamber R2 is made vacuum, atmospheric pressure is applied in such a direction as to push up the pedestal 21a, where the outer diameter of the bellows 31 acts a pressure receiving surface. The difference between

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this atmospheric pressure and gravity of pedestal 21a or the like is received by the cross linear guide 25 and rotary bearing 28 so that the bellows will not be loaded. If this atmospheric pressure is assumed as approximately equal to
5 the gravity of pedestal 21a or the like, there is no need of worrying about the atmospheric pressure acting on the lower table (suction table) 21 and bellows 31 during the movement of the lower table (suction table) 21 in each of X- and Y-axis directions in the step of positioning the
10 substrates. This ensures smooth positioning of substrates.

The drive system of the lower table (suction table) 21 is present on the side of atmosphere. This makes it possible to restrict the dimensions of the vacuum assembling
15 chamber R2 to the narrow space enough to incorporate each of the suction tables 21 and 42 required for assembling of the upper and lower substrates. This permits high speed evacuation of the interior.

The space between the vacuum assembling chamber R2 and
20 atmosphere release chamber R3 can be vacuum-separated by a gate valve 4.

Fig. 4 shows the internal structure of the atmosphere release chamber R3.

Numeral 51 denotes the feed (or transfer) roller to
25 feed the cells assembled in the vacuum assembling chamber

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R2 on the flat suction table 52 by forward and reverse rotation. The flat suction table 52 has a suction hole for vacuum suction of the substrate. The structure is so designed that the vacuum suction chamber 53 installed inside
5 the atmosphere release chamber R3 movably in the vertical direction is raised, and the flat suction table 52 is loaded and made integral with it. Then evacuation is performed through the tube 54 when the atmosphere release chamber R3 is opened to the atmosphere. Thus, the cell is vacuum
10 sucked onto the flat suction table 52 through the vacuum suction chamber 53.

Numeral 8 denotes a gate valve provided on the lower portion of the atmosphere release chamber R3, and is connected to the vacuum pump 55. The atmosphere release
15 chamber R3 can be released to the atmosphere by the atmosphere release valve 9.

An elevation pin 56 is mounted on the lower part of the vacuum suction chamber 53. Said pin raises the cell on the flat suction table 52 by penetrating through the
20 flat suction table 52 and vacuum suction chamber 53. Numeral 57 denotes a pneumatic cylinder to actuate the elevation pin 56. There are four elevation pins 56 and pneumatic cylinders 57 on the right, left, front and back, and support the cell at four corners.

25 A gate valve 5 is located at the outlet of the atmosphere

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release chamber R3. When the valve is opened, pressure is applied by atmospheric pressure, the cell subjected to this assembling process is fed out by a robot hand or the like.

5 The following describes the step of aligning the substrates and producing a cell in this apparatus 1. The description starts from the time when the substrate is carried into the load lock chamber R1.

10 In Fig. 5, 14 denotes a feed jig having an external view of a U-shape formed by removing one short side from a frame, and is used to mount substrates B1 and B2 to be bonded onto the bar and protrusion of the lower and upper portions of the inner wall, where a certain space is kept in the vertical direction. In the substrate (lower substrate) B1 on the lower side, the sealing material 15 is coated to on the peripheral area of the upper surface in a box form, and liquid crystal 16 is dripped at several positions within the box. The upper substrate (upper substrate) B2 is placed is mounted on this substrate B1 by the protrusion on the inner wall of the feed jig 14 at 15 a specified distance from the upper surface of the lower substrate B1.

20 The gate valve 2 is opened with the gate valve 3 closed, and the upper and lower substrates B1 and B2 installed on the feed jig 14 is fed into the load lock chamber R1 by the feed roller 11. After that, the gate valve 2 is closed.

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Then the gate valve 6 is opened, and the vacuum pump 12 is used to evacuate the load lock chamber R1 at a high speed.

