

(Title) SPECIFICATION

(Title of the Invention) a base plate structure, a transfer system,
and method and apparatus for
assembling a head gimbal assembly

(Detailed Description of the Invention)

(0001)

(Industrial Field of the Invention)

The present invention relates to a method of assembling a head gimbal assembly (to be referred to as an HG assembly) that is comprised in a hard disk drive. More specifically, the invention relates to a method of assembling an HG assembly by using members in the series state.

(0002)

(Prior Art)

Figs. 25 through 29 are drawings to be used for explanation about the construction of an HG assembly to be assembled according to the present invention or a conventional method. Fig. 25 is a perspective view showing the appearance of an HG assembly 51 (a suspension section 59 to be described later) before a slider is attached thereto, and Fig. 26 is an exploded view showing the configuration.

(0003)

As clear from these drawings, the HG assembly 51 comprises a stacked layer structure of a base plate 52, a load beam 53, and a flexure 54. A flat surface 53a of the load beam 53 is joined to an opposed flat surface 52a of the base plate 52 by a method to be described later.

(0004)

In this case, positioning is accomplished such that an opening 53c of the load beam 53 is superimposed on an opening 52c of the base plate 52, a reference opening 53b of the load beam 53 is superimposed on a reference opening 52b of the base plate 52, and an edge 52d of the base plate 52 is aligned with an indicator line 201 along the longer sides of an oblong opening 53d formed in the load beam 53. The load beam 53 is made of an elastic stainless steel having a thickness of approximately 0.038 to 0.05 mm, so that it is made thin, light, and can be kept sufficiently stiff.

(0005)

Flanges 53e for strengthening the load beam are formed at the edges of a tapered portion 53m excluding an area near the oblong opening 53d. The tapered portion 53m extends longitudinally from the joined portion between the load beam 53 and the base plate 52. The portion where the oblong opening 53d is formed corresponds to a hinge portion 53f. The hinge portion maintains resilience even after it has been bent, as will be described later.

(0006)

A tapered oval-shaped guide opening 53g and a generally rectangular opening 53h are formed in the tapered portion 53m. A gimbal pivot 53i to be described later, that lifts upwards, is formed in the protruding portion that extends from the center of the hinge portion 53f side of the opening 53h to the center of the opening 53h, and a tab 53j is formed at the leading end of the tapered portion 53m through the medium of a warped support 53k.

(0007)

The flexure 54 is made of a stainless steel with desired elasticity and a thickness of approximately 20 μ m, for example, and part of the flexure is fixedly joined to the load beam 53. At this point, the reference opening 54b of the flexure 54 is superimposed on the reference opening 53b of the load beam 53, and the guide opening 54c of the flexure 54 is superimposed on the guide opening 53g of the load beam 53. The portion of the flexure 54 leading from an indicator line 202 is not joined so as to be movable.

(0008)

An extendable joint 54d is formed in the flexure 54. The joint is disposed in a position to be superimposed on the hinge portion 53f of the load beam 53 so as not to prevent the elastic action of the hinge portion 53f when the flexure is joined to the load beam 53. An arch-shaped opening 54e is formed in the unjoined portion of the flexure 54, and a flexure tongue 54f protruding toward the center of the opening 54e is formed in the center of the bottom close to the leading end of the flexure 54.

(0009)

An integral-type conducting lead 55 having four leads is also disposed on the flexure 54. In the integral-type conducting lead 55, four leads 55a to 55d (refer to Fig. 26) are provided so as not to touch to each other through a very thin insulating sheet 55e. One end of each of the leads is disposed on a connector portion 54a of the flexure 54. These lead ends are aligned so as to form a multi-connector 55f. The other ends of the leads are formed such that they can be respectively connected to the pads for four bonding pads 56a to 56d (shown in Fig. 29) formed in the slider 56.

(0010)

The hinge portion 53f of the load beam 53 of the HG assembly 51 excluding the slider 56, configured as described above, is bent by approximately 19 degrees, for example, as shown in the dot-dash line in Fig. 25. This bending occurs due to plastic deformation, so that this bending angle is naturally maintained. Herein, the parts that exclude the slider 56 from the HG assembly 51, shown in Fig. 25, will be referred to as a suspension section 59.

(0011)

In the slider 56, a magneto resistive read head to be referred to as an MR head 57 for reading data and an electromagnetic induction-type write head 58 are disposed in predetermined positions. Incidentally, the heads in Fig. 26 are just illustrated for reference, so that their positions in the drawing are not accurate ones. Each of the heads has two leads not shown, and leads are connected to the four bonding pads 56a to 56d shown in Fig. 29, respectively. The slider 56 is attached to the flexure tongue 54f of the flexure in Fig. 27 to be described later, with an adhesive.

(0012)

Next, the arrangement of a pair of flexure arms 54g and 54h formed on both sides of the opening 54e of the flexure 54, a pair of openings 54i and 54j formed in the vicinity of the leading end of the flexure 54, the gimbal pivot 53i formed in the load beam 53, and the slider 56 attached to the flexure tongue 54f will be described.

(0013)

Fig. 27 is a partially expanded view of the leading end of the HG assembly 51 before the slider 56 is attached, or the suspension section 59. Fig. 28 is a vertical sectional view of the portion indicated by an indicator line 203 in Fig. 27, as seen in the direction of arrow H. Fig. 29 is a perspective view of the leading end of the HG assembly 51 with the slider 56 attached to the flexure tongue 54f.

(0014)

As described before, the gimbal pivot 53i (shown in Fig. 28) is formed in the load beam 53. The flexure arms 54g and 54h of the flexure 54, which extend without being joined elastically support the flexure tongue 54f coupled thereto.

(0015)

The flexure tongue 54f is brought into contact with and supported by the gimbal pivot 53i due to joining of the flexure 54 to the load beam 53. The contact point is on an axis 200X in Fig. 27, corresponding to the center line of the flexure 54 in the longitudinal direction. An axis 200Y that passes through the contact point and is perpendicular to the axis 200X is also shown in Fig. 27. At this time of the contact, the flexure arms 54g and 54h are bent to some extent to press the flexure tongue 54f against the gimbal pivot 53i.

(0016)

The slider 56 is attached to the flexure tongue 54f such that its center is generally superimposed over the point where the flexure tongue 54f keeps in contact with the gimbal pivot 53i, as indicated by the broken line in Fig. 28. The slider 56 can be thereby rotated to some extent with respect to the axes 200X and 200Y, and can be tilted to a predetermined degree in all directions.

(0017)

The four leads 55a to 55d (in Fig. 27) are fixed to the flexure 54 up to a leading end 55g of the insulating sheet 55e. The four leads are also fixed to a platform 53n in the leading end of the flexure 54 through the insulating sheet 55e, on the opposite side of the flexure tongue 54f with the two openings 54i and 54j interposed therebetween.

(0018)

From the leading end 55g of the insulating sheet 55e to the platform 53n, the four leads 55a to 55d are bent along the flexure arms 54g and 54h in pairs to shape like cranks, being suspended in air without being brought into contact to each other.

(0019)

The other ends of the paired leads 55a to 55d are bent to extend from the platform 53n to the flexure tongue 54 through the two openings 54i and 54j, and then comprise the lead pads 55h to 55k for the bonding pads 56a to 56d (in Fig. 29), respectively. The bonding pads are formed in the slider 56 to be attached to the flexure tongue 54f.

(0020)

As shown in Fig. 28, although part of the lead pad 55i is supported by the platform 53n for the strengthening purpose, the lead pad 55i, for the most part, is suspended in air. Further, it is preferable to form the lead pad 55i to have approximately the same thermal capacity as the bonding pad 56b. Other lead pads are formed in the same manner.

(0021)

Further, as shown in Fig. 27, a pair of crank-shaped limiters 54m and 54n that extend downwards are formed on both sides of the flexure tongue 54f of the flexure 54. When the flexure 54 is joined to the load beam 53, the limiters 54m and 54n are disposed with their leading ends extended downwards through the opening 53h of the load beam 53, as shown in Fig. 28. With this arrangement, if the unjoined portion of the flexure 54 is displaced to be further separated from the load beam 53 by some action, the leading ends of the limiters 54m and 54n are brought into contact with an underside 53q of the load beam 53, thereby serving to prevent the flexure and the load beam from being separated more than necessary.

(0022)

When the HG assembly 51 configured as described above is assembled, trays or blocks are conventionally prepared as assembling jigs, and the base plate 52, load beam 53, and flexure 54 are positioned by using these assembling jigs to be stacked and then joined to one after another.

(0023)

In order to complete the manufacturing process of the suspension section 59, the hinge portion 53f of the suspension section 59 of the HG assembly 51 is bent in the direction of arrow F (in Fig. 25) by approximately 19 degrees, for example, before the slider 56 is attached.

(0024)

When the slider 56 is attached to the flexure tongue 54f of the suspension section 59 and then the bonding pads of the slider are electrically connected to the lead pads of leads, trays or blocks are also used as the assembling jigs for positioning or fixing each of the members.

(0025)

(Problems to be Solved by the Invention)

As described above, according to the conventional assembling method, when uncompleted HG assemblies are transferred for each of the manufacturing processes, the assembly should always be mounted on the assembly jig such as a tray or a block for transference. For this reason, it becomes necessary to prepare the assembling jigs that are at least numerically equal to the uncompleted HG assemblies remaining at the respective manufacturing processes. Thus, the space efficiency of workspace is reduced, and the workplace is put in disorder. In addition, manufacturing cost rises with the number of the assembling jigs required, and management of these assembling jigs is time-consuming and inconvenient.

(0026)

The process of attaching the slider and the process of connecting the slider to the leads are performed with the hinge portion of the HG assembly already bent. Accordingly, after these processes are finished, the bending state of the hinge portion might be changed and might not be kept in the desired state.

(0027)

It is accordingly an object of the present invention to provide a more efficient method of assembling an HG assembly that eliminates the need for assembling jigs such as trays or blocks during its manufacturing processes. Another object of the invention is to provide a method of assembling an HG assembly, which reduces variations in the bending state of the hinge portion, thereby enhancing yield.

(0028)

(Means of Solution to the Problems)

A method of assembling an HG assembly as set forth in claim 1 comprises the steps of:

stacking a base plate, a load beam, and a flexure to form a three-layered stacked series with at least the bottom layer being a base plate series, the base plate series comprising the base plates formed in a series manner;

joining at least predetermined portions of the load beam to the base plate, and the flexure to the load beam in said three-layered stacked series to make a suspension section, thereby forming a suspension series that comprises the suspension sections;

attaching a slider to said flexure in the suspension section of said suspension series to make a head gimbal assembly, thereby forming a HG assembly series that comprises the head gimbal assemblies;

electrically connecting terminals to leads, the terminals connecting to a head of said slider of said HG assembly series, the leads being disposed on said flexure and electrically connected outside said HG assembly; and

load-bending a hinge portion formed in said head gimbal assembly of said HG assembly series.

(0029)

The method of assembling an HG assembly as set forth in claim 2 further comprises a bending-load adjusting step of:

heating said hinge portion after performing said load-bending step in the HG assembly assembling method as set forth in claim 1, so as to adjust a bending load on said hinge portion at a predetermined bending angle to a predetermined value.

In the method of assembling an HG assembly as set forth in claim 3, said flexure is stacked on a two-layered stacked series including said base plate series and a load beam series that comprises said load beams formed in a series manner in the HG assembly method as set forth in claim 1, thereby forming said three-layered stacked series.

