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Hussinger et al.

[54] **THIN FILM HEAD SLIDER FABRICATION PROCESS**

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[73] Assignee: **Quantum Corporation**, Milpitas, Calif.

[21] Appl. No.: **346,821**

[22] Filed: **Nov. 16, 1994**

Related U.S. Patent Documents

[63] Continuation of Ser. No. 56,515, May 3, 1993, abandoned.

Reissue of:

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Issued: **Mar. 17, 1992**
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Filed: **Jun. 29, 1990**

[51] **Int. Cl.**[6] **G11B 5/42**

[52] **U.S. Cl.** **29/603.07**; 29/423; 29/559

[58] **Field of Search** 29/603, 423, 424, 29/559

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Attorney, Agent, or Firm—David B. Harrison

[57] **ABSTRACT**

In an improved process for fabricating thin film head sliders from a wafer on one face of which a plurality of electromagnetic devices are arranged in rows, a single-row bar is mechanically processed to form sliders while it remains an integral part of the wafer, or after it is bonded to a fixture under a condition which induces no bow on the bar. Alternatively, a double-row bar sliced from the wafer is used for fabrication of sliders, wherein each single-row bar is mechanically processed while it remains an integral part of the double-row bar, or after it is bonded to a fixture as an integral part of a double-row bar followed by severance of the bonded double-row bar into two single-row bars. The process eliminates or materially reduces any inducement of bow of the bar, which is a serious cause of throat height control problem associated with the prior fabrication methods.