When the degree of vacuum of the load lock chamber R1 has reached approximately the same value as that of the vacuum assembling chamber R2, the gate valve 3 is opened, and the feed jig 14 is fed into the vacuum assembling chamber R2 by forward rotation of the feed roller 11 of the load lock chamber R1 and the feed roller 22 of the vacuum assembling chamber R2. The vacuum assembling chamber R2 is evacuated in advance by a vacuum pump (not illustrated).

With reference to Fig. 6, the following describes how the substrates B1 and B2 on the feed jig 14 are loaded onto the upper and lower suction tables 21 and 42 in the vacuum assembling chamber R.

After the feed jig 14 has moved into the vacuum assembling chamber R2, the servo motor 36 is operated. The upper suction table 42 is led by the guide 40 through the shaft 37 and is lowered together with the pressure board 41, thereby approaching the upper substrate B2. Under this condition, voltage is applied to the electrostatic suction electrode built in the upper suction table 42, and the upper substrate B2 is electrostatically sucked onto the lower surface of the upper suction table 42. Then the pressure board 41 is raised, and the upper substrate B2 is lifted from the feed jig 14. Furthermore, the pin 32 is raised by a pneumatic

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cylinder 33, allowing the lower substrate B1 to be lifted from the feed jig 14 as well. At this time, both substrates B1 and B2 are still away from each other.

Under this condition, both the feed rollers 11 and 22
5 are rotated in the reverse direction to feed the feed jig 14 back to the load lock chamber R1 and to close the gate valve 3. Then the pin 32 is lowered and voltage is applied to the electrostatic suction electrode built in the lower suction table (lower table) 21. Then the lower substrate
10 B1 is electrostatically sucked onto the lower suction table 21.

Then the upper suction table 42 is lowered on the side of the lower suction table 21, so that the upper substrate B2 comes close to the lower substrate B1.

15 In this state, the positioning marks located on the substrates B1 and B2 are read out by means of an image recognition camera 44 through the sight glass 43 located on the upper portion of the vacuum assembling chamber R2, and positions are measured by image processing. Then
20 high-precision positioning (positioning of substrates B1 and B2) is achieved by fine movement of each of the stages 23a and 23b on XYθ stage 23.

In said fine movement, the bellows 31 maintains the vacuum inside the vacuum assembling chamber (vacuum
25 chamber) R2 for the movement in the X- and Y-axis directions,

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and the vacuum seal 29 maintains it for movement in the θ direction (rotary movement).

After positioning, the pressure board 41 is lowered until the lower surface of the upper substrate B2 contacts the sealing material 15 and liquid crystal 16 of the lower substrate B1. Pressure is applied to both substrates B1 and B2. In this lowering process, positioning marks are read out and the position is measured by image processing, thereby avoiding possible misregistration of the upper and lower substrates.

When the upper substrate B2 contacts the sealing material 15, the liquid crystal 16 is surrounded by both substrates B1 and B2 and sealing material 15.

When pressure is applied to the upper and lower substrates B1 and B2, an ultraviolet light source (not illustrated) is used to apply the ultraviolet ray to the UV adhesive (sealing material) 15 coated in advance between the upper and lower substrates B1 and B2, through the sight glass (not illustrated) of the vacuum assembling chamber R2 and through the penetration hole on each of the pressure board 41 and the upper suction table 42. Thus, both substrates B1 and B2 are fixed temporarily. Until this temporary fixing is performed, both substrates B1 and B2 are sucked in parallel onto the upper and lower suction tables, respectively. This makes it possible to achieve

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high precision positioning. Furthermore, with the substrates B1 and B2 kept in parallel, the distance between them can be reduced. Therefore, the spacer which keeps the distance between both scattered substrates B1 and B2
5 constant can be kept unchanged at the present position.