In the method of assembling an HG assembly as set forth in claim 4, when said flexure is stacked in the HG assembly assembling method as set forth in claim 3, leading ends of limiters formed in said flexure and projecting like cranks are passed through an opening formed in said load beam and then disposed on opposite sides of the opening.

(0030)

In the method of assembling an HG assembly as set forth in claim 5, said stacking-and-joining step in the HG assembly assembling method as set forth in claim 1 comprises performing said joining by spot-welding that employs laser radiation.

In the method of assembling an HG assembly as set forth in claim 6, an adhesive is applied to an attaching surface of said slider for temporary placement of said slider near a predetermined position of said flexure in the HG assembly assembling method as set forth in claim 1, and in said electrical connection step in the HG assembly assembling method as set forth in claim 1, said slider is accurately positioned in the predetermined position of said flexure.

In the method of assembling an HG assembly as set forth in claim 7, the head gimbal assembly of said HG assembly series is inclined with respect to a horizontal direction without undergoing plastic deformation, a solder ball is disposed to be in contact with a bonding pad in said slider and a lead pad formed at an edge of said lead, and then said solder ball is heated to be melted, thereby forming a solder joint therebetween to perform

the electrical connection in the electrical connection step in the HG assembly assembling method as set forth in claim 1.

In the method of assembling an HG assembly as set forth in claim 8, a bending angle not less than said predetermined bending angle is formed, a bending load when said predetermined bending angle has been recovered is sensed, and then a laser beam is irradiated to said hinge portion to make said adjustment in the HG assembly assembling method as set forth in claim 2.

(0031)

A head gimbal assembly assembling apparatus as set forth in claim 9 comprises:

stacking means for stacking a base plate, a load beam and a flexure to form a three-layered stacked series with at least the bottom layer being a base plate series, the base plate series comprising the base plates formed in a series manner;

first transfer means for transferring said three-layered stacked series intermittently in a state in which said base plate, said load beam, and said flexure mutually maintain predetermined positional relationships;

stacking-and-joining means for stacking and joining at least predetermined portions of said load beam to said base plate, and said flexure to said load beam to make a suspension section, thereby forming a suspension series while said three-layered stacked series transferred by said first transfer means is in a state of rest;

second transfer means for functioning on at least said base plate series of said suspension series to transfer said suspension series, in synchronization with said first transfer means;

slider attaching means for attaching a slider to said flexure of said suspension series that is at rest in a predetermined position after having been transferred by said second transfer means to form a head gimbal assembly, thereby forming an HG assembly series;

third transfer means for functioning on at least said base plate series of said HG assembly series to transfer said HG assembly series, in synchronization with said first transfer means; and

load-bending means for bending a hinge portion formed in said head gimbal assembly of said HG assembly series by a predetermined angle while said HG assembly series is at rest in a predetermined position after having been transferred by said third transfer means.

(0032)

In the HG assembly assembling apparatus as set forth in claim 10, the stacking means in the HG assembly assembling apparatus as set forth in claim 9 comprises:

a first transfer portion for intermittently transferring a two-layered stacked series formed by stacking a load beam series on said base plate series, the load beam series comprising said load beams formed in a series manner;

a second transfer portion for intermittently transferring a flexure series in synchronization with said first transfer portion, the flexure series comprising said flexures formed in a series manner;

a cutting device for separating from said flexure series a flexure piece in which the flexure and a flexure frame are integrally formed; and

a transferring device for placing said separated flexure piece on the load beam of said two-layered stacked series.

In the head gimbal assembly assembling apparatus as set forth in claim 11, said transferring device in the HG assembly assembling apparatus as set forth in claim 10 rotates a transferring arm having at an end thereof a sucking pad for sucking the frame of said flexure piece, and the sucking pad is made to be slightly displaceable in a direction of an axis of rotation such that leading ends of limiters formed in said flexure and projecting like cranks are passed through an opening formed in said load beam and then disposed on opposite sides of the opening.

In the head gimbal assembly assembling apparatus as set forth in claim 12, said base plate series in the HG assembly assembling apparatus as set forth in claim 10 comprises:

a first band portion having first conveying holes formed at a predetermined pitch in a longitudinal direction; and

a plurality of said base plates disposed via connecting portions integrally formed at edges on one side of said first band portion at a predetermined series pitch;

and said load beam series comprises:

a second band portion having second conveying holes formed at said predetermined pitch in the longitudinal direction; and

a plurality of said load beams disposed via connecting portions integrally formed at edges on one side of said second band portion at the predetermined series pitch.

In the head gimbal assembly assembling apparatus as set forth claim 13, said first transfer portion in the HG assembly assembling apparatus as set forth in claim 12 comprises:

first conveying pins for repeating a cyclic motion of being inserted into said first and second conveying holes at an insertion position in a conveying direction, integrally conveying said base plate series with said load beam series from said insertion position to a release position separated by said series pitch in the conveying direction, separating from said first and second conveying holes, and then returning to said insertion position; and

suppression pins to be inserted into said first and second conveying holes in synchronization with separation of said first conveying pins from said first and second conveying holes, for positioning said base plate series and said load beam series.

(0033)

In the head gimbal assembly assembling apparatus as set forth in claim 14, said first transfer means in the HG assembly assembling apparatus as set forth in claim 13 comprises:

- a third transfer portion having a same configuration as said first transfer portion;
- second conveying pins to be inserted into third conveying holes formed in said frame of said flexure piece, for integrally conveying said flexure piece with said load beam by a cyclic motion, in synchronization with said first conveying pins; and
- a placing portion having suction openings for sucking predetermined spots of said flexure piece in synchronization with separation of said second conveying pins from said third conveying holes.

In the head gimbal assembly assembling apparatus as set forth in claim 15, said slider attaching means in the HG assembly assembling apparatus as set forth in claim 9 comprises:

- a table unit for intermittently rotating a table through a $1/n$ of a turn in synchronization with said intermittent transference, the table including n slider-holding recesses for receiving and then holding the sliders, the slider-holding recesses being formed near edges of a top surface of the table in such positions that the table is divided into n equal parts, each of the slider-holding recesses having a through hole at the center thereof; and

- an adhesive applicator disposed below a predetermined rest position for said slider-holding recesses, for applying an adhesive to the slider held in said slider-holding recess through said through hole.

In the head gimbal assembly assembling apparatus as set forth in claim 16, said load-bending means in the HG assembly assembling apparatus as set forth in claim 9 comprises:

- a mandrel disposed in a position to face said hinge portion and having an edge rounded for guiding bending of said hinge portion; and

- a pressing roller for pressing said hinge portion along said rounded edge of said mandrel.

In the head gimbal assembly assembling apparatus as set forth in claim 17, said second and third transfer means in the HG assembly assembling apparatus as set forth in claim 13 have a same configuration as said first transfer portion.

(0034)

A transfer system for transferring a series of members as set forth in claim 18, the series of members having a band portion including conveying holes formed at a predetermined pitch in a longitudinal direction and a plurality of the members to be transferred, the members disposed via connecting portions integrally formed at edges of one side of the band portion at a predetermined series pitch, the transfer system comprises:

conveying pins for repeating a cyclic motion of being inserted into said conveying holes at an insertion position in a conveying direction, conveying said series of the members from said insertion position to a release position separated by said series pitch in the conveying direction, separating from said conveying holes, and then returning to said insertion position; and

suppression pins to be inserted into said conveying holes, for positioning said series of the members in synchronization with separation of said conveying pins from said conveying holes.

(0035)

The transfer system as set forth in claim 19, further comprises a placing portion having suction openings for sucking said series of the members in synchronization with insertion of said suppression pins into said conveying holes, in the transfer system as set forth in claim 18.

(0036)

A base plate structure as set forth in claim 20, having a plurality of base plates in a head gimbal assembly formed by a base plate, a load beam, and a flexure disposed one atop another,

wherein the base plate structure is made of a plate member stiffer than plate members for said load beam and said flexure, and

wherein the base plate structure comprises:

a band portion having conveying holes and positioning holes formed at a predetermined pitch respectively in a longitudinal direction; and

a plurality of said base plates disposed via connecting portions integrally formed at a predetermined pitch at edges on one side of the band portion.

(0037)

(Embodiments)

First Embodiment.

Fig. 1 is a schematic diagram of the overall configuration of a suspension-section assembling apparatus for assembling a suspension according to a first embodiment, in an HG assembly assembling apparatus of the present invention. First, the overall flow of the assembly processes will be outlined by referring to the schematic diagram of Fig. 1, and the details of the respective processes will be described thereafter.

(0038)

In Fig. 1, a suspension-section assembling apparatus 1 assembles the suspension section 59 (in Fig. 25) corresponding to the HG assembly 51 before the slider 58 (in Fig. 26) is attached thereto, and a transfer system 2 transfers in the direction of arrow A a base plate series 3 (in Fig. 2(a)) and a load beam series 4 (in Fig. 2(b)) that have been stacked

up. A bending device 5 bends the predetermined portions of the load beam 53 (in Fig. 26) by pressing.

(0039)

As shown in Fig. 2(a), the base plate series 3 is formed by processing a stainless steel sheet into a desired shape by punching or etching. The base plate series 3 comprises a band portion 3a and a plurality of the base plates 52. The base plates 52 are in the form of a series and are integrated into the band portion 3a via connecting portions 3d formed in the band portion 3a at a predetermined series pitch P1. The load beam series 4 shown in Fig. 2(b) is also formed in the similar manner. The load beam series 4 comprises a band portion 4a and a plurality of the load beams 53. The load beams 53 are in the form of a series and are integrated into the band portion 4a via connecting portions 4d formed in the band portion 4a at the predetermined series pitch P1.

(0040)

Conveying holes 3c serving as the first conveying holes and conveying holes 4c serving as the second conveying holes are formed in the band portion 3a serving as the first band portion and the band portion 4a serving as the second band portion, respectively. The conveying holes 3c and 4c are formed in the longitudinal direction at the series pitch P1.

(0041)

Herein, a configuration where a plurality of the same members are integrated into a band portion, via connecting portions formed in the band portion in the longitudinal direction at a predetermined pitch in this manner will be referred to as a series.

(0042)

A flexure series 7 to be described later is formed in the same manner, as shown in Fig. 7. The flexure series 7 comprises a first band portion 7a and a second band portion 7b disposed on both sides of the series, a plurality of the flexures 54 mutually adjacent to each other, frames 54p formed around the respective flexures 54. Herein, a single piece comprising the flexure 54 and the frame 54p joined together is referred to as a flexure piece 7c. The flexure 54 in Fig. 7 excludes the integral-type lead 55 (in Fig. 26) for quick and easy reference.

(0043)

A flexure transfer system 6 transfers the flexure series 7 (in Fig. 7) in the direction of arrow B perpendicular to the direction of arrow A. The flexure-bending device 8 bends the predetermined portions of the flexure 54 (in Fig. 26) by pressing. A cutting device 9 cuts the transferred flexure series 7 into the flexure pieces 7c, and a transferring device 11 places each of the flexure pieces 7c on the predetermined position of the load beam 53 of the load beam series 4 (in Fig. 2(b)) transferred to a limiter-loading region 12, as will be described later.

(0044)

A flexure-piece holding mechanism 13 transports the base plate series 52 and the load beam series 53 in a series state and the flexure pieces 7c as a single piece, stacked up in a three-layered state, to a predetermined position in a laser-welding device 14, in cooperation with the transfer system 2. The laser-welding device 14 spot-welds predetermined spots to be described later for joining, and then cuts off the frames 54p from the flexure pieces 7c to complete the suspension sections 59. In this stage, the suspension sections 59 remain in the series form.