22 Claims, 10 Drawing Sheets

10 16 18 23 12 22a 40 20 22

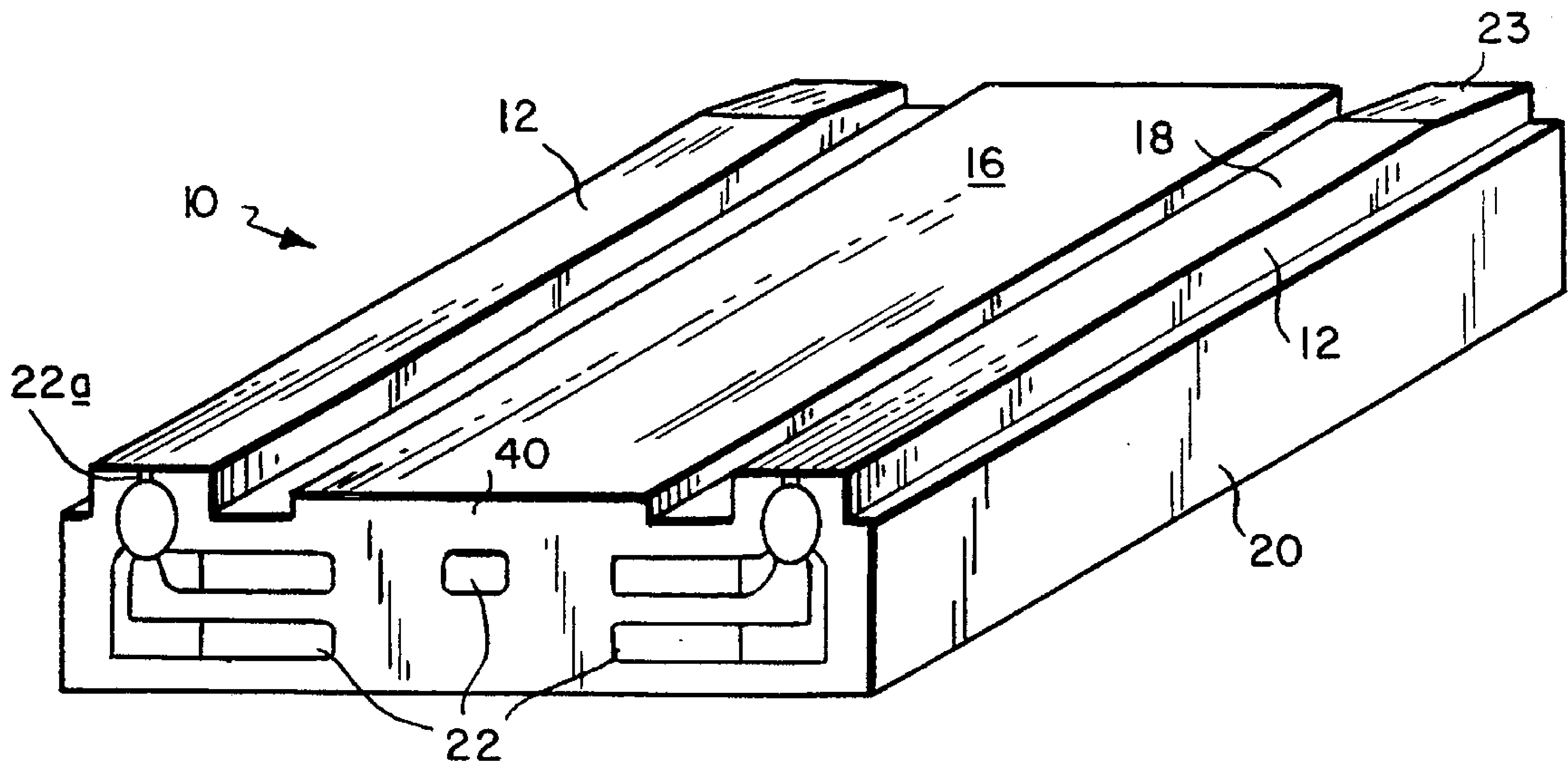

FIG. 1

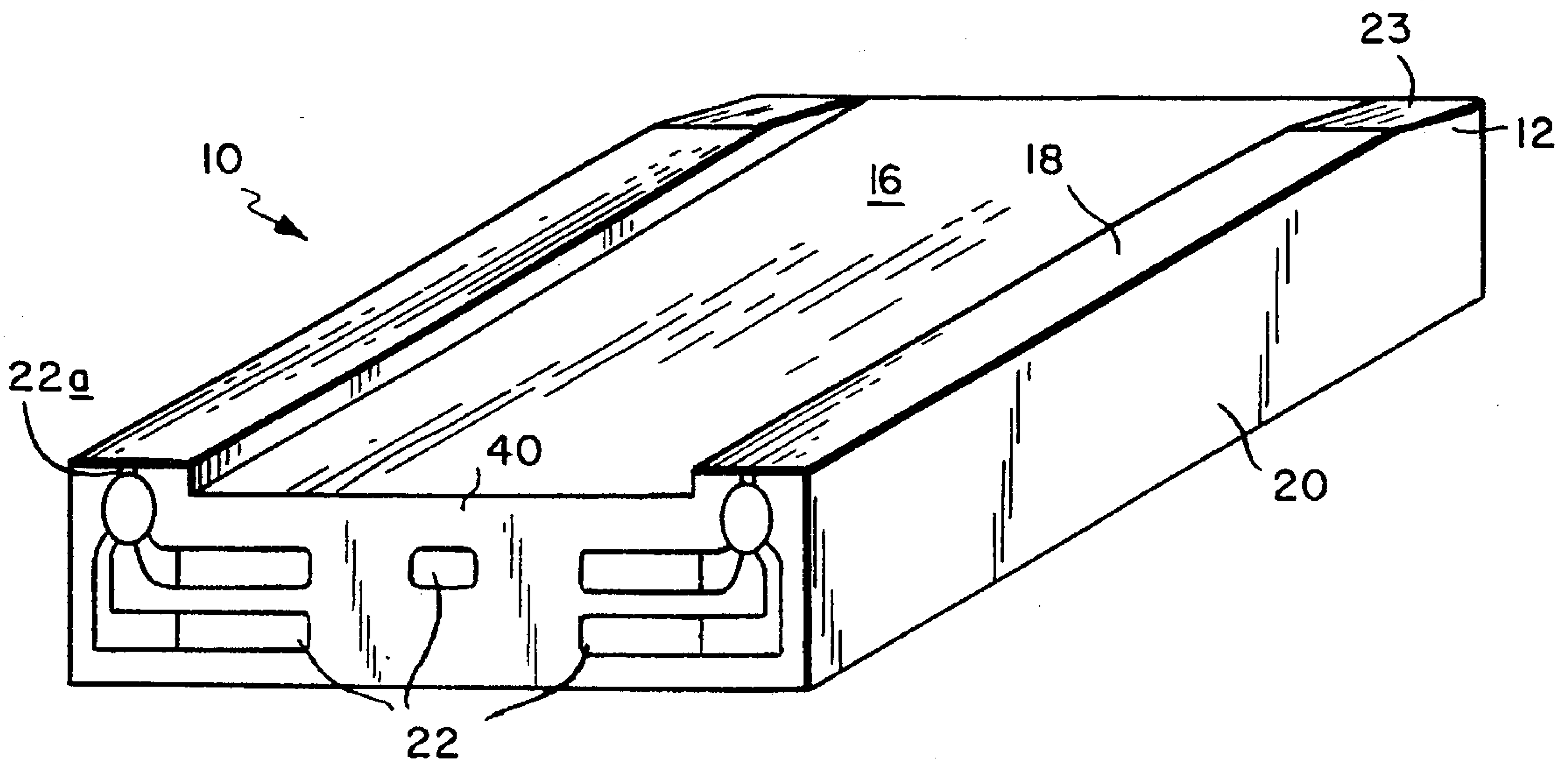

FIG. 6

34
30
28
26
35
40
20

FIG. 2

30
14
28
40
20

FIG. 2A