Then the voltage applied to electrode for electrostatic suction built in the lower suction table 21 is cut off, and the pressure board 41 is raised while the pin 32 is moved upward. Voltage is applied to the electrode for
10 electrostatic suction built in the upper suction table 42. The upper and lower substrates B1 and B2 made integral by temporary fixing are electrostatically sucked on the lower surface of the upper suction table 42. After that, the pin 32 is lowered. The gate valve 4 is opened which is located
15 between the vacuum assembling chamber R2 and the atmosphere release chamber R3 with the degree of vacuum set at the same value in advance. The flat suction table 52 is fed into the vacuum assembling chamber R2 by reverse rotation of the feed roller 22 of the vacuum assembling chamber R2
20 and the feed roller 51 of the atmosphere release chamber R3.

Fig. 7 shows that the flat suction table 52 has moved under the upper suction table 42 of the vacuum assembling chamber R2.

25 Then the upper suction table 42 together with the

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pressure board 41 are lowered onto the flat suction table 52 to turn off the voltage applied to the electrode for electrostatic suction built in the upper suction table 42. Thus, the substrates B1 and B2 made integral with each other
5 by temporary fixing is transferred onto the flat suction table 52.

After that, the flat suction table 52 is fed into the atmosphere release chamber R3 by forward rotation of the feed roller 22 of the vacuum assembling chamber R2 and the
10 feed roller 51 of the atmosphere release chamber R3. Then the gate valve 4 is closed.

After the flat suction table 52 is fed into the atmosphere release chamber R3, the vacuum suction chamber 53 is raised by the raising shaft 58 (see Fig. 4), and is made to contact
15 the lower surface of the flat suction table 52 on the feed roller 51. The vacuum suction chamber 53 is evacuated through the tube 54.

Under this condition, the gate valve 8 is closed, and the atmosphere release valve 9 is opened. When the
20 atmosphere release chamber R3 is released to atmosphere, atmosphere is applied to the temporarily fixed substrates B1 and B2 being vacuum-sucked onto the flat suction table 52. In this case, the flat suction table 52 maintains the flatness of the substrates B1 and B2 fixed temporarily.

25 After atmospheric pressure has been applied, evacuation

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by the tube 54 of the vacuum suction chamber 53 is suspended,
and release to the atmosphere takes place. The pin 56 is
raised, and the gate valve 5 is opened to insert a robot
hand (not illustrated). After the bonded cell to which
5 atmospheric pressure is applied is transferred onto the
robot hand, it is taken out.

When the gate valves 3 and 4 are opened, and the vacuum
assembling chamber R2 and the load lock chamber R1 or
atmosphere release chamber R3 are to be connected, each
10 of the chamber R1 and R3 is kept vacuum, so there is no
need of evacuating the vacuum assembling chamber R2.
Atmospheric pressure is not applied to the vacuum assembling
chamber R2 to cause its deformation. Thus, this ensures
high precision assembling of substrates B1 and B2 in a short
15 time.

Then the substrates assembled with the flat suction
table 52 are fed out to the atmosphere release chamber R3.
When the gate valve 4 is closed, the gate valve 3 opens,
and the substrates B1 and B2 installed on the feed jig 14
20 are fed from the load lock chamber R1 into the vacuum
assembling chamber R2. Since these operations can be
performed in parallel, productivity is further increased.

The present invention is not restricted to said
embodiment. The following embodiments are also possible:

25 1. The vacuum assembling chamber is not provided with

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a load lock chamber or atmosphere release chamber. Each substrate and assembled cell are fed in and out by the robot hand or the like. Since the load lock chamber and atmosphere release chamber are not connected with each other, waiting
5 time is required for evacuation of the vacuum assembling chamber vacuum. Despite that, the volume of the vacuum assembling chamber is smaller since the vacuum assembling chamber does not contain any drive system of the table. So evacuation does not take time.