(0045)

The operation of the suspension-section assembling apparatus 1 was outlined by referring to the schematic diagram of Fig. 1. Now, the detailed configuration and operation of each of the components of the apparatus will be described.

(0046)

Fig. 3 is a partial top view showing the configuration of the pertinent part of the transfer system 2. Fig. 4 is a partial front view showing the configuration of the pertinent part of the same transfer system 2, and Fig. 5 is a side view showing the configuration of the pertinent part of the same transfer system 2. The coordinate axes illustrated in the drawings according to this embodiment show the directions for common use. The directions of arrows A and B shown in Fig. 1 are set to coincide with the negative directions of the X-axis and the Y-axis, respectively.

(0047)

Figs. 3 through 5 show the outlines of the base plate series 3 and the load beam series 4 stacked on a base-plate placing surface 2b in a stacked-up state, by dotted lines. The base-plate placing surface 2b is the top surface of a base-plate placing portion 2a of the transfer system 2. In this embodiment, the base plate series 3 and the load beam series 4, parts of which are shown in Fig. 2, are set to have a predetermined longitudinal dimension as long as 12 base plates 52 or 12 load beams 53 aligned.

(0048)

Further, as shown in Fig. 2, the common series pitch $P1$ is used for formation of the base plate series 3 and the load beam series 4, and positioning holes 3b and 4b are formed to have the same diameter. It is arranged that, when the positioning holes 3b and 4b are superimposed so as to coincide with each other, the base plates 52 and the load beams 53 are aligned to each other, as shown in Fig. 2(c). It is further arranged that conveying holes 3c and 4c formed in the base plate series 3 and the load beam series 4, respectively, at the series pitch $P1$ are aligned in the direction perpendicular to the longitudinal direction, being separated from each other by a distance $L1$.

(0049)

Incidentally, herein, the base plate series 3 and the load beam series 4 stacked up in this way will be referred to as a two-layered stacked series 15. Further, herein, the state

where the positioning holes 3b and 4b are aligned as described above will be referred to as a desired stacked state.

(0050)

The transfer system 2 (in Figs. 3 through 5) comprises a conveying block 20 in a drive mechanism therein, not shown. As will be described later, the conveying block 20 holds a pair of conveying pins 20a as first conveying pins. In order to move the two-layered stacked series 15 in the negative direction of the x-axis, the conveying pins are inserted into the conveying holes 3c and 4c of the two-layered stacked series 15 from beneath the base-plate placing surface 2b and slide along predetermined paths in the X-axis and Z-axis directions. The transfer system 2 also comprises a pressing block 21 in the drive mechanism not shown. The pressing block 21 holds a pair of suppression pins 21a. The suppression pins are displaced along the z-axis, in synchronization with the conveying pins 20a, and then they are inserted into the conveying holes 3c and 4c to press down the two-layered stacked series 15. Further, receiving slots 2c for receiving the suppression pins 21a are formed in the base-plate placing portion 2a.

(0051)

Suction openings 2d are also formed in the base-plate placing portion 2a. When the two-layered stacked series 15 is in the rest position indicated by the dotted lines in Fig. 3(a) to be described later, the suction openings 2d suck the predetermined portions of the two-layered stacked series 15 with timing to be described later, so as to confine the movement of the two-layered stacked series 15.

(0052)

These conveying block 20, pressing blocks 21, and suction openings 2d are disposed in a plurality of positions in the conveying path of the transfer system 2 from the upstream of the bending device 5 to the laser-welding device 14 shown in Fig. 1, so as to intermittently and sequentially transport a plurality of the two-layered stacked series 15 in the direction of arrow A by the conveyance operation to be described later.

(0053)

Next, the transference operation of the transfer system 2 will be described by referring to operation diagrams of Fig. 6.

First, the two-layered stacked series 15 in which the load beam series 4 is superimposed on the base plate series 3, as shown in Fig. 2(c) is placed on the base-plate placing surface 2b of the transfer system 2 at the predetermined placing position in the upstream of the bending device 5 (in Fig. 1) by a worker or placement means not shown.

(0054)

Fig. 6(a) shows the two-layered stacked series 15 at rest in the transferring cycle of intermittently transferring the two-layered stacked series 15 placed on the transfer

system 2 in the direction of arrow A. In this case, the suppression pins 21a are inserted into the conveying holes 3c and 4c (in Fig. 2(c)) of the two-layered stacked series 15 to press the two-layered stacked series 15 against the base-plate placing surface 2b while keeping the two-layered stacked series 15 in the desired stacked state. Further, in this case, the suction openings 2d are brought into the state where air is drawn by suction means not shown, and sucks the opposed portions of the two-layered stacked series 15 to lock the series in place. The conveying pins 20a held in the conveying block 20, on the other hand, move downward, separating from the two-layered stacked series 15.

(0055)

Then, as shown Fig. 6(b), the conveying block 20 underneath the two-layered stacked series moves in the positive direction of the X-axis with the pressing state of the suppression pins 21a and the suction state of the suction openings 2d maintained. In this case, the conveying block 20 moves just by the series pitch P1 (in Fig. 2) of the two-layered stacked series 15, and stops at an insertion position Ps1 (in Fig. 3) where the conveying pins 20a are placed directly below the conveying holes 3c and 4c (Fig. 2(c)) of the two-layered stacked series 15.

(0056)

Next, as shown in Fig. 6(c), the conveying block 20 moves in the positive direction of the Z-axis, and the conveying pins 20a are inserted into the conveying holes 3c and 4c of the two-layered stacked series 15. Then, the conveying block 20 stops in the higher position in which the two-layered stacked series 15 is slightly lifted. In this case, the suction openings 2d cancel the suction state immediately before the conveying block 20 lifts the two-layered stacked series 15. The pressing blocks 21 then move in the positive direction of the Z-axis after the conveying pins 20a have reached the positions where they are inserted into the conveying holes 3c and 4c of the two-layered stacked series 15. Then, the pressing blocks 21 stop at retracted positions shown in Fig. 6(c) where the suppression pins 21a are separated from the two-layered stacked series 15. Switching from the suppression pins 21a to the conveying pins 20a, for being inserted into the conveying holes 3c and 4c, is thereby performed, without disturbing the desired stacked state of the two-layered stacked series 15.

(0057)

Next, as shown in Fig. 6(d), the conveying block 20 in the higher position where the two-layered stacked series 15 has been pressed up slightly, moves in the negative direction of the X-axis just by the series pitch P1 to reach a release position Ps2. Thus, the two-layered stacked series 15 is transferred in the same direction or in the direction of arrow A just by the series pitch P1 with this movement, and adjacent right-hand conveying holes 3c and 4c of the two-layered stacked series 15 move to the positions directly below the suppression pins 21a.

(0058)

Next, as shown in Fig. 6(e), the conveying block 20 moves in the negative direction of the Z-axis in this release position Ps2, to place the two-layered stacked series 15 again on the base-plate placing surface 2b. Then, the conveying block 20 further moves in the same direction to stop in the lower position described before. In this case, the suction openings 2d are brought into the suction state when the two-layered stacked series 15 is placed on the base-plate placing surface 2b, and the pressing blocks 21 move in the negative direction of the Z-axis. Then, while the conveying pins 20a are inserted into the conveying holes 3c and 4c of the two-layered stacked series 15, the suppression pins 21a are inserted into conveying holes 3c and 4c of the two-layered stacked series 15 immediately below the suppression pins 21a to press the two-layered stacked series 15 against the base-plate placing surface 2b again. The two-layered stacked series 15 is thereby brought into the state of rest shown in Fig. 6(a). Switching from the conveying pins 20a to the suppression pins 21a, for being inserted into the conveying holes 3c and 4c, can be thereby performed again without disturbing the desired stacked state of the two-layered stacked series 15.

(0059)

As described above, the transfer system 2 keeps on the cyclic operation of transferring the two-layered stacked series 15 in the direction of arrow A just by the series pitch P1 in one cycle, thereby transferring the two-layered stacked series 15 in the direction of arrow A intermittently and sequentially from one assembly station to another.

(0060)

While the two-layered stacked series 15 being transported sequentially by the cyclic transference operation of the transfer system 2 is in the state of rest in the cycle shown in Fig. 6(a), the bending device 5 (in Fig. 1) bends the predetermined portions of the load beam 53 transported to the processing position in the device. The flanges 53e (refer to Fig. 27), gimbal pivot 53i (refer to Fig. 28), and support 53k in the load beam 53 shown in Fig. 26 are bent at this time.

(0061)

On the other hand, the flexure transfer system 6 in Fig. 1 transfers the flexure series 7 shown in Fig. 7 in the direction of arrow B or the negative direction of the Y-axis. Since its transference manner is just the same as that of the transfer system 2, its detailed description will be omitted. Conveying holes 7d into which the pins not shown, corresponding to the conveying pins 20a and the suppression pins 21a (in Fig. 5) are inserted are formed in the first band portion 7a of the flexure series 7.

(0062)

The flexure series 7 comprises a plurality of the flexure pieces 7c formed adjacent to each other. In this embodiment, the longitudinal dimension of the flexure series 7 is set

to be as long as 32 flexure pieces 7c aligned. Further, as shown in Fig. 7, the flexure pieces 7c are formed into a series, being separated from each other by a series pitch P2, and the conveying holes 7d are also formed at the series pitch P2.

(0063)

The flexure transfer system 6 therefore keeps on the cyclic operation of transferring the flexure series 7 in the direction of arrow B just by the series pitch P2 in one cycle in the same manner as that with the transfer system 2 described before. The flexure series 7 is thereby transferred in the direction of arrow B sequentially.

(0064)

While the flexure series 7 being transported sequentially in the cyclic operation of the flexure transfer system 6 is in the state of rest of the cycle (corresponding to the state shown in Fig. 6(a)), the flexure-bending device 8 (in Fig. 1) bends the predetermined portions of the flexure 54 transported to the processing position in the device. The crank-shaped limiters 54m and 54n projected downward at the leading end of the flexure 54 and flexions 54s and 54t formed in the flexure arms 54g and 54h, respectively, shown in Fig. 8 are bent at this time.

(0065)

The flexure series 7 that has undergone bending is transported to the cutting device 9.

Fig. 9 is a drawing showing the configurations of the pertinent parts of the cutting device 9 and the transferring device 11 to be used in cooperation therewith. Fig. 9(a) shows a front view, while Fig. 9(b) shows a top view.

(0066)

The cutting device 9 comprises a punch 9a and a die 9b disposed to face the upper side and lower side of the flexure series 7, respectively, that has been transported by the flexure transfer system 6. Blanking performed by pressure welding of these tools cuts and separates from the first band portion 7a and the second band portion 7b the flexure piece 7c of the flexure series 7 (in Fig. 7) transported to the predetermined cutting position between these tools and then held at rest. A disposal device 10 (in Fig. 1) cuts through and disposes of the unwanted first band portion 7a and the second band portion 7b transported as band portions after the flexure piece 7c has been blanked.

(0067)

The transferring device 11 comprises a transferring arm 11b having a sucking pad 11c at its leading end and an arm-driving shaft 11a for rotating the transferring arm 11b in the directions of arrows C and D about the Z-axis and slightly displacing the sucking pad 11c in the directions of the Z-axis and the Y-axis.

(0068)

The stacking procedures to be performed by the combined use of stacking means comprising the transfer system 2 as the first transfer portion, flexure transfer system 6 as the second transfer portion, cutting device 9, and transferring device 11 will be described by referring to a flowchart in Fig. 15.