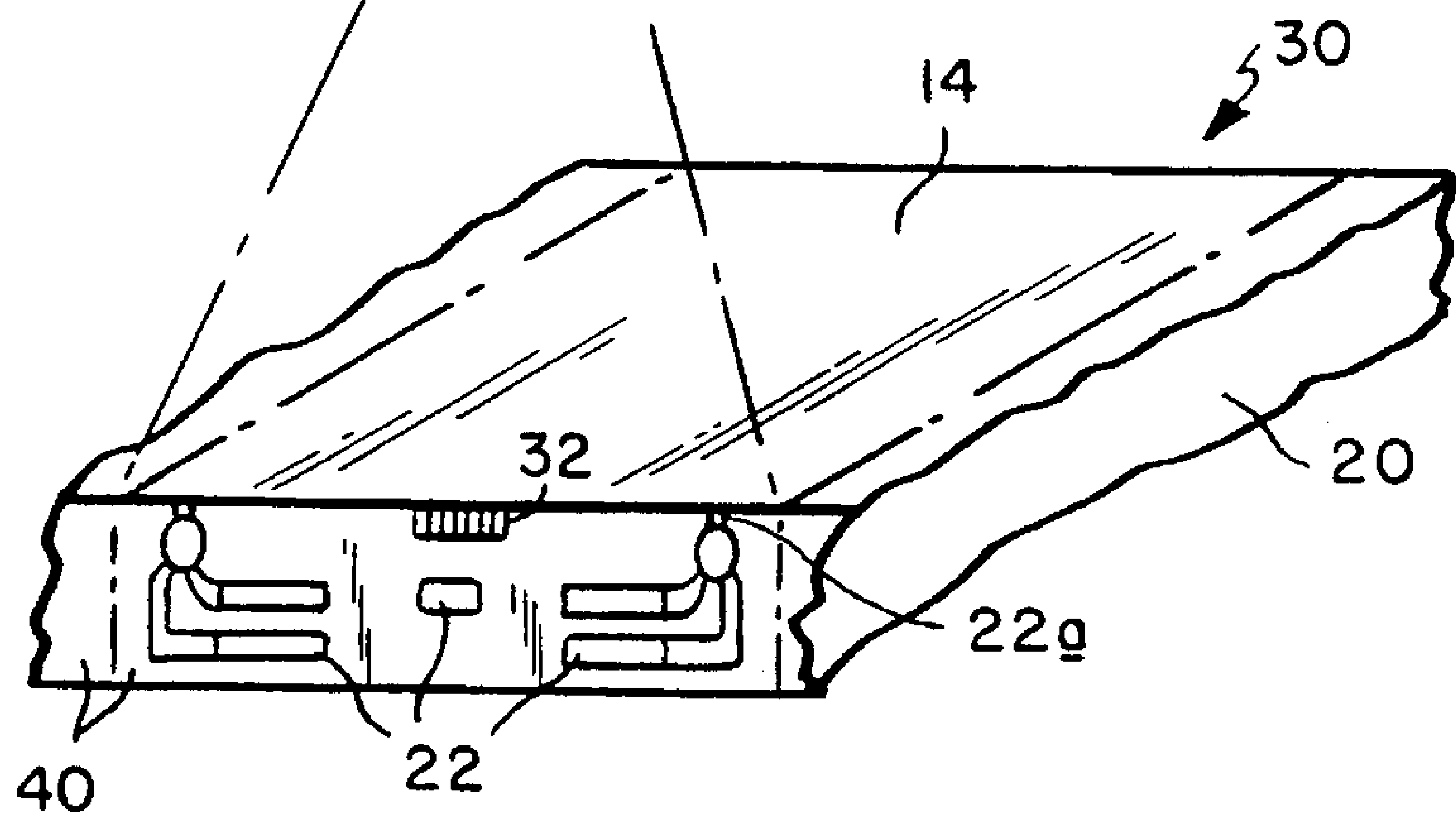

FIG. 2B

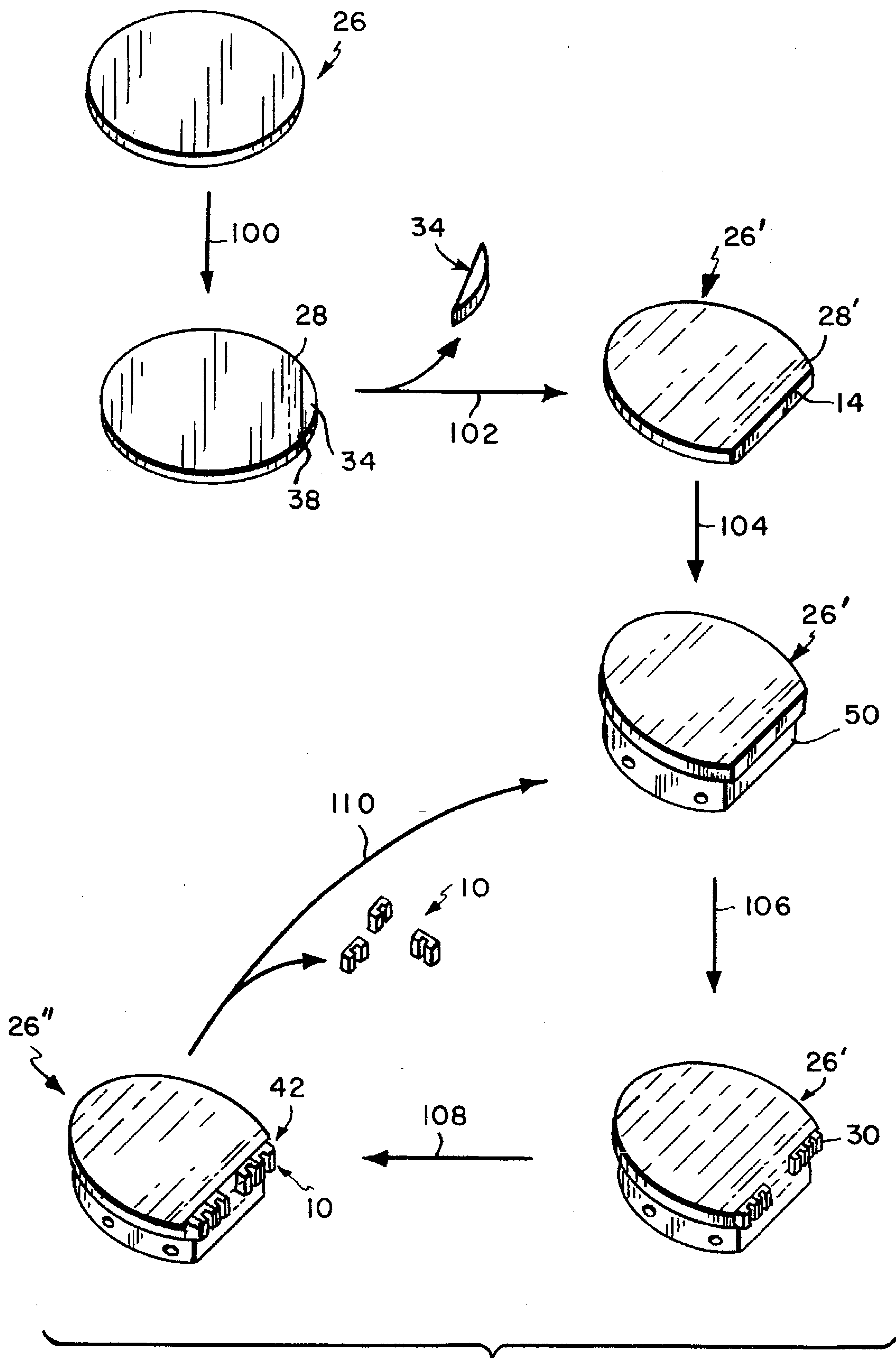

FIG.3

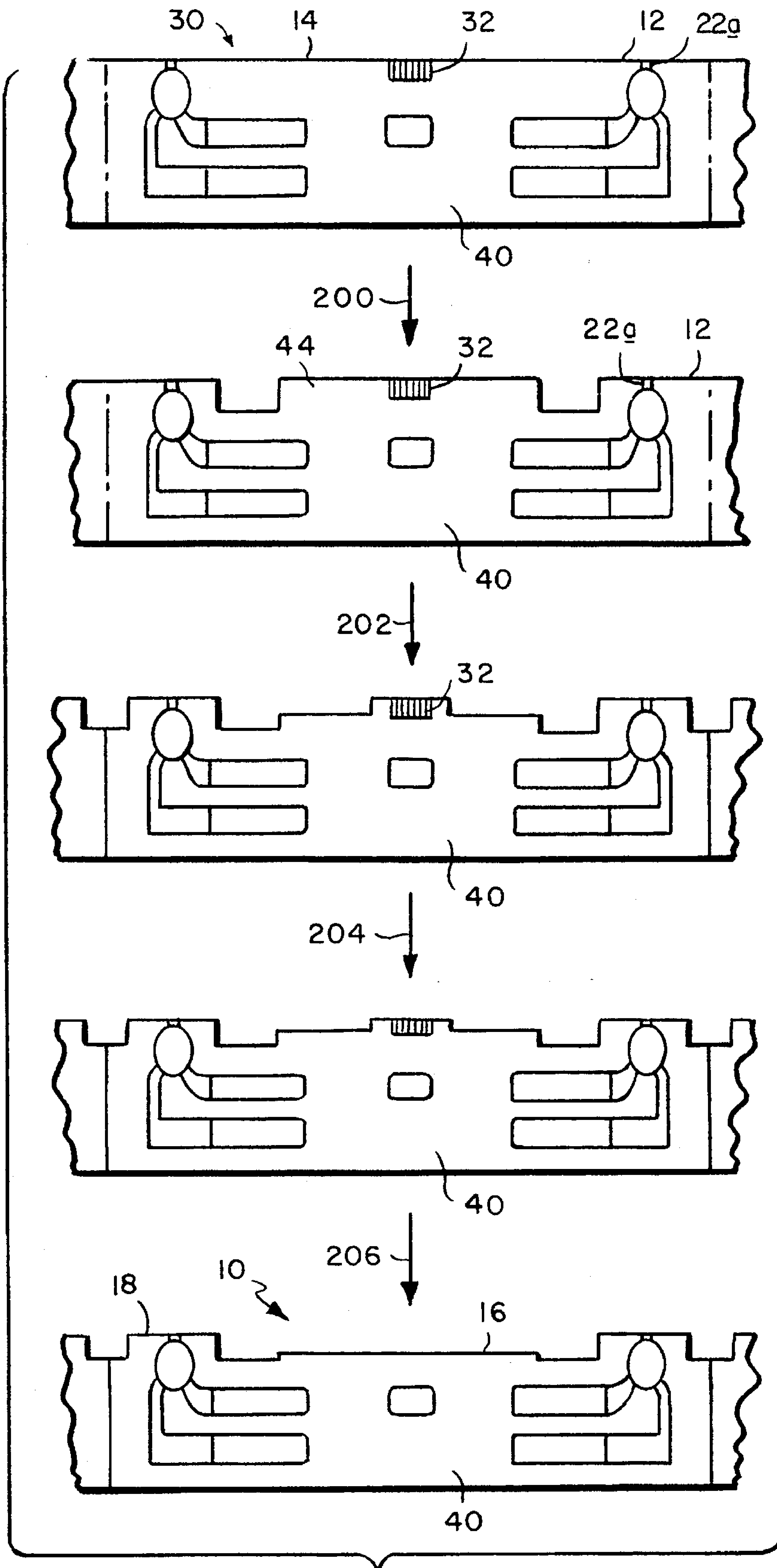

FIG. 4

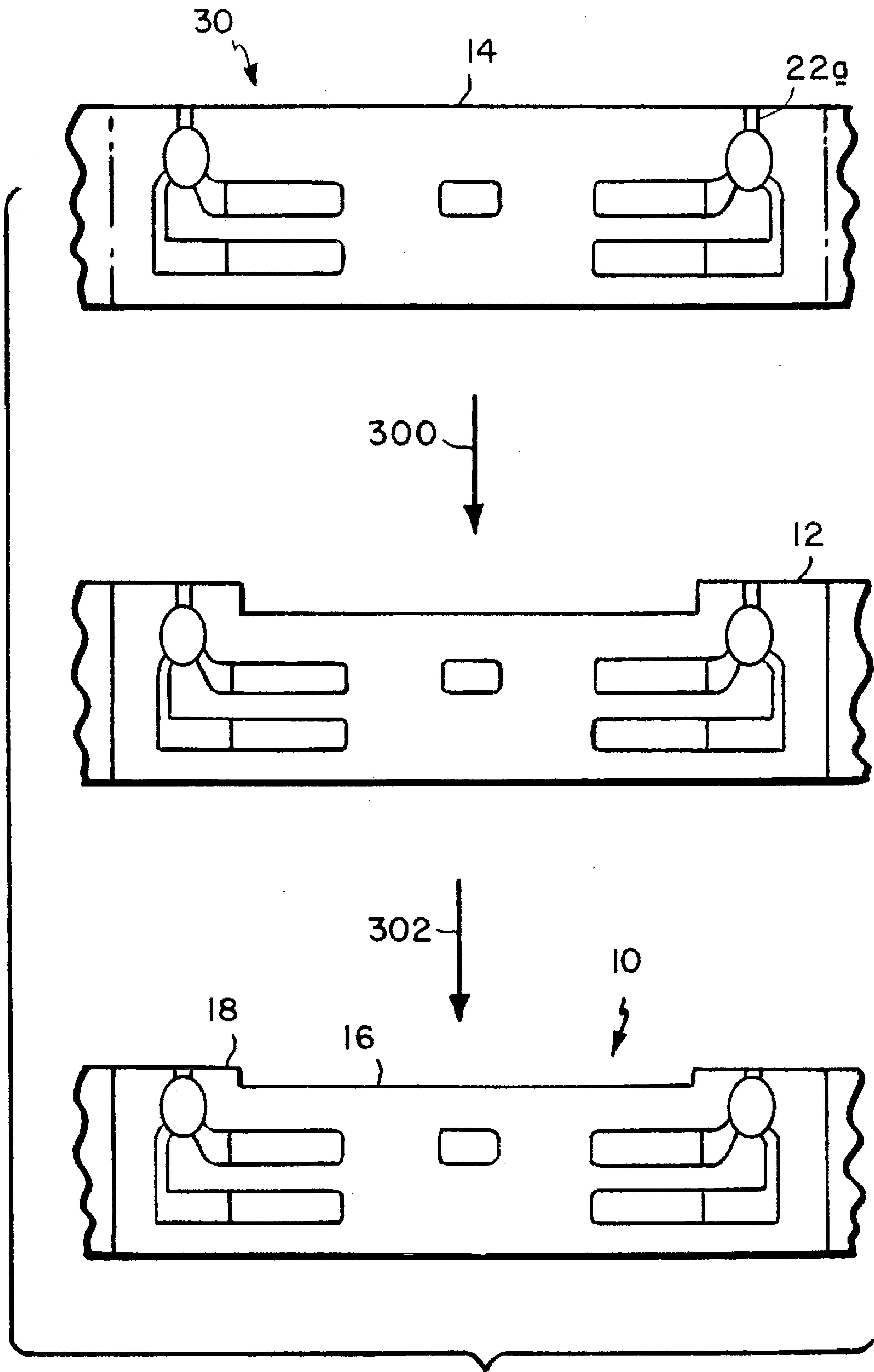

FIG.5

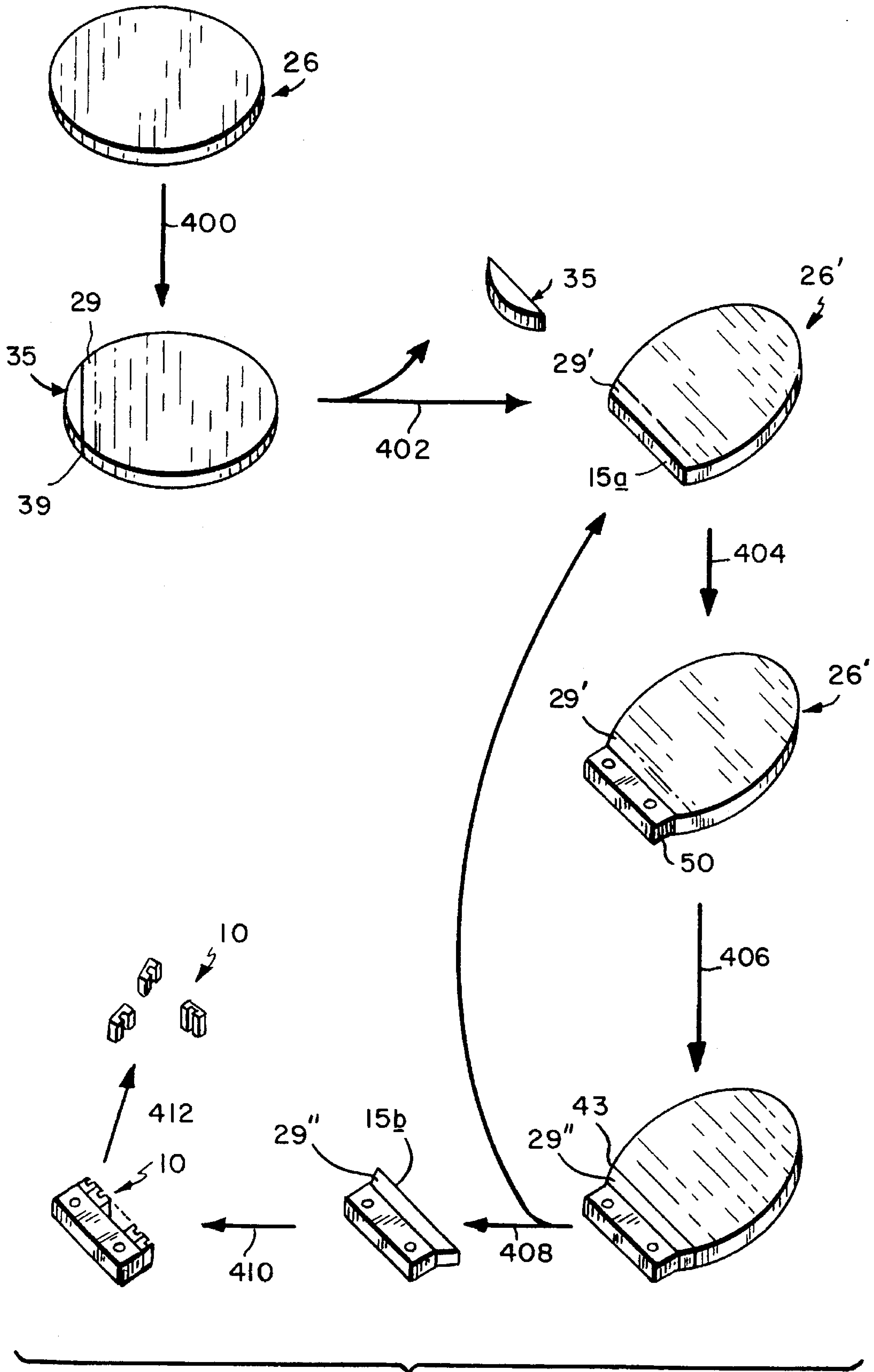