10 2. Instead of the bellows 31, an elastic body to be used is a bellows type or folding or telescopic type lantern shaped member where the outer and inner edges of multiple annular dish formed metallic plates are hermetically connected with each other alternately such as a Chinese
15 lantern. Furthermore, it is also possible to separate functions of hermeticity and elasticity of the bellows, and to use a concentric dual structure consisting of a cylindrical elastic body with greater emphasis placed on hermeticity and a screw spring with greater emphasis placed
20 on elasticity.

3. The lower table in Fig. 3 is fixed in the X- and Y-axis direction, and the upper table is movable in each of X-, Y- and θ -axis directions by the elastic body and linear guide, vacuum seal and rotary bearing. In this case,
25 the weight of the upper table is transmitted to the vacuum

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assembling chamber through the linear guide, and almost no load is applied to the elastic body.

4. Vacuum suction (suction) is also used for assembling of the substrates on the lower and upper tables in Fig.

5 3. A drop preventive claw is provided so that it can be retreated without disturbing pressure applied to substrates. Said claw is intended to prevent the substrate from dropping due to extinction of substrate suction force on the upper table and to keep the substrates a little below the upper
10 table before electrostatic suction is applied, when the vacuum assembling chamber is in the vacuum state.

5. An elevating means of the lower suction table 21 is incorporated in the pedestal 21a, and the lower suction table 21 is raised to the side of the upper suction table
15 42. Substrates B1 and B2 are temporarily fixed.

The following describes another embodiment of the present invention with reference to drawings:

In Fig. 8, 100 denotes a substrate assembling apparatus according to the present invention. A upper table 103 to
20 hold the substrate and a lower table (one of the tables) 104 are provided inside the vacuum chamber 102 equivalent to vacuum assembling chamber R2 shown in Fig. 1. Only one vacuum chamber is provided in the present embodiment, so it is directly called a "vacuum chamber".

25 A vacuum chamber 102 has a gate valve 105 to feed in

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and out the substrates and an exhaust valve 106 for connection to the vacuum pump (not illustrated). Furthermore, the vacuum chamber 102 incorporates a holding claw 107 to hold the substrate and a holding mechanism 108 to move said holding
5 claw 107 in the vertical direction (Z-axis direction) and front/back direction (Y-axis direction) of the drawing.

A pair of said holding claw 107 and said holding mechanism 108 are located in the front/back Y-axis direction of the drawing. The edge portions on both sides of the substrate
10 are held to ensure that the substrate can be held horizontal in the direction horizontally crossing the direction of the substrate to be fed in and out in the X-axis direction (right/left) when the gate valve 105 opens.

The upper table 103 is mounted on the Z-axis traveling
15 base 110 through the shaft (the second shaft) 109 penetrating the opening 102a of the vacuum chamber 102. The Z-axis traveling base 110 is moved in the Z-axis direction by the linear guide 111, motor (a drive means in the vertical direction) 112 and ball screw 113. This raises the upper
20 table 103. Furthermore, the vacuum bellows (bellows type elastic body) 114 is provided between the margin of the opening 102a and shaft 109 to surround the shaft 109. Hermeticity is maintained to allow the upper table 103 to rise and fall even when the vacuum chamber 102 is kept vacuum.

25 The lower table 104 is connected to a traveling table

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(a drive means in the horizontal direction) T1 outside the vacuum chamber 102 by the multiple shafts 115 individually penetrating the openings 102b of the vacuum chamber 102. It can be moved in the horizontal surface (movable in X- and Y-axis directions parallel to the surface of the substrate to be bonded, and in the rotary direction inside the surface) by the traveling table T1.

The traveling table T1 comprises XY θ stages. Namely, the X stage 116 is designed to move the Y stage 118 in the X-axis direction (right/left) in the drawing by means of the drive motor 117. The Y stage 118 is located on the X stage 116, and is designed to move θ stage 120 in the Y-axis direction by means of a drive motor 119. The θ stage 120 is located on the Y stage 118 and is designed to rotate the combined body 115A of the each shaft 115 in the horizontal direction with respect to the θ stage 120 through the rotary bearing 121 by means of the drive motor 122. The each shaft 115 to support the lower table 104 is fixed on the combined body 115A.