First, a flexure piece 7c is transported to the cutting position in the cutting device 9 by the cyclic transference operation of the flexure transfer system 6 in step 1. At this point, the punch 9a and the die 9b of the cutting device 9 are detached, as will be described later. Next, in step 2, the transferring arm 11b is rotated in the direction of arrow C to move the sucking pad 11c at its leading end to a sucking position indicated by the dotted line in Fig. 9(b) where the pad faces the frame 54p of the flexure piece 7c in the cutting position.

(0069)

Next, in step 3, the sucking pad 11c sucks the predetermined portion of the frame 54p of the flexure piece 7c to hold the flexure piece 7c. It is assumed that the sucking pad 11c has the shape that does not disturb the blanking operation of the cutting device 9 to be described later, though not shown.

(0070)

Next, in step 4, the flexure piece 7c held by suction of the sucking pad 11c is cut out from the first band portion 7a and the second band portion 7b through blanking performed by pressure welding between the punch 9a and the die 9b of the cutting device 9. Then, in step 5, the transferring arm 11b is rotated in the direction of arrow D to a loading position indicated by the solid line in Fig. 9(b) from the sucking position so as to transport the flexure piece 7c held by sucking to the limiter-loading region 12.

(0071)

As will be described later, an integration process is performed in step 6. In this process, the flexure piece 7c is stacked on the load beam 53 of the two-layered stacked series 15 (in Fig. 2(b)) that had been transferred by the transfer system 2 and then held at rest in the limiter-loading region 12. Then, as soon as this integration process has been performed, or in synchronization with this integration process, transference described in step 1 is performed, and operations from step 1 to step 6 are repeated.

(0072)

Next, the operation of the integration process in step 6 will be described.

Fig. 10 is a partially exploded perspective view showing the partial configurations of the transfer system 2, load beam 53, and flexure piece 7c in the vicinity of the limiter-loading region 12 where the integration process is performed. Fig. 11 is a side view showing the transfer system 2 and the flexure-conveying block 13c of the flexure-piece holding mechanism 13 (in Fig. 1) in the transference path from the limiter-loading region 12 to the laser-welding device 14.

(0073)

In the region of this transference path, a load-beam placing portion 2e is formed in the transfer system 2. Recessed areas 2f are formed in the load-beam placing portion 2e in the positions where the respective load beams 53 rest when the two-layered stacked series 15 is brought into the state of rest. The recessed area 2f accommodates the flanges 53e (refer to Fig. 27) and the support 53k of the load beam 53 that have been bent by the bending device 5. Long grooves 2g and 2h for receiving the leading ends of stepped pins 13a and 13b of the flexure-piece holding mechanism 13 (in Fig. 11) to be described later are formed in both sides of the load-beam placing portion 2e, along the X-axis.

(0074)

When the load beam 53 is in this rest position in the limiter-loading region 12, the load beam 53 is positioned such that a convex portion 2i formed in the recessed area 2f of the transfer system 2 comes into contact with a contact region 53p (in Fig. 10) indicated by the dotted line, so that the flanges 53e (refer to Fig. 27) and the support 53k of the load beam 53 are accommodated in the recessed area 2f. The contact region is located in the vicinity of the opposite side of the gimbal pivot 53i of the load beam 53 remote from the opening 53h.

(0075)

On the other hand, the transferring arm 11b holding the flexure piece 7c transports the flexure piece 7c to the limiter-loading region 12. At this point, a pair of the limiters 54m and 54n formed in the flexure 54 are set to be positioned over the opening 53h of the load beam 53. Then, the transferring arm 11b slightly displaces the flexure piece 7c in the negative directions of the Z-axis and the Y-axis as indicated by arrow E in Fig. 10. The leading ends of a pair of the limiters 54m and 54n are thereby moved to the predetermined positions where they can come into contact with the underside 53q of the load beam 53 (refer to Fig. 28) after having being passed through the opening 53h of the load beam 53.

(0076)

At this point, four suction portions 54u indicated by dotted lines in the frame 54p of the flexure piece 7c in Fig. 10 face respective four suction openings 2j formed in the load-beam placing portion 2e to be suctioned, so that the flexure piece 7c is positioned on the load beam 53. At this stage, the flexure piece 7c is set free from the sucking pad 11c of the transferring arm 11b, so that the integration process in step 6 is completed.

(0077)

Next, the configuration of transferring the two-layered stacked series 15 and the flexure pieces 7c from the limiter-loading region 12 to the laser-welding device 14 (in Fig. 1) in a three-layered stacked state, as shown in Fig. 12 will be described. The

two-layered stacked series 15 is in the desired stacked state, while the flexure pieces 7c are placed and positioned on the respective load beams 53 of the load beam series 4. Herein, the three-layered stacked series that comprises the two-layered stacked series 15 and the flexure pieces 7c will be referred to as a three-layered stacked series 16.

(0078)

As described before, Fig. 11 is a side view of the transfer system 2 and the flexure-conveying block 13c in the stacked-layer-series transference region. In this region as well, the two-layered stacked series 15 is transferred by the cyclic transference operation described before and performed by the combined use of the conveying block 20 and the pressing block 21 that comprise a third transfer portion. On the other hand, the stepped pins 13a and 13b as the third conveyance pins of the flexure-piece holding mechanism 13 are disposed in the positions capable of being inserted into conveying holes 7e and 7f (in Figs. 7 and 12), respectively. The conveying holes 7e and 7f are formed in the frames 54p of the flexure pieces 7c and serve as the third conveying holes. The number of the stepped pins 13a and 13b is made to be equal to the number of all the flexure pieces 7c in this stacked-layer-series transference region.

(0079)

First, the flexure-conveying block 13c moves in the negative direction of the Z-axis so as to insert the stepped pins 13a and 13b into the conveying holes 7e and 7f of the flexure piece 7c that is at rest with the two-layered stacked series 15 after the integration process in step 6 is completed. The side view of Fig. 11 shows the state in which the flexure-conveying block 13c has completed this movement, and the transfer system 2 is in the state illustrated by Fig. 6(b) of the transference cycle shown in Fig. 6, or the state in which the conveying block 20 is in the standby position.

(0080)

The operation of the flexure-piece holding mechanism 13 will be described with reference to the transference cycle of the transfer system 2 described in the explanation of the drawings in Fig. 6. Since the operation of the transfer system 2 is identical to that described before, a description will be given by focusing on the operation of the flexure-piece holding mechanism 13.

(0081)

Next, as described in the explanation of Fig. 6(c), the conveying block 20 moves in the positive direction of the Z-axis to insert the conveying pins 20a into the conveying holes 3c and 4c of the two-layered stacked series 15. Then, the conveying block 20 stops in the higher position where the two-layered stacked series 15 is slightly lifted. At this point, the flexure-conveying block 13c also slightly moves upward by a distance that allows the flexure piece 7c placed on the two-layered stacked series 15 to be lifted upward with the two-layered stacked series 15. The four suction openings 2j that suck

the frame 54p cancels its suction state immediately before the conveying block 20 lifts the two-layered stacked series 15.

(0082)

Next, as described in the explanation of Fig. 6(d), the conveying block 20 moves in the negative position of the X-axis by the series pitch p1, so that the two-layered stacked series 15 is transferred in the same direction or direction of arrow A by the series pitch P1. With the movement of the conveying block 20, the flexure-conveying block 13c also moves together in the same direction, so that the flexure pieces 7c are transferred in the same direction without disturbing the stacking relationship between the two-layered stacked series 15 and the flexure piece 7c.

(0083)

Next, as described in the explanation of Fig. 6(e), the conveying block 20 moves to the lower position along the Z-axis, where the pressing blocks 21 press the two-layered stacked series 15 against the base-plate placing surface 2b again. The two-layered stacked series 15 is thereby brought into the state of rest shown in Fig. 6(a). Then, when the flexure piece 7c is brought into contact with the load-beam placing portion again, the four suction openings 2j that suck the frame 54p are brought to the suction state to fix the flexure piece 7c. Thereafter, in synchronization with the downward movement of the conveying pins 20a, the flexure-conveying block 13c is moved upward so as to move the stepped pins 13a and 13b to the positions (indicated by the dotted line in Fig. 11) where they are separated from the conveying holes 7e and 7f of the flexure piece 7c, respectively.

(0084)

Then, as described in the explanation of Fig. 6(b), the conveying block 20 in the lower position moves to the insertion position Ps1 (in Fig. 3) to stop. With the movement of the conveying block 20, the flexure-conveying block 13c also moves together in the same direction by the series pitch P1 (in Fig. 2) for the two-layered stacked series 15. Then, the flexure-conveying block 13c stops in the insertion position in which the stepped pins 13a and 13b are directly above the conveying holes 7e and 7f of the subsequent flexure piece 7c.

(0085)

Incidentally, Fig. 11 shows the state in which the flexure-conveying block 13c moves downward to insert the stepped pins 13a and 13b into the conveying holes 7e and 7f of the flexure piece 7c, respectively, for positioning. This state is brought about in the course of the operation that proceeds from the step in Fig. 6(b) to the step in Fig. 6(c), before the conveying pins 20a are inserted into the conveying holes 3c and 4c of the two-layered stacked series 15, respectively.

(0086)

The transfer system 2, in cooperation with the flexure-piece holding mechanism 13, continues the cyclic transference operation of transferring the three-layered stacked series 16 in the direction of arrow A by the series pitch P1 in one cycle. The stacking relationship between the two-layered stacked series 15 and the flexure piece 7c would not be therefore disturbed, so that they are transferred in the direction of arrow A sequentially from one assembly station to another. The transfer system 2, flexure-piece holding mechanism 13, and load-beam placing portion 2e in the stacked-layer-series transference region correspond to the first transfer means.

(0087)

Fig. 13 shows the state of the three-layered stacked series 16 transferred to the laser-welding device 14 in the manner described above, before being further transported to the inside of the laser-welding device 14. The holes of the flexure piece 7c to be used by the flexure-conveying block 13c are switched from the conveying holes 7e and 7f to auxiliary holes 7g and 7h.

(0088)

Fig. 14 is a top view showing the position where the three-layered stacked series 16 transferred to the rest position inside the laser-welding device 14 is positioned by a plurality of positioning pins projecting upward from underneath the placing portion of the series.

(0089)

The laser-welding device 14, as stacking-and-joining means, irradiates a laser beam onto the predetermined portions of the base plate 52, load beam 53, and flexure 54 stacked up in the three-layered stacked series 16 placed in the state of rest in the predetermined position of the device, to perform spot welding. Thus, for accurate positioning of the respective members before performing the spot welding, the laser-welding device 14 positions the respective members by using a plurality of positioning pins 14a to 14g projecting from underneath the placing surface of the three-layered stacked series 16 held at rest.

(0090)

The positioning pins 14a and 14b are respectively inserted into the conveying holes 7e and 7f formed in the frame 54p of the flexure piece 7c, to position the flexure 54. The positioning pins 14c and 14d are respectively inserted into the guide opening 53g of the load beam and the positioning hole 4b of the load beam series 4 shown in Fig. 2(b), to position the load beam 53. The positioning pins 14e, 14f, and 14g are inserted into the reference opening 52b and the opening 52c of the base plate 52, shown in Fig. 2(a) to position the base plate 52.

(0091)

Two-dot chain lines 205, 206, and 207 shown in Fig. 26 connect the spots to be joined by the laser radiation to show the positions where the respective members are joined together.