FIG. 7

52

FIG. 8

54

14

54a

56

54b

FIG. 8A

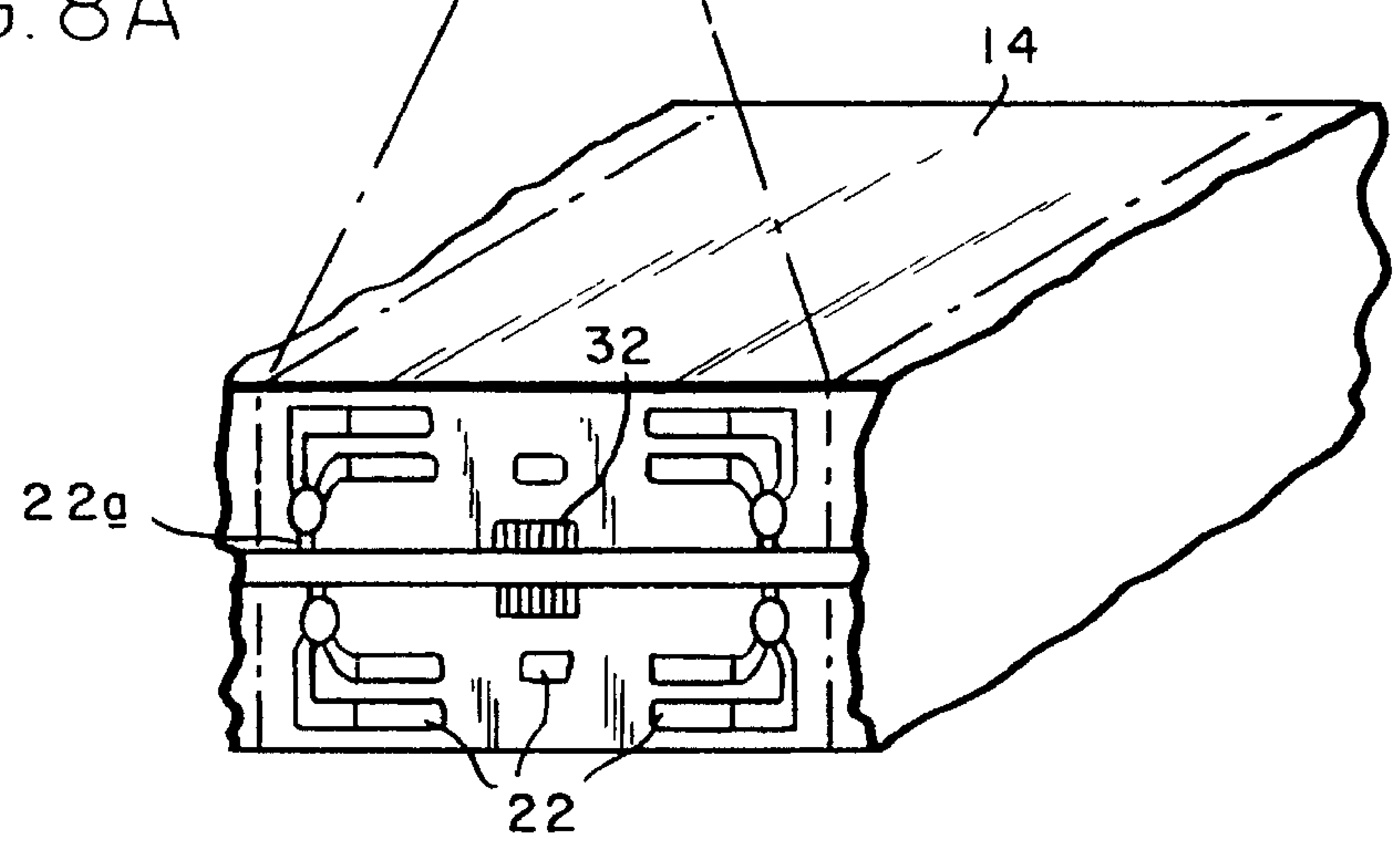

FIG. 8B

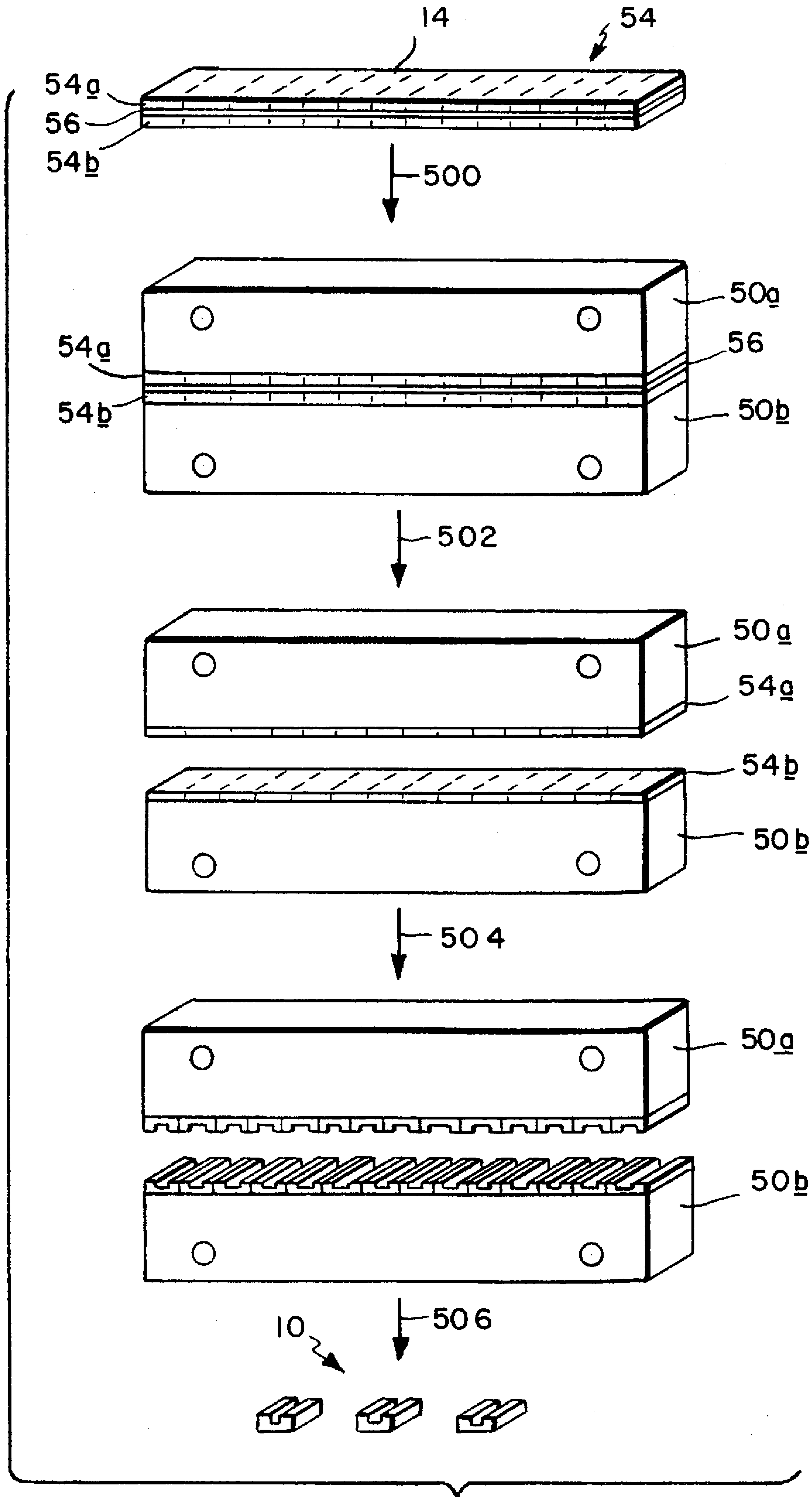

FIG. 9

62

FIG. 10

14a
64
64a
66
64b
14b

FIG. 10A

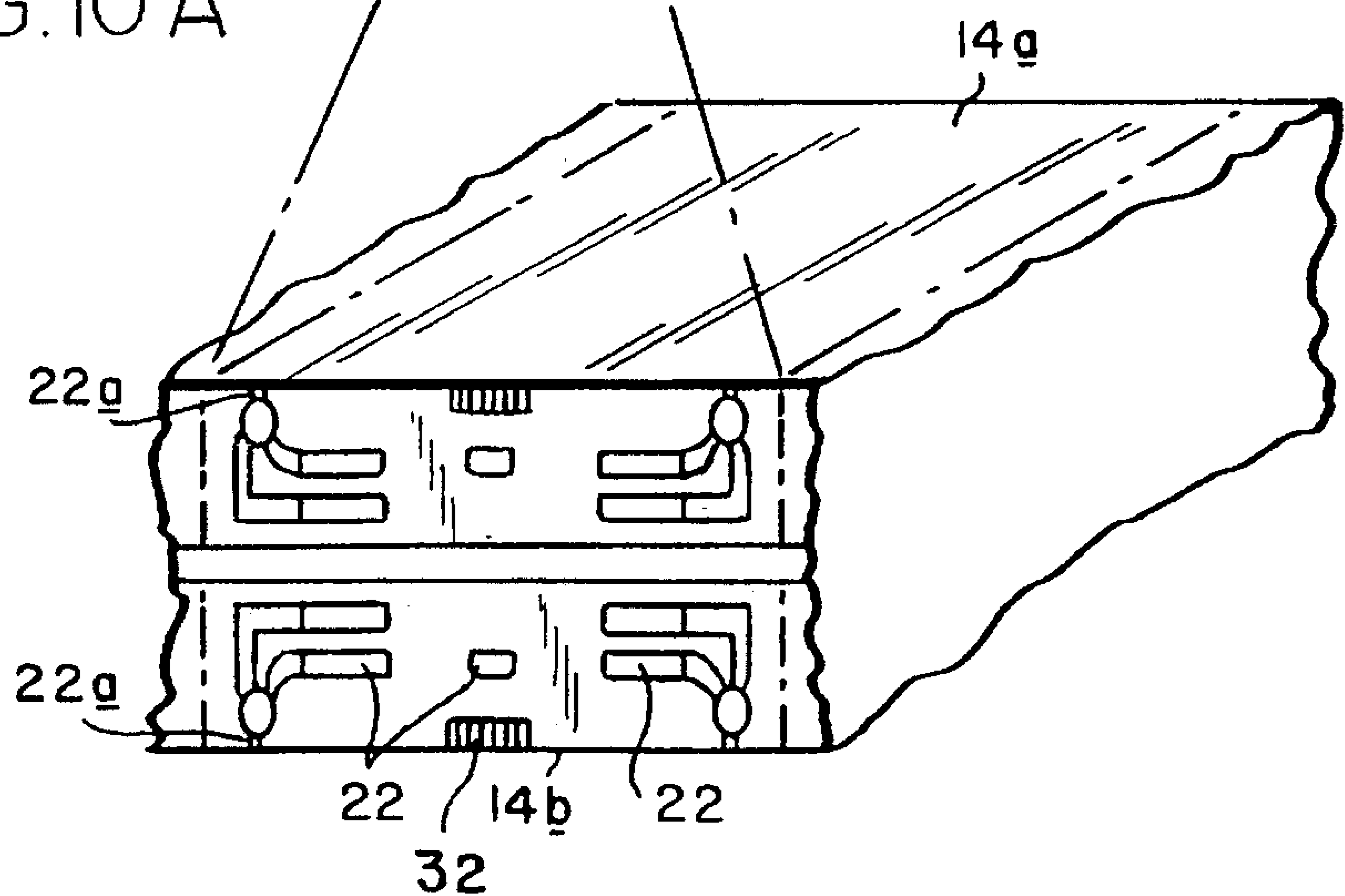