A vacuum seal S1 is provided between the margin of the each opening 102b and each shaft 115 to surround the each shaft 115. Sealing is provided to ensure that vacuum can be maintained in the vacuum chamber 102 even if the each shaft 115 moves on the traveling table T1.

In other words, said vacuum seal S1 comprises vacuum

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bellows (bellows type elastic body) 123, magnetic seal 124, cross roller guide (slide member) 125 and support base 126.

The magnetic seal 124 is composed of bearings 124a and 124b, magnetic body sealing portion 124c, housing 124d.

5 The vacuum bellows 123 has its top end fixed to the lower surface of the margin of the each opening 102b in the vacuum chamber 102, and has the lower end fixed to the top end of the housing 124d. The lower end of the housing 124d is fixed to the plate 125a on the cross roller guide 125.

10 The lower portion of the cross roller guide 125 is fixed to the support base 126 fixed to the vacuum chamber 102.

Each shaft 115 penetrates the openings (not illustrated) having a great diameter provided on the upper plate 125a of the cross roller guide 125 and support base 126. When each shaft 115 moves in conformity to the movement of the traveling table T1, it moves together in the horizontal direction since the lower end of the vacuum bellows 123 is connected in the direction where the cross roller guide 125 can be moved. When the traveling table T1 makes a θ movement (rotary movement), a magnetic body seal 124c absorbs rotational component of each shaft 115.

20 A window 127 used to measure the substrate positioning mark through the hole (not illustrated) provided on the upper table 103 is provided on the upper portion of the vacuum chamber 102. An optical system C1 for mark

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observation is installed on it.

Said optical system C1 for mark observation are provided in multiple numbers to allow observation of the positioning mark provided on the substrate at two or four diagonal positions. Said C1 comprises an image recognition camera 128 and XYZ stages 129. In XYZ stages 129, an electric motor is installed for each axis so that image recognition camera 128 can be moved in each axial direction.

Furthermore, each of the tables 103 and 104 has an electrode for electrostatic suction and suction hole for vacuum suction, and is designed to ensure that substrates can be held by static electricity or vacuum suction.

With reference to Fig. 9 and thereafter, the following describes how upper and lower substrates are held and assembled on tables 103 and 104.

The sealing material is coated on one of the upper and lower substrates to a specified height and specified coated cross section in a solid square form with a single stroke of a brush in order to enclose and seal the liquid crystal in a specified frame when the upper and lower substrates are bonded. Also, the upper substrate held on the upper table 103 is reversed in advance so that the film surface is located on the lower position. A certain amount of liquid crystal is dripped on the lower substrate held on the lower table 104 in order to get the optimum gap when bonded.

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In Fig. 9, the sealing material is coated in a solid square form on the substrate feeding robot hand 130 installed outside the substrate assembling apparatus 100, and the lower substrate B2 where liquid crystal is dripped is fixed inside the solid square form by suction. The gate valve 105 of the vacuum chamber 102 is released, and the robot hand 130 is inserted through this opening 102c. Then suction of the lower substrate B2 is released. In the holding mechanism 108, the holding claw 107 is fed forward in the direction (Y-axis direction) of the lower substrate B2, and is then raised (moved in the Z-axis direction). Through this step, the lower substrate is received and transferred on the holding claw 107. After transfer, the robot causes the hand 130 to retreat. After this hand 130 has retreated, the holding mechanism 108 is lowered to transfer the lower substrate B2 onto the lower table 104. The lower substrate B2 is vacuum sucked by the lower table 104.

Here the lower table 104 has a groove where the holding claw 107 is placed. The holding claw 107 is put inside this groove. As it is lowered below the upper surface (substrate holding surface) of the lower table 104, the substrate B2 is transferred onto the lower table 104.