The load beam 53 is joined to the base plate 52 at four spots indicated by the indicator lines 205a to 205d, the flexure 54 is joined to the load beam 53 at four spots indicated by the indicator lines 207a to 207d, and the base plate 52, load beam 53, and flexure 54 are joined together at three spots indicated by the indicator lines 206a to 206c.

(0092)

In this way, the laser-welding device 14 performs laser spot-welding to join the base plate 52, load beam 53, and flexure 54 positioned by the positioning pins 14a to 14g at 11 spots in total while the three-layered stacked series 16 is in the state of rest. The suspension section 59 is thereby formed by a combination of the base plate 52, load beam 53, and flexure 54.

Herein, a series of the suspension sections 59 formed by joining the predetermined spots of the three-layered stacked series 16 by the stacking-and-joining process will be referred to as a suspension series 17 (in Fig. 16).

(0093)

As described above, according to the suspension-section assembling apparatus 1 of the first embodiment, the base plate 52, load beam 53, and flexure 54 can be provided in the series state and can be transferred in the series state for the respective processes to allow assembly of the suspension section. For this reason, trays or assembling blocks as the assembling jigs, on which suspension sections to be assembled should be mounted, become unnecessary for the respective processes.

(0094)

Second Embodiment.

Fig. 16 is a perspective view showing the configuration of the pertinent part of a slider attacher according to a second embodiment, in the HG assembly assembling apparatus of the present invention. The slider attacher attaches a slider to the suspension section 59 of the suspension series 17 assembled by the suspension section assembling device 1 described before.

(0095)

Referring to Fig. 16, a transfer system 26 that comprises a slider attacher 25 as the second transfer means, indicated by the dotted line, includes a transference mechanism that is identical to the mechanism of the transfer system 2 described before. Thus, the transfer system 26 continues the cyclic operation of transferring the suspension series 17 by the series pitch P1 in the direction of arrow A in one cycle. This cycle is identical to the transference cycle of the transfer system 2 that uses the conveying holes 3c and 4c of

the suspension series 17, shown in Fig. 2. For this reason, a detailed description of the transfer system 26 will be omitted. Incidentally, it is assumed herein that the frame 54p that has become unnecessary is removed from the flexure 54 in the suspension series 17 to be transferred by the transfer system 26, by the processing means not shown.

(0096)

The negative direction of the X-axis in Fig. 16 is set to coincide with the arrow A, and the Y-axis is set to be parallel with the plane including the suspension series 17 to be transferred by the transfer system 26. The coordinate axes in the drawings in this embodiment show the directions for common use.

(0097)

A table unit 27 rotates a table 27a disposed on an X-Y plane in the direction of arrow F about the Z-axis, with timing to be described later. Four slider-holding recesses 27b for receiving and holding the sliders 56 are formed near the edges of the top surface of the table 27a, and are formed in such positions that the table is divided into four equal parts. Fig. 17 is a partially expanded view showing an area near the slider-holding recess 27b. The slider-holding recess 27b, as shown in Fig. 17, is divided into two parts; a stepped portion 27c for placing peripheral part of the bottom of the slider 56 and a through hole 27d that passes from the edges of the stepped portion 27c through the underside of the table 27a.

(0098)

A plurality of cells 28a in a lattice arrangement for holding the sliders 56 is formed in the top surface of a slider-holding tray 28. The slider-holding tray is disposed in a predetermined position near the table unit 27.

(0099)

A suspension-fixing jig 30 is disposed below the tip of the suspension section 59 in the suspension series 17 transferred by the transfer system 26. The suspension-fixing jig moves upward when the sequentially transferred suspension section 59 has been brought into the state of rest in a predetermined rest position, and supports the portion near the flexure tongue 54f of the flexure 54 (in Fig. 27) to temporarily fix the suspension section 59.

(0100)

A collet 61 performs a slider-transfer operation: it sucks a slider 56 placed on a cell 28a of the slider-holding tray 28 onto its leading end 61a, transfers the slider to the slider-holding recess 27b in a slider-placing position Ps4 of the table 27a, and then cancels suction.

(0101)

An adhesive applicator 29 is disposed below the table 27a. It is disposed in such a position that the center of the adhesive injection from a tip 29a of the applicator

coincides with the center of the opening 27d in the slider-holding recess 27b in an adhesive-applying position Ps5 rotated through 90 degrees from the slider-placing position Ps4. The adhesive applicator 29 injects an adhesive with the timing to be described later.

(0102)

A collet 62, on the other hand, sucks a slider 56 in a slider-release position Ps6 rotated 180 degrees from the slider-placing position Ps4. The collet 62 carries the slider 56 to a predetermined attaching position on the flexure tongue 54f (in Fig. 27) fixedly supported by the suspension fixing jig 30 to press the slider against there, and then cancels suction. As described before, the predetermined attaching position is the one in which, when attaching the slider 56 to the flexure tongue 54f, the center of the slider 56 is generally superimposed over the contact point between the flexure tongue 54f and the gimbal pivot 53i, as shown in the broken line in Fig. 28.

(0103)

Incidentally, the table unit 27, slider-holding tray 28, suspension-fixing jig 30, adhesive applicator 29, and collets 61 and 62 comprise slider attaching means.

(0104)

Now, a description will be directed to the overall operation of the slider attacher 25 having the above-mentioned configuration of the components.

The table 27a rotates through 90 degrees in one cycle, in synchronization with the transference cycle of the transfer system 26. The table 27a is controlled such that, when a suspension section 59 is brought into the state of rest, the table 27a comes to rest in the positions where the slider-holding recesses 27b are opposed to the positions Ps4 to Ps6, respectively.

(0105)

During the rest period, the collet 62 performs the slider-transfer operation described before. The adhesive applicator 29 applies the adhesive to the underside or the attaching surface of a slider 56 placed in a slider-holding recess 27b in the adhesive-applying position Ps5, via the through hole 27d. The collet 62 sucks a slider 56 in the slider release position Ps6, to which the adhesive has been applied, and carries the slider 56 to the before-mentioned, predetermined attaching position over the flexure tongue 54f fixedly supported by the suspension-fixing jig 30, for attachment.

(0106)

When the transfer system 26 transfers the suspension series 17 by the series pitch P1 in the direction of arrow A in the next cycle, the table 27a further is rotated through 90 degrees in synchronization therewith and then comes to rest. The respective operations of the collets 61, 62 and the adhesive applicator 29 are then repeated, so that a slider 56 is attached to a sequentially transferred suspension section 59. By attaching the slider

56 to the suspension section 59 in the slider attaching process as described above, an HG assembly 51 is formed. Herein, a series of the HG assemblies thus formed will be referred to as the HG assembly series 18 (in Fig. 18).

(0107)

As described above, the slider attacher 25 according to the second embodiment, allows the suspension sections 59 to be transferred in the form of the suspension series 17, and allows the sliders to be attached to the respective suspension sections 59 in the series state. For this reason, the need for trays or assembling blocks as assembling jigs for positioning the suspension sections and the sliders and maintaining their states is eliminated.

(0108)

Third Embodiment.

Fig. 18 is a perspective view showing the configuration of the pertinent part of a solder-ball bonding unit according to a third embodiment, in the HG assembly assembling apparatus of the present invention. The solder-ball bonding unit electrically connects the bonding pads 56a to 56d (in Fig. 29) of the slider 56 in the HG assembly series 18 attached by the slider attacher 25 to the lead pads 55h to 55k (in Fig. 29), respectively. The lead pads comprise the integral-type conducting lead 55 disposed on the flexure 54 shown in Fig. 26.

(0109)

Referring to the Fig. 18, the transfer system 26 indicated by the dotted line, which comprises the solder-ball bonding unit 31, has the same configuration as the transfer system described in the second embodiment, so that by assigning the same reference numerals, its detailed description will be omitted. The transfer system 26 therefore continues the cyclic operation of transferring the HG assembly series 18 by the series pitch P1 in the direction of arrow A in one cycle. In this cycle, the conveying holes 3c and 4c of the HG assembly series 18 are used, and this cycle is identical to the transference cycle of the transfer system 2 shown in Fig. 6. The HG assembly series 18 is therefore transferred in the direction of arrow A sequentially from one assembly station to another.

(0110)

Incidentally, the negative direction of the X-axis in Fig. 18 is set to coincide with the arrow A, and the Y-axis is set to be parallel with the plane including the HG assembly series 18 transferred by the transfer system 26. The coordinate axes in the drawings in this embodiment show the directions for common use.

(0111)

The positioning-and-holding device 32 is disposed below the tip of the HG assembly 51 of the HG assembly series 18 transferred by the transfer system 26. The

positioning-and-holding device 32 moves upward when the sequentially transferred HG assembly 51 has come to rest in a predetermined rest position, to press up the tip of the HG assembly. Then, the positioning-and-holding device 32 inclines the tip by a predetermined angle such as approximately three to five degrees from the X-Y plane, to the extent that plastic deformation is not caused. Then, the positioning-and-holding device 32 positions the tip of the load beam 53 in this state, and then accurately positions the slider 56 attached to the flexure tongue 54f with the adhesive before hardening.

(0112)

Fig. 19 is a partially expanded view of an area near the leading end of the positioning-and-holding device 32. The positioning-and-holding device 32 moves upward along the Z-axis, receives the tip of the load beam 53 in an outer groove 32e formed to conform to the shape of the tip, and then presses up the tip of the load beam 53 in contact with a placing surface 32a inclined by approximately three to four degrees relative to the X-Y plane. Then, the positioning-and-holding device 32 stops in a holding position where the tip of the load beam 53 is inclined by substantially the same degree, and the entire placing surface 32a is brought into contact with the underside of the tip of the load beam 53.

(0113)

At this point, the bent portions of the load beam 53 and the flexure 54 are accommodated in a recess 32b formed in the outer groove 32e, so that the tip of the load beam 53 is positioned by the outer groove 32e. Incidentally, the inclination of the tip of the load beam 53 is absorbed by the elasticity of the load beam 53 around the hinge portion 53f (in Fig. 25), so that the band portions 3a and 4a held by the transfer system 26 will not be affected by the inclination.

(0114)

The positioning-and-holding device 32 is disposed in the holding position in which the tip of the load beam 53 is positioned, and slides a pair of slider-positioning levers 32c and 32d in the positive and negative positions of the X-axis. The leading ends of the positioning levers 32c and 32d are tapered so as to guide the slider 56 to a predetermined position in the Y-axis direction. The both sides of the slider 56 are sandwiched by the leading ends of the positioning levers to position the slider 56 in both of the X-axis and Y-axis directions.

(0115)

After the slider 56 is positioned, a solder-ball bonding device 33 is brought close to the HG assembly 51 that has been inclined by the positioning-and-holding machine 32, by transfer means not shown. The lead pads 55h to 55k are electrically connected to the bonding pads 56a to 56d, respectively, by the solder ball method.

(0116)

Fig. 20 is a drawing showing the configuration of the pertinent part of the solder-ball bonding device 33.

An optical system 34 that comprises the solder-ball bonding device 33 receives a laser beam from a laser generator not shown through an optical fiber 34a, focuses it through a focusing lens system that focuses laser beams, and supplies it to a hollow portion 36a of a capillary tube 36 through a laser beam path 35a of a solder-ball feed bed 35. The hollow portion 36a serves as the path for passing solder balls as well as the focused laser beam, and has an ejection opening 36b at its leading edge.

(0117)

In the solder-ball feed bed 35, the laser beam path 35a, a solder-ball storage unit 35b for storing a plurality of solder balls 37, a solder-ball transfer disk 35c rotatably held within the solder-ball feed bed 35 by driving means not shown, an inflow pipe 35d for introducing through a tube 38 a nitrogen gas N from a nitrogen gas cylinder not shown, and a vent path 35e for sending the introduced nitrogen gas N into the laser beam path 35a are formed.