FIG. 10B

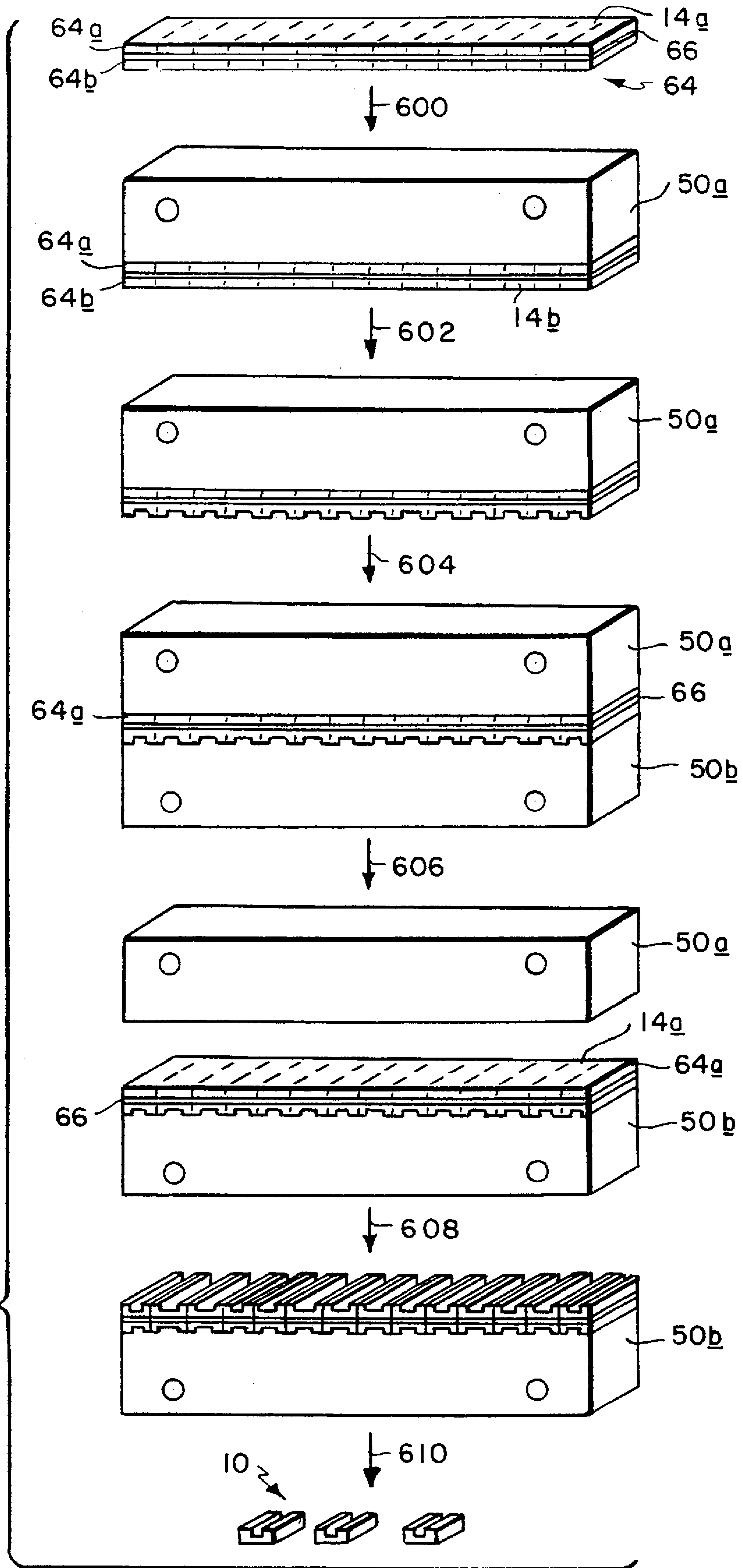

FIG.11

THIN FILM HEAD SLIDER FABRICATION PROCESS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

This invention relates generally to fabrication of thin film electromagnetic read/write head assemblies, and particularly to a method for fabricating thin film head sliders from a pre-processed wafer which contains on one face a plurality of electromagnetic devices arranged in rows.