Fig. 10 shows that the holding claw 107 is lowered by the holding mechanism 108 and the lower substrate B2 is transferred onto the lower table 104 from the holding claw

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107.

After the lower substrate B2 has been vacuum sucked the lower table 104, the holding mechanism 108 causes the holding claw 107 to retreat from the lower substrate B2 and to rise. Then it pushes forward the holding claw 107 again so that the upper substrate B1 can be transferred.

Then the reversed upper substrate B1 is fixed by suction on the robot hand 130, and the robot hand 130 is inserted through the opening 102c of the vacuum chamber 102. Then suction of the upper substrate B1 is released, and the holding claw 107 is raised by the holding mechanism 108. This allows the upper substrate B1 to be transferred onto the holding claw 107. After transfer, the holding mechanism 108 raise the upper substrate B1 on the holding claw 107 so that the upper substrate B1 vacuum sucked onto the upper table 103. After the upper table 103 has vacuum sucked the upper substrate B1, the holding claw 107 is kept at the current position.

Then the robot hand 130 is retreated. After retreat of this hand, the gate valve 105 is closed to switch the exhaust valve 106, and the vacuum chamber 102 is evacuated by a vacuum pump (not illustrated).

When the desired vacuum preset pressure has been reached inside the vacuum chamber 102 by evacuation, holding of the upper substrate B1 by the upper table 103 is switched

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over to electrostatic suction by electrostatic chuck.
Furthermore, the lower substrate B2 is sucked and fixed
in position by the electrostatic chuck of the lower table
104.

5 Incidentally, the following step is also possible:
When the holding claw 107 is raised, the substrate is held
by the holding claw 107, without being vacuum sucked by
the upper table 103. When a desired vacuum pressure has
been reached, the upper substrate B1 is directly is held
10 by electrostatic suction.

After the upper substrate B1 is held by the upper table
103, the holding claw 107 is retreated by the holding
mechanism 108.

After this retreat, Z-axis traveling base 110 is lowered
15 by the motor 112 as shown in Fig. 11. Through this step,
the upper substrate B1 is made to come close to the lower
substrate B2. When the upper and lower substrates are close
to each other, the positioning mark of the upper substrate
B1 is observed by the image recognition camera 128 of the
20 optical system C1 for observation. XYZ stages 129 are
controlled to adjust the position so that the central axis
of the camera 128 is matched to the positioning mark of
the upper substrate B1.

Then the positioning mark of the lower substrate B2
25 is observed under this condition to measure the deviation

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of positioning marks between the upper substrate B1 and lower substrate B2. Based on this deviation, the traveling table T1 is driven to ensure that the mark positions of the upper and lower substrates B1 and B2 agree with each other.

Fig. 12 is a schematic representation of the behavior of the each shaft 115, vacuum bellows 123 and cross roller guide 125 when the upper and lower substrates B1 and B2 are positioned by the traveling table T1.

Fig. 12 shows that the combined body 115A of the each shaft 115 moved by the traveling table T1 has moved in conformity to rotation with respect to the support base 126 integral with the vacuum chamber 102.

In Fig. 12, P denotes the central position of the support base 126, and indicates the central position of the combined body 115A. To facilitate understanding, the combined body 115A is shown a little bigger than the support base 126, conversely to Fig. 8.

The Y-axis of the cross roller guide 125 is fixed on the side of the support base 126, so it has not moved. However, X axis is moved by the movement of the combined body 115A through the movement of the each shaft 115 through the upper plate 125a of the cross roller guide 125. However, the lower end of the vacuum bellows 123 is fixed to the housing 124d of the magnetic seal 124 fixed on the X axis of the upper

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plate 125a, so the lower end of the vacuum bellows 123 travels in the XY direction without rotation. Since each shaft 115 is integral with the combined body 115A, rotation is performed as a whole. However, the individual deviation
5 in rotation between each shaft 115 and vacuum bellows 123 is sucked by the magnetic seal 124.