(0118)

The solder-ball transfer disk 35c has the predetermined number of solder-ball slots 35f formed to be uniformly spaced on the circumference of a circle having a predetermined radius from the center of the disk. When a solder-ball slot 35f becomes aligned with a slot not shown and formed at the bottom of the solder-ball storage unit 35b, the solder-ball slot 35f accommodates a dropped solder ball 37. Then, when the solder-ball transfer disk 35c is rotated such that the solder-ball slot 35f accommodating the solder ball is in the position in the vent path 35e, the solder ball 37 drops by gravity. In addition to that, the solder ball 37 is propelled by the nitrogen gas N that flows within the vent path 35e in the direction of arrow, to be fed into the capillary tube 36.

(0119)

The solder-ball bonding device 33 configured as described above is held such that it can slide in the Z-axis or vertical direction that can use gravity, by the transfer means not shown. The partial cross section of the HG assembly 51 in Fig. 20 corresponds to the section through the indicator line 204 which passes through the center of the bonding pad 56b in Fig. 29, as seen from the direction of arrow G.

(0120)

The HG assembly 51 held to be inclined by the positioning-and-holding device 32 (in Fig. 19) and the solder-ball bonding device 33 are positioned relatively such that, when the solder-ball bonding device 33 slides by a predetermined distance in the negative direction of the Z-axis, the tip of the capillary tube 36 approaches the HG assembly 51

without coming into contact with the bonding pad 56b and the lead pad 55i, as shown in Fig. 20.

(0121)

Next, the solder-ball transfer disk 35c is rotated through the predetermined angle to feed a solder ball 37 into the capillary tube 36 through the vent path 35e of the nitrogen gas N_2 . The solder ball 37 drops through the capillary tube 36, and then guided by the ejection opening 36b, comes to a stop in a position which is in contact with the bonding pad 56b and the lead pad 55i. During this period, the predetermined amount of the nitrogen gas N_2 is injected into the capillary tube 36 to propel the drop of the solder ball and press the solder ball 37 against both sides of the bonding pad 56b and the lead pad 55i due to the injection pressure.

(0122)

The laser beam is generated under this condition and then irradiated. The solder ball 37 is melted by radiation of a focused laser beam 39 to form a solder joint between the bonding pad 56b and the lead pad 55i. The nitrogen gas N_2 which flows out, presses the melted solder against both of the joined surfaces and covers the solder to prevent its oxidation.

(0123)

When soldering three portions formed of other pairs of a bonding pad and a lead pad, the solder-ball bonding device 33 is moved by a predetermined distance along the X-axis to perform the same soldering operations. Soldering of all of the four portions between the bonding pad and the lead pad is thereby completed.

(0124)

When the electrical connections of one HG assembly are completed as described above, the solder-ball bonding device 33 is retracted upward along the Z-axis, and the positioning-and-holding device 32 is retracted downward along the Z-axis. With these movements, the inclined HG assembly 51 recovers its original state. Then, when the transfer system 26 transfers the HG assembly series 18 by the series pitch P1 in the direction of arrow A in the next cycle, the subsequent HG assembly comes to rest in the predetermined position over the positioning-and-holding device 32. Then, the above-mentioned solder-ball bonding operations are repeated.

(0125)

As described above, the solder-ball bonding unit 31 according to the third embodiment allows the HG assemblies 51 to be transferred in the form of the HG assembly series 18 and enables the electrical connections between the leads and the slider of the respective HG assemblies 51 in the series form. For this reason, the need for trays or assembling blocks, as assembly jigs for positioning the slider and the leads of the respective HG

assemblies 51 such that they face a connecting device such as the solder-ball bonding device 33, is eliminated.

(0126)

Fourth Embodiment.

Fig. 21 is a perspective view showing the configuration of the pertinent part of a load-bending device according to a fourth embodiment, in the HG assembly assembling apparatus of the present invention. The load-bending device performs the operation of load-bending the hinge portion 53f (refer to Fig. 25) of each of the HG assemblies 51 in the HG assembly series 18, which has undergone electrical connections between the bonding pads and the lead pads 55h to 55k.

(0127)

Referring to Fig. 21, the transfer system 26 is indicated by the dotted line and comprises the load-bending device 41. The configuration of the transfer system 26, as the third transfer means, is the same as that of the before-mentioned transfer system according to the third embodiment, except for a pressing board 21b to be described later and indicated by the dotted line. Thus, by assigning like reference numerals, its detailed description will be omitted. The transfer system 26 therefore uses the conveying holes 3c and 4c of the HG assembly series 18 to continue the cyclic operation of transferring the HG assembly series 18 by the series pitch P1 in the direction of arrow A in one cycle. This operation is identical to that performed by the transfer system 2, shown in Fig. 6. The HG assembly series 18 is therefore transferred in the direction of arrow A sequentially from one assembly station to another.

(0128)

In Fig. 21, the negative position of the X-axis is set to coincide with the direction of arrow A, and the Y-axis is set to be parallel with the plane including the HG assembly series 18 transferred by the transfer system 26 before the load-bending operation. The coordinate axes in all the drawings in this embodiment show the directions for common use.

(0129)

The load-bending device 41 comprises a pressing roller 41b and a mandrel 41a to be disposed near the hinge portion 53f of the HG assembly 51 of the HG assembly series 18 that has been transferred by the transfer system 26 and then comes to rest in a predetermined position. When the HG assembly 51 comes to rest, the mandrel 41a disposed above the HG assembly series 18 goes down to a position where the mandrel comes into contact with the hinge portion 53f. When the HG assembly 51 has come to rest, the pressing roller 41b disposed below the HG assembly series 18 goes up to press the hinge portion 53f against the mandrel 41a for load-bending.

(0130)

Fig. 22 comprises operating principle diagrams schematically showing the configuration of the pertinent part and the operating states of the load-bending device 41. As shown in the drawings, when the HG assembly 51 is in the state of rest, the pressing block 21 (in Fig. 6) presses the portion near the transferring holes 3c and 4c of the HG assembly series 18 against the base-plate placing portion 2a for fixation. The pressing board 21b formed to be integral with the pressing block 21 presses the portion up to the vicinity of the hinge portion 53f of the HG assembly 51 against the base-plate placing portion 2a, thereby fixing the stacked layer of the base plate 52 and the load beam 53 (refer to Fig. 25) securely.

(0131)

In this state, the load-bending device 41 causes the mandrel 41a with its leading edge rounded for load-bending the hinge portion 53f to go down and causes the pressing roller 41b to go up, until the mandrel and the pressing roller come into contact with the hinge portion 53f. Fig. 22(a) shows this state.

(0132)

As shown in Fig. 22(a), the pressing roller 41b is rotatably held at the leading edge of a rotating arm 41f rotatably supported by a slide plate 41e. The slide plate goes up and down along the Z-axis by a cam mechanism 41d driven by a stepping motor 41c. A coil spring 41g is hung between the rotating arm 41f and the projecting plate of the slide plate 41e.

(0133)

When the slide plate 41e is raised by driving the step motor 41c in this state, the pressing roller 41b rotates while pressing the hinge portion 53f of the HG assembly against the rounded edge of the mandrel 41a. The rotating arm 41f rotates in the direction of arrow H against the force of the coil spring 41g. The hinge portion 53f can be pressed along the rounded edge of the mandrel 41a by the pressing roller 41b that has been subject to this force. Fig. 22(b) shows the state in which the slide plate 41e has moved upward by a predetermined distance in these circumstances.

(0134)

At this point, the hinge portion 53f of the HG assembly 51 undergoes plastic deformation by being bent along the rounded edge of the mandrel 41a as shown in Fig. 22(b). Although the hinge portion returns to its original state in some degree when the pressing roller 41b is removed, the hinge portion maintains this bent state. A bending angle (1 (in Fig. 21) of the hinge portion 53f formed due to this plastic deformation is set to be a little larger than a final desired bending angle (2 to be described later.

(0135)

When the load-bending operation of one HG assembly 51 is completed as described above, the mandrel 41a is retracted upward along the Z-axis, and the slide plate 41e is

retracted downward along the Z-axis. Then, when the transfer system 26 transfers the HG assembly series 18 by the series pitch P1 in the direction of arrow A in next cycle, the subsequent HG assembly comes to rest at the predetermined position of the load-bending device 41. Then, the above-mentioned load-bending operation is repeated. The load-bending device 41 excepting the transfer system 26 corresponds to load-bending means.

(0136)

As described above, the load-bending device 41 according to the fourth embodiment allows the HG assemblies 51 to be transferred in the form of the HG assembly series 18 and enables load-bending of the hinge portion of each of the HG assemblies 51 formed in the series. For this reason, the HG assemblies can be assembled in the form of the series, so that complexity in the manufacture of the respective HG assemblies can be eliminated.

(0137)

Further, since the load-bending process can be set to be performed after attachment of the slider and electrical connections of the leads, a change in the bending state that would occur after the bending operation in the manufacturing process can be prevented.

(0138)

Fifth Embodiment.

Fig. 23 is a perspective view showing the configuration of a bending-load adjusting device according to a fifth embodiment, in the HG assembly assembling apparatus of the present invention. The bending-load adjusting device adjusts a bending load for the HG assembly series 18 in which the hinge portion 53f of each of the HG assemblies 51 is bent by the order of the bending angle (1 by the load-bending process described before.

(0139)

Referring to Fig. 23, the transfer system 26 that comprises the bending-load adjusting device 43, indicated by the dotted line has the same configuration as the transfer system described in the fourth embodiment. Accordingly, by assigning like reference numerals, its detailed description will be omitted. The transfer system 26 therefore uses the conveying holes 3c and 4c of the HG assembly series 18 to continue the cyclic operation of transferring the HG assembly series 18 by the series pitch P1 in the direction of arrow A in one cycle. This cyclic transference operation is identical to as that performed by the transfer system 2 shown in Fig. 6. The HG assembly series 18 is therefore transferred in the direction of arrow A sequentially from one assembly station to another.

(0140)

Incidentally, the negative direction of the X-axis is set to coincide with the arrow A, and the Y-axis is set to be parallel with the plane including the HG assembly series 18

transferred by the transfer system 26 before bent. The coordinate axes in the drawings in this embodiment show the directions for common use.

(0141)

While the HG assembly 51 of the HG assembly series 18 transferred by the transfer system 26 rests in a predetermined rest position under a device cover 43a, the bending-load adjusting device 43 irradiates a laser beam onto the hinge portion 53f bent by the order of the bending angle (1 to adjust a bending load. (0142)

Fig. 24 comprises operating principle diagrams that schematically show the configuration of the pertinent part of the bending-load adjusting device 43 under the device cover 43a and its operating states. As shown in Fig. 24(a), when the HG assembly 51 rests in the rest position under the device cover 43a, the pressing block 21 (in Fig. 6) presses the portion near the conveying holes 3c and 4c of the HG assembly series 18 against the base-plate placing portion 2a, for fixation. The pressing plate 21b formed to be integral with the pressing block 21 presses the portion up to the vicinity of the hinge portion 53f of the HG assembly 51 against the base-plate placing portion 2a, thereby fixing the stacked layer of the base plate 52 and the load beam 53 (refer to Fig. 25) securely.