BACKGROUND OF THE INVENTION

Magnetic disk drive systems are used to read and write information to and from magnetic disks. Typically, the disk is mounted on a spindle such that the disk can rotate to permit an electromagnetic head mounted on a movable arm positioned near the disk's surface read or write information thereon.

During operation, the system moves the head to a desired radial position on the surface of the rotating disk where the head electromagnetically reads or writes data. Usually, the head is integrally mounted in a carrier called a "slider." A slider generally serves to mechanically support the head and any electrical connections between the head and the rest of the drive system.

Since the slider is aerodynamically shaped to glide over moving air, it generally maintains a uniform distance from the surface of the rotating disk, thereby preventing the head from undesirably contacting the disk.

Typically, a slider is formed with two parallel rails with a recessed area between the rails and with each rail having a ramp at one end. The surface of each rail that glides over the disk surface during operation is known as the "air-bearing surface."

A head is typically an electromagnetic device containing magnetic poles. These poles terminate on the air bearing surface and function to electromagnetically interact with the data contained in the magnetic disk.

According to the prior methods, a group of thin film sliders are fabricated from a single wafer that contains on its top face electromagnetic devices, i.e., heads, arranged in rows. Initially, single-row bars are sliced from a wafer, each bar comprising a row of units which can be processed into sliders having heads on their end faces. Each bar is then bonded to a fixture where the bar is then processed and separated into individual sliders.

During this process, it is critical to lap the bar to a desired thickness in order to achieve a desired throat height, i.e., the height of a pole above the pole widening point, for all the poles on the bar. The single-row bars tend to bow or bend. making it very difficult to attain this objective.

There is a need, therefore, to solve the bow problems associated with single-row bars so that sliders with desirable throat heights can be easily fabricated.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a head assembly fabrication method which greatly improves the control of an important performance parameter of magnetic recording heads. i.e., throat height.

Mechanical processing of thin bars, which incline to bow, to fabricate sliders is the main cause of throat height control problems. The present invention provides a solution to these problems by thickening the workpieces. Since the bowing of an object is inversely proportional to the cube of its thickness, this reduces bowing of the workpieces to negligible proportions.

More specifically, we increase the effective thickness of a bar to be fabricated into sliders by anchoring it to a relatively rigid and thick object before it is severed to a single-bar status. As a result, the resistance of the bar to bowing is materially enhanced, and an identical and desired throat height for the poles on such a bar can be easily attained by lapping.

Four embodiments are disclosed herein. Two of them use the wafer from which the bars are formed to add effective thickness to the bar and thereby resist bending or bowing of the bars. The other two operate on integral pairs of bars, the bars in each pair being severed from each other only after they have been bonded to a fixture or have been mechanically processed. Even the latter embodiments of the invention effectively solve the bow problems by doubling the thickness of a bar, since they provide an increase of an order of magnitude in the stiffness of the workpieces. Thus, the foregoing embodiments represent the maximal and minimal applications of the concept, namely, effectively thickening the workpieces.

A wafer used for fabrication of sliders typically comprises rows of bars; each row can be processed to form a plurality of sliders. In the first embodiment of this invention, a single-row bar is lapped to the desired throat height while remaining integral with the remainder of the wafer. The bar is later sliced from the wafer only after it has been fabricated into sliders.

The second embodiment differs from the first one in that a single-row bar is sliced from the wafer after it has been bonded to a lapping fixture. Bonding of a single-row bar to a fixture in this manner induces no or little bow on the bar, as compared with bonding of a free standing single-row bar. Nor does lapping of such a single-row bar cause the bar to bow, since the future increases effective thickness, or resistance to bowing, of the bar.

According to the third and fourth embodiments, a double-row bar sliced from a wafer is first bonded to a lapping fixture before it is lapped or sliced into two single-row bars.

In none of the embodiments is it necessary to bond a free standing, single-row bar to a lapping fixture. In other words, a single-row bar is lapped only when it is anchored to a relative rigid and thick object under conditions which induce no bow on it.

There are several advantages to this invention. First of all, it solves all the bow problems associated with the use of a free-standing single-row bar. In addition, it improves air beating surface ("ABS") flatness, another important performance parameter, of raiders. This problem is lessened by the present invention, since it is now possible to lap sliders in a bar without bonding the bar to a transfer tool and without inducing bow of the bar. The adhesive bond is known to adversely effect ABS flatness.

Also, the cycle time for slider fabrication is materially reduced, as many intermediate processing steps may be eliminated, including visual inspection of throat heights using lapping guides as the indicator. Thus, it is no longer necessary to fabricate one lapping guide for each head on the wafer. All these lead to decrease in production costs.

The above and further advantages of the invention may be better understood by referring to the following description in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a typical 2-rail design thin film head slider;

FIG. **2** is a perspective view of a pre-processed wafer and FIGS. **2**A and **2**B depict detailed structure thereof, from which the FIGS. **1** and **6** sliders are fabricated according to the processes depicted in FIGS. **3** and **7**;

FIG. **3** is a schematic representation of one embodiment in accordance with the present invention;

FIG. **4** illustrates one approach for mechanically processing a bar containing electromagnetic devices into FIG. **1** sliders, the bar being shown in side elevation;

FIG. **5** illustrates another approach for mechanically processing a bar containing electromagnetic devices into FIG. **6** sliders, the bar being shown in side elevation;

FIG. **6** is a perspective view of a modified 2-rail design thin film head slider;

FIG. **7** is a schematic representation of a second embodiment in accordance with the present invention;

FIG. **8** is a perspective view of a pre-processed wafer and FIGS. **8**A and **8**B depict well as detailed structure thereof, from which the FIGS. **1** and **6** sliders are fabricated according to the process depicted in FIG. **9**;

FIG. **9** is a schematic representation of a third embodiment in accordance with the present invention;

FIG. **10** is a perspective view of a pre-processed wafer and FIGS. **10**A and **10**B depict detailed structure thereof, from which the FIGS. **1** and **6** sliders are fabricated according to the process depicted in FIG. **11**; and,

FIG. **11** is a schematic representation of a fourth embodiment in accordance wnh the present invention.

In all the drawings, identical numbers represent identical or similar elements. Various elements shown in the drawing are not necessarily in proportion to their actual sizes. Further, as used herein the terms such as "top", "bottom" and the like are intended only to denote relative direction solely with reference to the illustrations in the accompanying drawings.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

In FIG. **1** we have illustrated a typical 2-rail, thin film head slider. This slider, designated by the numeral **10**, is generally rectangular in shape. It consists of two portions, i.e., a slider portion **20** and a head portion **40** on an end face of the slider portion **20**.

The slider portion **20**, which constitutes the bulk of the thin film head slider **10**, is made of Al_2O_3-TiC or other suitable material. This portion **20** comprises, in general, two parallel rails **12** on both sides of a recessed face **16** of the slider **10**. The top surface **18** of each rail **12** constitutes an air bearing surface of the slider **10**. At the end of the air bearing surface **18** opposite the head portion **40** is a slope or a ramp **23**. The rails **12**, the recessed face **16**, and the air bearing surfaces **18** are all important structural features that enable the head portion **40** to "fly" at a short distance from the surface of a magnetic disk.

The head portion **40** is a thin layer of Al_2O_3 containing an electromagnetic device **22** which is constructed by a conventional photolithography process. The electromagnetic device **22** includes poles **22**a that terminate at their upper ends on the surface **18** of the rails **12**. The device **22** also includes other components which are unrelated to the

present invention. The poles **2242** are made of a suitable ferromagnetic material such as NiFe. As mentioned above, for a thin film head slider **10** to function properly, it is important that the throat height, i.e., the height of pole **22**a above a so-called "pole widening point" (not shown), be near "zero throat" or about 40 microinches.