Therefore, the movement of each shaft 115 is absorbed by the magnetic seal 124 and cross roller guide 125, even if the lower table 104 is moved in each of the XYθ directions
10 by the traveling table T1 through the combined body 115A and each shaft 115 in order to position the upper and lower both substrates B1 and B2. Thus, a vacuum can be maintained without damaging the vacuum bellows 123.

Similarly to the embodiment in Fig. 1, the traveling
15 table T1 is located outside the vacuum chamber 12, so the vacuum chamber 102 can be small. The degree of vacuum inside the vacuum chamber 10 can be increased to a desired value at a high speed.

In positioning of the upper and lower both substrates
20 B1 and B2, what is moved by the traveling table T1 is only the portion from the combined body 115A of each shaft 115 to the lower table 104. The lower table 104 is supported by multiple shafts 115. There is no need of use a rigid one for improved stiffness. The lower table 104 can be a
25 light one. It is not bent by dead weight, or flatness is

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not lost. Since the lower table 104 is supported by multiple shafts 115, each shaft 115 itself need not be a rigid one. A slender shaft will be sufficient for the purpose. Each magnetic seal 124 can be a small one. Therefore, when a vacuum is produced inside the vacuum chamber 2, the external pressure applied to each magnetic seal 124 is also reduce.

As discussed above, the flatness of the lower table 104 is maintained according to the present apparatus. Hence, both substrates B1 and B2 are parallel. Moreover, the weight and external pressure have been reduced. This ensures high precision and high speed positioning using an image recognition camera 128.

In the illustrated configuration, external pressure applied to the magnetic seal 124 is applied in the direction of compressing the vacuum bellows 123, but is transmitted to the support base 12 through the cross roller guide 125 and is borne thereby. This reduces the load of the vacuum bellows 123.

The service life is not reduced at the bonded portion by welding or the like.

After positioning of the upper and lower both substrates B1 and B2, the upper table 103 is further lowering by the Z-axis traveling base 110. Through this step, substrates B1 and B2 are bonded, and a certain amount of sealing material is crushed between the substrates B1 and B2.

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As discussed above, both substrates B1 and B2 are parallel with each other. Hence, when the sealing material is crushed, there remains no uncrushed portion. Spacing is uniformly reduced, so if liquid crystal is pushed, a
5 small amount of liquid crystal spreads into the internal area surrounded by the sealing material in a solid square form.

Under this condition, to ensure that positioning of substrates B1 and B2 is not deviated, a light source (not
10 illustrated) is used to apply light to the photo-cured type temporary fixing adhesive as a misregistration preventive applied between the substrates in advance, thereby fixing the substrate in position.

After that, electrostatic suction of the upper table
15 103 and lower table 104 is cut off, and the upper table 103 is raised. After the exhaust valve 106 is closed, the interior of the vacuum chamber 102 is released to the atmosphere using an atmosphere release valve (not illustrated).

20 Atmospheric pressure is applied between substrates B1 and B2 by said step of release to the atmosphere. Further pressure is applied to the substrates, and liquid crystal spreads into surrounded by sealing material in a solid square form.

25 After release to atmosphere, the holding claw 107 is

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lowered by the holding mechanism 108 to the groove position of the lower table 104, and the holding claw 107 is moved forward. The holding claw 107 is raised, and temporarily fixed substrates B1 and B2 (cell) are transferred onto the
5 holding claw 107.

Then the gate valve 105 is opened and the robot hand 130 illustrated in Fig. 9 is used to take out the temporarily fixed substrates B1 and B2 on the holding claw 107 as one integral member (cell). It is transferred to a downstream
10 system to perform final fixing. Incidentally, final fixing can be completed in the vacuum chamber 102.