(0143)

In this state, as shown in Fig. 24(b), a load bar 43b is pressed onto the load beam 53 bent by the bending angle (1 until the load beam 53 is pressed down such that the bending angle (is reduced substantially to zero against the resistance. Next, a load cell 43c is moved in the negative direction of the Y-axis to a position that faces a disk-facing surface 56f of the slider 56, and then the load bar 43b is retracted upward again. At this point, the load beam 53 will return to the position where its bending angle is (1, but comes into contact with a sensing projection 43d of the load beam cell 43c in the course of the return. Then, this contact state is maintained.

(0144)

The load cell 43c at this point is in the position where the bending angle (of the load beam 53 is the predetermined test angle (2. The load cell 43c senses the returning force or the bending load of the load beam 53 at this bending angle by using the sensing projection 43d, and adjusts a sensed load value F_g to a predetermined adjustment value F_{g1} . This adjustment is made by irradiating a laser beam onto the hinge portion 53f through a laser fiber 43e so as to reduce the sensed load value F_g . The laser fiber 43e is disposed under the load beam 53, facing the hinge portion 53f.

(0145)

When the load adjusting operation of one HG assembly 51 is completed as described above, the load cell 43c is retracted. Then, when the transfer system 26 transfers the HG assembly series 18 by the series pitch P1 in the direction of arrow A in the subsequent one cycle, the subsequent HG assembly comes to rest in the predetermined

rest position under the device cover 43a. Then, the above-mentioned bending-load adjusting process is repeated.

(0146)

As described above, the bending-load adjusting device 43 according to the fifth embodiment allows the HG assemblies 51 to be transferred in the form of the HG assembly series 18, and can adjust a bending load on the hinge portion of each of the HG assemblies. For this reason, assembly of the HG assemblies in the form of a series can be performed, so that the complexity in the manufacture of the respective HG assemblies can be eliminated.

(0147)

Further, since the bending-load adjusting process can be set to be performed in the final stage of the assembly process, a change in the bending state that would occur after the bending-load adjustment in the manufacturing process can be prevented.

(0148)

In the embodiments described before, the length of each series was set to be as long as 12 or 32 members aligned. The length of each series is not limited to this, and it may also be set to be long such that each series can be reeled.

(0149)

In the embodiments described before, it is arranged that the base plate series and the load beam series are transferred in the form of a stacked series so as to be processed in all the assembling stages. However, it may also be arranged that only the base plate series is processed in all stages of the assembly process, and that the load beam is stacked on each of the base plates in the base plate series as a single piece, as in the case of the flexure.

(0150)

In the embodiments described before, electrical connections between the slider and the leads are made by using the solder ball method. The connection method is not limited to this; other connection method such as the one using an ultrasonic wave or the solder bump method may also be employed.

(0151)

(Effects of the Invention)

According to the assembling method as set forth in claim 1, the assembling operation in each process is performed on a series of members with at least the bottom layer being a base plate series. Therefore, trays or blocks as assembling jigs become unnecessary, so that the increased efficiency of work space and cost reduction can be achieved. Further, since load-bending of a hinge portion is performed in the final process, a change in the bending state in the process of manufacturing, which would occur after the bending operation can be prevented.

(0152)

According to the assembling method as set forth in claim 2, a bending load on the hinge portion of an HG assembly can be accurately adjusted to a desired value in the final process, so that assembly of HG assemblies with high yield becomes possible.

(0153)

According to the assembling method as set forth in claim 3, and the assembling apparatus as set forth in claim 10, a flexure is stacked as a single piece. Thus, when a flexure series is formed, formation of the series with the fewest possible unnecessary portions without restricted by a series pitch becomes possible.

(0154)

According to the assembling method as set forth in claim 4, and the assembling apparatus as set forth in claim 11, an HG assembly with limiters that prevent a load beam and a flexure from being separated more than necessary can be provided.

(0155)

According to the assembling method as set forth in claim 5, instantaneous joining between a plurality of desired portions in the stacked members becomes possible.

(0156)

According to the assembling method as set forth in claim 6, when attaching a slider to the predetermined position of a flexure, accurate positioning is not required. Accordingly, a device with a low attaching accuracy can be used.

(0157)

According to the assembling method as set forth in claim 7, just by slightly inclining an HG assembly in the series form, electrical connections become possible.

(0158)

According to the assembling method as set forth in claim 8, an accurate bending load can be obtained just by irradiating a laser beam onto the bent hinge portion of an HG assembly. Thus, this method is suited to handling HG assemblies in the series form.

(0159)

According to the assembling apparatus as set forth in claim 9, a series of HG assemblies on the basis of a base plate series is transferred, and the HG assemblies are assembled in the series form. For this reason, the need for trays or blocks as assembly jigs is eliminated. Further, means are successively disposed. Therefore, load-bending means for a hinge portion can be disposed in the final stage. A change in the bending state in the process of manufacturing, which would occur after the bending operation can be thereby prevented.

(0160)

According to the assembling apparatus as set forth in claim 12, by using the transferring holes of respective series and inserting predetermined pins into the holes, transference

and position control of a series can be performed. The conveying holes are formed in the band portion that would eventually become unnecessary. Thus, even if a change in the shape occurs in the course of the processes, the HG assembly accuracy would not be affected.

(0161)

According to the assembling apparatus as set forth in claim 13, a two-layered stacked series of a base plate series and a load beam series can be transferred intermittently, with the desired stacked layer state maintained.

(0162)

According to the assembling apparatus as set forth in claim 14, a three-layered stacked series of a two-layered stacked series and a flexure in the form of a single piece can be transferred intermittently, with the desired mutual positional states between the layers of the three-layered stacked series maintained.

(0163)

According to the assembling apparatus as set forth in claim 15, in synchronization with the movement of a suspension series transferred with the predetermined timing intermittently, a slider immediately after an adhesive has been applied thereto can be efficiently supplied one by one.

(0164)

According to the assembling apparatus as set forth in claim 17, the same transfer means is employed for being used in cooperation with respective means. An improvement in maintenance thus can be effected.

(0165)

According to the assembling apparatus as set forth in claims 18 and 19, when transferring a plurality of members stacked in the form of a layered series to a predetermined direction intermittently, they can be transferred, with the desired relative positional relationships between the members in the layered series maintained.

(0166)

According to the base plate structure as set forth in claim 20, when an HG assembly is assembled, a series of members with at least the bottom layer being the base plate series is transferred. HG assemblies can be thereby assembled in the series form.

(Brief Description of the Drawings)

(Fig. 1)

is a schematic diagram of the overall configuration of a suspension-section assembling apparatus according to a first embodiment, for assembling a suspension section, in an HG assembly apparatus of the present invention.

(Fig. 2)

comprises drawings showing the configurations of a base plate series, load beam series, and a two-layered stacked series formed by stacking the load beam series on the base plate series.

(Fig. 3)

is a partial top view showing the configuration of the pertinent part of a transfer system 2.

(Fig. 4)

is a partial front view showing the configuration of the pertinent part of the transfer system 2.

(Fig. 5)

is a side view showing the configuration of the pertinent part of the transfer system 2.

(Figs. 6)

comprises operation diagrams for explaining the cyclic transference operation of the transfer system 2.

(Fig. 7)

is a top view showing the configuration of a flexure series.

(Fig. 8)

is a partial perspective view showing a bent portion in a flexure to be processed by a flexure-bending device 8.

(Fig. 9)

comprises drawings view showing the pertinent part of a cutting device 9 and a transferring device 11 to be used in cooperation therewith, and Fig. 9(a) is a front view and Fig. 9(b) is a top view.

(Fig. 10)

is a partially exploded perspective view showing the partial configurations of the transfer system 2, a load beam 53, and a flexure piece 7c in the vicinity of a limiter-loading region 12 in which an integration process is performed.

(Fig. 11)

is a side view showing the transfer system 2 and a flexure-conveying block 13c in a flexure-piece holding mechanism 13.

(Fig. 12)

is a top view showing a three-layered stacked series formed by stacking on a two-layered stacked series 15 flexure pieces 7c positioned on the respective load beams 53.

(Fig. 13)

is a top view showing a state where a three-layered stacked series 16 transferred to a laser-welding device 14 is further transported to the inside of the laser-welding device 14.

(Fig. 14)

is a top view showing a position where the three-layered stacked series 16 transferred to a rest position within the laser-welding device 14 is positioned by positioning pins.

(Fig. 15)

is a flowchart showing a stacking process performed by the combined use of the transfer system 2, a flexure transfer system 6, the cutting device 9, and the transferring device 11.

(Fig. 16)

is a perspective view showing the configuration of the pertinent part of a slider attacher according to a second embodiment, for attaching a slider to a suspension section 59 in a suspension series 17, in the HG assembly apparatus of the present invention.

(Fig. 17)

is a partially expanded view showing an area near a slider-holding recess 27b.

(Fig. 18)

is a perspective view showing the configuration of the pertinent part of a solder-ball bonding unit according to a third embodiment, for electrically connecting a slider 56 in an HG assembly series 18 to an integral-type conducting lead 55, in the HG assembly apparatus of the present invention.

(Fig. 19)

is a partially expanded view showing an area near the leading end of a positioning-and-holding device 32.

(Fig. 20)

is a drawing showing the configuration of the pertinent part of a solder-ball bonding device 33.

(Fig. 21)

is a perspective view showing the configuration of the pertinent part of a load-bending device according to a fourth embodiment, for bending a hinge portion 53f of each of HG assemblies 51 in the HGA series 18, in the HG assembly apparatus of the present invention.

(Figs. 22)

comprises operating principle diagrams schematically showing the configuration of the pertinent part of a load-bending device 41 and its operating states.

(Fig. 23)

is a perspective view showing the arrangement of a bending-load adjusting device according to a fifth embodiment, for adjusting a bending load on the HG assembly series 18, in the HG assembly assembling apparatus of the present invention.

(Figs. 24)

comprises operating principle diagrams schematically showing the configuration of the pertinent part of a bending-load adjusting device 43 under a device cover 43a and its operating states.

(Fig. 25)

is a perspective view showing the appearance of the HG assembly 51 (suspension section 59) before the slider is attached thereto.

(Fig. 26)

is an exploded perspective view showing the configuration of the HG assembly 51.

(Fig. 27)

is a partial expanded view of the leading end of the HG assembly 51 (suspension section 59) before the slider 56 is attached thereto.

(Fig. 28)

is a sectional view of a position indicated by an indicator line 203 in Fig. 27, as seen from the direction of arrow H.

(Fig. 29)

is a perspective view showing the leading end of the HG assembly 51 in which the slider 56 is attached to a flexure tongue 54f.