In said embodiment, the lower table 104 is supported by four shafts 115. The number of shafts 115 is not limited to four. A desired number of shafts may be used.
15 Furthermore, different numbers of the upper and lower shafts 109 and 115 may be used.

In addition, the substrate assembling apparatus discussed above is not limited to the production of the liquid crystal display panel. Application can also be found
20 in cases where bonding of the resist film to the substrate is performed inside the vacuum chamber, or assembling of print substrates is performed in the vacuum chamber.

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WHAT IS CLAIMED IS:

1. A substrate assembling apparatus wherein upper and lower substrates to be bonded are held face to face with each other and are positioned, and the distance between them is reduced so that the upper and lower substrates are bonded with each other under vacuum by an adhesive provided in at least one of said substrates;

said substrate assembling apparatus further characterized in that

a first table where any one of the two substrates can be removably fixed on the upper or lower surface thereof and a second table where the other of the two substrates can be removably fixed on the lower or upper surface thereof are provided in a vacuum chamber such that the upper and lower surfaces of the substrates are placed face to face with each other,

one of the first and second tables is coupled with a drive means which is disposed at the atmosphere side of the vacuum chamber and which permits the one table to move at least in the horizontal direction through a partitioning elastic body provided at the wall of the vacuum chamber which permits hermetical coupling of the one table with the drive means, and

one of the first and second tables is further coupled with another drive means for reducing the distance between the substances located face to face with each other.

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2. A substrate assembling apparatus according to Claim 1 further characterized in that said drive means of the one of tables moves the one of tables with respect to the vacuum chamber through a linear guide, and is provided with a bellows type elastic body between the vacuum chamber and linear guide, and a vacuum seal and bearing on the atmospheric side partitioned by said elastic body.

3. A substrate assembling apparatus according to Claim 1 further characterized in that the one of tables is a lower table in the vacuum chamber.

4. A substrate assembling apparatus according to Claim 1 further characterized in that the other of tables has a vertical drive means for reducing the distance between two substrates, while the one of tables has a drive means which is specialized in driving in the horizontal direction.

5. A substrate assembling apparatus according to Claim 1 further characterized in that a load lock chamber and atmosphere release chamber are provided on the front and rear of said vacuum chamber, and each chamber is partitioned with the other by a gate valve, and connection between chambers or with atmosphere is provided by opening of said gate valve, thereby permitting substrates to be transported.

6. A substrate assembling apparatus according to Claim

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1 further characterized in that said drive means located
on the atmosphere side outside said vacuum chamber to move
the one of tables at least in the horizontal direction with
respect to the vacuum chamber is linked to the one of tables
5 by means of multiple shafts each penetrating through
multiple openings which are provided separately from each
other in the vacuum chamber; and each opening of the vacuum
chamber has an elastic body which maintains a vacuum chamber
and each shaft hermetic.

10 7. A substrate assembling apparatus according to Claim
6 further characterized in that said elastic body is a bellows
type elastic body which encloses each shaft, fixes one end
to the margin of the each opening in said vacuum chamber,
and allows the other end freely slidable with the
15 circumference of each shaft through the magnetic seal.

8. A substrate assembling apparatus according to Claim
7 further characterized in that the other end of the of
the bellows type elastic body in said elastic body is linked
with said vacuum chamber through a slide member movable
20 in the direction parallel to the surfaces of substrates
to be bonded.

9. A substrate assembling apparatus according to Claim
6 further characterized in that said drive means for reducing
the distance between substances located face to face with
25 each other drives the other table,

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said drive means is linked to the other table by means of multiple second shafts each penetrating through multiple second openings which are provided separately from each other in the vacuum chamber and

5 each of said second openings has an elastic body which maintains said vacuum chamber and each second shaft hermetic.

10 10. A substrate assembling apparatus according to Claim 1 or 6 further characterized in that said first and second table has at least one of said vacuum suction means and electrostatic suction means, and each of one and the other substrates is removably fixed thereon.