(Reference Numerals)

- 1 suspension-section assembling apparatus
- 2 transfer system
- 2a base-plate placing portion
- 2b base-plate placing surface
- 2c receiving slot
- 2d suction opening
- 2e load-beam placing portion
- 2f recessed area
- 2g, 2h long groove
- 2i convex portion
- 2j suction opening
- 3 base plate series
- 3a band portion
- 3b positioning hole
- 3c conveying hole
- 3d connecting portion

- 4 load beam series
- 4a band portion
- 4b positioning hole
- 4c conveying hole
- 4d connecting portion
- 5 bending device
- 6 flexure transfer system
- 7 flexure series
- 7a first band portion
- 7b second band portion
- 7c flexure piece
- 7d, 7e, 7f conveying hole
- 7h, 7g auxiliary hole
- 8 flexure-bending device
- 9 cutting device
- 9a punch
- 9b die
- 10 disposal device
- 11 transferring device
- 11a arm-driving shaft
- 11b transferring arm
- 11c sucking pad
- 12 limiter-loading region
- 13 flexure-piece holding mechanism
- 13a, 13b stepped pin
- 13c flexure-conveying block
- 14 laser-welding device
- 15 two-layered stacked series
- 16 three-layered stacked series
- 17 suspension series
- 18 HG assembly series
- 20 conveying block
- 20a conveying pin
- 21 pressing block
- 21a suppression pin
- 21b pressing board
- 25 slider attacher
- 26 transfer system

- 27 table unit
- 27a table
- 27b slider-holding recess
- 27c stepped portion
- 27d through hole
- 28 slider-holding tray
- 28a cell
- 29 adhesive applicator
- 30 suspension-fixing jig
- 31 solder-ball bonding unit
- 32 positioning-and-holding device
- 32a placing surface
- 32b recess
- 32c, 32d slider-positioning lever
- 33 slider-ball bonding device
- 34 optical system
- 34a optical fiber
- 35 solder-ball feed bed
- 35a laser beam path
- 35b solder-ball storage unit
- 35c solder-ball transfer disk
- 35d inflow pipe
- 35e vent path
- 35f solder-ball slot
- 36 capillary tube
- 36a hollow portion
- 36b ejection opening
- 37 solder ball
- 38 tube
- 39 focused laser beam
- 41 load-bending device
- 41a mandrel
- 41b pressing roller
- 41c stepping motor
- 41d cam mechanism
- 41e slide plate
- 41f rotating arm
- 41g coil spring

- 43 bending-load adjusting device
 - 43a device cover
 - 43b load bar
 - 43c load cell
 - 43d sensing projection
 - 43e laser fiber
- 51 HG assembly
- 52 base plate
 - 52a flat surface
 - 52b reference opening
 - 52c opening
- 53 load beam
 - 53a opposed surface
 - 53b reference opening
 - 53c opening
 - 53d oblong opening
 - 53e flanges
 - 53f hinge portion
 - 53g guide opening
 - 53h opening
 - 53i gimbal pivot
 - 53j tab
 - 53k support
 - 53m tapered portion
 - 53n platform
 - 53p contact region
 - 53q underside contact region
- 54 flexure
 - 54a connector portion
 - 54b reference opening
 - 54c guide opening
 - 54d joint
 - 54e opening
 - 54f flexure tongue
 - 54g, 54h flexure arm
 - 54i, 54j opening
 - 54m, 54n limiter
 - 54p frame

54s, 54t flexion
54u suction portion
55 integral-type conducting lead
55a, 55b, 55c, 55d lead
55e insulating sheet
55f multi-connector
55g leading end
55h, 55i, 55j, 55k lead pad
56 slider
56a, 56b, 56c, 56d bonding pad
56f disk-facing surface
59 suspension section
61,62 collet



(Claims)

(Claim 1) A method of assembling a head gimbal assembly comprising the steps of:
stacking a base plate, a load beam, and a flexure to form a three-layered stacked series with at least the bottom layer being a base plate series, the base plate series comprising the base plates formed in a series manner;

joining at least predetermined portions of said load beam to said base plate, and said flexure to said load beam in said three-layered stacked series to make a suspension section, thereby forming a suspension series that comprises the suspension sections;

attaching a slider to said flexure in the suspension section of said suspension series to make a head gimbal assembly, thereby forming a HG assembly series that comprises the head gimbal assemblies;

electrically connecting terminals to leads, the terminals connecting to a head of said slider of said HG assembly series, the leads being disposed on said flexure and electrically connected outside said HG assembly; and

load-bending a hinge portion formed in said head gimbal assembly of said HG assembly series.

(Claim 2) The method of assembling a head gimbal assembly as set forth in claim 1, further comprising a bending-load adjusting step of:

heating said hinge portion after performing said load-bending step, so as to adjust a bending load on said hinge portion at a predetermined bending angle to a predetermined value.

(Claim 3) The method of assembling a head gimbal assembly as set forth in claim 1, wherein said stacking step comprises stacking said flexure on a two-layered stacked series including said base plate series and a load beam series that comprises said load beams formed in a series manner, thereby forming said three-layered stacked series.

(Claim 4) The method of assembling a head gimbal assembly as set forth in claim 3, wherein when said flexure is stacked, leading ends of limiters formed in said flexure and projecting like cranks are passed through an opening formed in said load beam and then disposed on opposite sides of the opening.

(Claim 5) The method of assembling a head gimbal assembly as set forth in claim 1, wherein said stacking-and-joining step comprises performing said joining by spot-welding that employs laser radiation.

(Claim 6) The method of assembling a head gimbal assembly as set forth in claim 1, wherein said slider attaching step comprises applying an adhesive to an attaching surface of said slider for temporary placement of said slider near a predetermined position of said flexure, and

wherein in said electrical connection step, said slider is accurately positioned in the predetermined position of said flexure.



(Claim 7) The method of assembling a head gimbal assembly as set forth in claim 1, wherein in said electrical connection step, the head gimbal assembly of said HG assembly series is inclined with respect to a horizontal direction without undergoing plastic deformation, a solder ball is disposed to be in contact with a bonding pad in said slider and a lead pad formed at an edge of said lead, and then said solder ball is heated to be melted, thereby forming a solder joint therebetween to perform the electrical connection.

(Claim 8) The method of assembling a head gimbal assembly as set forth in claim 2, wherein said load-bending step comprises:

forming a bending angle not less than said predetermined bending angle;

sensing a bending load when said predetermined bending angle has been recovered;

and

radiating a laser beam to said hinge portion to make the adjustment.

(Claim 9) A head gimbal assembly assembling apparatus comprising:

stacking means for stacking a base plate, a load beam and a flexure to form a three-layered stacked series with at least the bottom layer being a base plate series, the base plate series comprising the base plates formed in a series manner;

first transfer means for transferring said three-layered stacked series intermittently in a state in which said base plate, said load beam, and said flexure mutually maintain predetermined positional relationships;

stacking-and-joining means for stacking and joining at least predetermined portions of said load beam to said base plate, and said flexure to said load beam to make a suspension section, thereby forming a suspension series while said three-layered stacked series transferred by said first transfer means is in a state of rest;

second transfer means for functioning on at least said base plate series of said suspension series to transfer said suspension series, in synchronization with said first transfer means;

slider attaching means for attaching a slider to said flexure of said suspension series that is at rest in a predetermined position after having been transferred by said second transfer means to form a head gimbal assembly, thereby forming an HG assembly series;

third transfer means for functioning on at least said base plate series of said HG assembly series to transfer said HG assembly series, in synchronization with said first transfer means; and

load-bending means for bending a hinge portion formed in said head gimbal assembly of said HG assembly series by a predetermined angle while said HG assembly series is at rest in a predetermined position after having been transferred by said third transfer means.

(Claim 10) The head gimbal assembly assembling apparatus as set forth in claim 9, wherein the stacking means comprises:



a first transfer portion for intermittently transferring a two-layered stacked series formed by stacking a load beam series on said base plate series, the load beam series comprising said load beams formed in a series manner;

a second transfer portion for intermittently transferring a flexure series in synchronization with said first transfer portion, the flexure series comprising said flexures formed in a series manner;

a cutting device for separating from said flexure series a flexure piece in which the flexure and a flexure frame are integrally formed; and

a transferring device for placing said separated flexure piece on the load beam of said two-layered stacked series.

(Claim 11) The head gimbal assembly assembling apparatus as set forth in claim 10,

wherein said transferring device rotates a transferring arm having at an end thereof a sucking pad for sucking the frame of said flexure piece, and

wherein said sucking pad is made to be slightly displaceable in a direction of an axis of rotation such that leading ends of limiters formed in said flexure and projecting like cranks are passed through an opening formed in said load beam and then disposed on opposite sides of the opening.

(Claim 12) The head gimbal assembly assembling apparatus as set forth in claim 10, wherein said base plate series comprises:

a first band portion having first conveying holes formed at a predetermined pitch in a longitudinal direction; and

a plurality of said base plates disposed via connecting portions integrally formed at edges on one side of said first band portion at a predetermined series pitch; and

wherein said load beam series comprises:

a second band portion having second conveying holes formed at said predetermined pitch in the longitudinal direction; and

a plurality of said load beams disposed via connecting portions integrally formed at edges on one side of said second band portion at said predetermined series pitch.

(Claim 13) The head gimbal assembly assembling apparatus as set forth in claim 12, wherein said first transfer portion comprises:

first conveying pins for repeating a cyclic motion of being inserted into said first and second conveying holes at an insertion position in a conveying direction, integrally conveying said base plate series with said load beam series from said insertion position to a release position separated by said series pitch in the conveying direction, separating from said first and second conveying holes, and then returning to said insertion position; and



suppression pins to be inserted into said first and second conveying holes in synchronization with separation of said first conveying pins from said first and second conveying holes, for positioning said base plate series and said load beam series.

(Claim 14) The head gimbal assembly assembling apparatus as set forth in claim 13, wherein said first transfer means comprises:

- a third transfer portion having a same configuration as said first transfer portion;
- second conveying pins to be inserted into third conveying holes formed in said frame of said flexure piece, for integrally conveying said flexure piece with said load beam by a cyclic motion, in synchronization with said first conveying pins; and
- a placing portion having suction openings for sucking predetermined spots of said flexure piece in synchronization with separation of said second conveying pins from said third conveying holes.

(Claim 15) The head gimbal assembly assembling apparatus as set forth in claim 9, wherein said slider attaching means comprises:

- a table unit for intermittently rotating a table through a $1/n$ of a turn in synchronization with said intermittent transference, the table including n slider-holding recesses for receiving and then holding the sliders, the slider-holding recesses being formed near edges of a top surface of the table in such positions that the table is divided into n equal parts, each of the slider-holding recesses having a through hole at the center thereof; and
- an adhesive applicator disposed below a predetermined rest position for said slider-holding recesses, for applying an adhesive to the slider held in said slider-holding recess through said through hole.

(Claim 16) The head gimbal assembly assembling apparatus as set forth in claim 9, wherein said load-bending means comprises:

- a mandrel disposed in a position to face said hinge portion and having an edge rounded for guiding bending of said hinge portion; and
- a pressing roller for pressing said hinge portion along said rounded edge of the mandrel.

(Claim 17) The head gimbal assembly assembling apparatus as set forth in claim 13, wherein said second and third transfer means have a same configuration as said first transfer portion.

(Claim 18) A transfer system for transferring a series of members, the series of members having a band portion including conveying holes formed at a predetermined pitch in a longitudinal direction and a plurality of the members to be transferred, the members disposed via connecting portions integrally formed at edges of one side of the band portion at a predetermined series pitch, the transfer system comprising:

- conveying pins for repeating a cyclic motion of being inserted into said conveying holes at an insertion position in a conveying direction, conveying said series of the members



from said insertion position to a release position separated by said series pitch in the conveying direction, separating from said conveying holes, and then returning to said insertion position; and

suppression pins to be inserted into said conveying holes, for positioning said series of the members in synchronization with separation of said conveying pins from said conveying holes.

(Claim 19) The transfer system as set forth in claim 18, further comprising a placing portion having suction openings for sucking said series of the members in synchronization with insertion of said suppression pins into said conveying holes.

(Claim 20) A base plate structure having a plurality of base plates in a head gimbal assembly formed by a base plate, a load beam, and a flexure disposed one atop another, wherein the base plate structure is made of a plate member stiffer than plate members for said load beam and said flexure, and

wherein the base plate structure comprises:

a band portion having conveying holes and positioning holes formed at a predetermined pitch respectively in a longitudinal direction; and

a plurality of said base plates disposed via connecting portions integrally formed at a predetermined pitch at edges on one side of the band portion.