The above-described 2-rail, thin film head slider **10** has been fabricated from a pre-processed wafer. FIGS. **2**, **2**A and 2B depicts the structure of such a wafer The wafer **26** comprises a wafer substrate **20** that is made of Al_2O_3-TiC, and is covered by a thin layer **40** of Al_2O_3. The electromagnetic devices **22** are formed in the layer **40**. The devices **22** are arranged in rows and are identically oriented.

Specifically, the wafer **26** comprises a matrix of slider units **30** which when fully processed will become sliders **10**. The view shown in FIG. **2** is an end view of the individual units **30**, the devices **22** having been formed on the ends of the units **30** exposed in this view. As shown in FIG. **2**, a plurality of identical bars **28** each of which comprises a row of identical slider units **30**, together with superfluous sections, such as a top section **34** and a bottom section **35**, constitute the wafer **26**.

A wafer may be fabricated to contain any desirable number of rows of slider units **30** and any desirable number of slider units **30** in each row. The pre-processed wafer **26** shown in FIG. **2**A contains thirty two rows of slider units **30**, and fourteen slider units **30** in each row.

The slider unit **30** shown in FIG. **2**B is identical with the finished slider **10** shown in FIG. **1**, except that the rails **12** and recessed face **16** are not yet formed and the throat height for the poles **22**a is greater in the unit **30**. Since the throat height for poles **22**a in each unit **30** is greater than that in finished slider **10**, lapping of the face **14** of each unit **30** in a controlled manner is accomplished to obtain a slider **10** with the desired throat height. This is achieved by the provision of a lapping guide **32** in each unit **30** when the wafer is fabricated (see FIG. **2**). Under the prior methods of fabrication, the lapping guide **32** can be used as an indicator of the throat height during microscopic inspection of the processed unit **30**, as will be discussed below.

One embodiment of the inventive process for fabricating the sliders is depicted in FIG. **3**. A single slice cut **38** is first made on the wafer **26** to remove the top superfluous, non-functional section **34** (steps **100** and **102**), thus exposing the face **14** of an outermost bar **28**. It should be noted that the face **14** is the face on which the poles **22**a terminate (see the lowermost view of FIG. **2**).

Once the slice cut **38** is made, the sliced wafer **26**' is affixed to a fixture **50** in such manner so that the exposed face **14** of the outermost bar **28**' is susceptible to mechanical processing, while the bulk of the sliced wafer **26**' is secured to the future **50** (step **104**). The fixture **50** is referred to as the lapping future hereinafter, since throat lapping (i.e., lapping the throat height to a desired height), as well as other mechanical processmg operations, is performed on the outermost bar **28**' while the wafer is affixed to this fixture **50**.

In the next step **106**, the exposed face **14** is subjected to a series of grinding and lapping processes to define the air bearing surface rails **12**, to form ramps **23** on the rails **12**, to create a recessed face **16** between the air bearing surface rails **12**, and to obtain a proper throat height for the poles **22**A on the bar **28** (see FIG. **1**). The bar **28**' thus processed is then subjected to the part-off process, i.e., vertical cuts are made to separate the slider units **30** therein. These rail definition, ramp formation, part-off, throat lapping and rail relief processes may be performed in two different ways,

which are shown in FIGS. **4** and **5**, respectively, and will be discussed in more detail below.

The processed bar **28**' is then sliced into individual thin film head sliders **10** by making a single cut **42** extending through the sliced wafer **26**' (step **108**). The remainder of the wafer, together with the sliders **10** thus formed, is then removed from the lapping fixture **50** (step **110**). The reduced sliced wafer **26**" can now be realigned and fastened onto the same fixture **50** so that the newly exposed face from the cut **42** is susceptible to mechanical processing, and the entire sequence is repealed until all bars on the wafer have been processed into individual sliders.

Since the sliced wafer has to be fastened to and detached from the lapping fixture **50** repeatedly, it will be more effective to affix the wafer to the fixture **50** by means of readily releasable mechanical clamp, instead of using a bonding agent.

Also, since the wafers are relatively fragile and may crack when subjected to excessive external form, it is desirable to bond each wafer to a lava substrate (not shown) so that the wafer can be indirectly secured to the fixture via the substrate during the entire fabrication process. The substrate portions attached to the individual sliders **10** are removed at the end of the fabrication process by debonding.

According to the prior method of fabricating sliders from a wafer, the wafer is first sliced into free-standing single-row bars. The single-row bars are then each fastened to a fixture via the slice surface distal from the poles, using an adhesive for grinding and lapping. As mentioned above, in order for a thin film head slider, such as that shown in FIG. **1**, to function properly, the throat height has to be within a precise range. This is achieved by lapping the exposed slice surface of the single-row bar until all the poles on the bar attain near "zero throat" with the aid of lapping guides. However, all poles on a single-row bar can be lapped simultaneously to the desired and identical throat height only if all the electromagnetic devices on the single-row bar are colinear during the throat lapping process.

The task of maintaining colinearity of the electromagnetic devices on a free-standing single-row bar is very difficult for several reasons. First of all, since a single-row bar is very thin (about 0.025 inches), it tends to bow. Fuxthermore, each single-row bar has two slice surfaces. These slice surfaces tend to have non-homogeneous stresses because of the slice cuts. Such stresses also cause the bar to bow. To minimize this effect, both slice surfaces are usually lapped to remove the stressed material before fastening to a lapping fixture. Also, the bonding process for fastening a free-standing single-row bar to a lapping fixture may induce bow on the bar.

The bow problems associated with a free-standing single-row bar result in different throat heights of the sliders fabricated by the prior methods. Such variance in throat heights, in turn, affects the read/write performance of the sliders- Processing a free-standing single-row bar also results in another drawback, i.e., unevenness of the air beanng surfaces. Although the flatness requirement for the air bearing surfaces is easier to attain than the throat height requirement for the poles, it nonetheless is somewhat difficult to meet when processing a free-standing single-row bar.

Both of these problems, which result from the bow of a free-standing single-row bar, are essentially eliminated in the fabrication process embodiment of the present invention described above, since a stiff, solid wafer rather than a bar, is lapped according to this new method and a solid wafer does not bow. The poles of all electromagnetic devices on one bar can therefore be lapped to an identical, specific throat height. In addition, according to the present invention, it is no longer necessary to lap the exposed slice surface to release stresses on it before bonding the sliced wafer to a lapping fixture. Neither is it necessary to perform the difficult task of bonding a very thin bar to a lapping fixture. Instead, a sliced wafer, which is relatively solid and large, can be easily fastened to such a fixture before it is further processed into sliders.

Refer now to FIG. **4**, which schematically illustrates one approach that may be taken to perform step **106** in FIG. **3**, namely, to contour the exposed surface **14** of a wafer **26**' fastened to a lapping future **50** to form sliders **10**. For each unit **30**, two parallel rails **12** on both sides and a third rail **44** between them are first formed on the surface **14**, where the poles **22**a terminate, by a grinding operation (step 200). A second grinding operation further defines the parallel rails **11** (step 202). One can also cut and divide all the units **30** in the bar from each other at this step.

Since throat lapping must be stringently controlled, it is the most time-consuming operation in the prior slider fabrication process, and is thus preferred to be performed only after the grinding operations are completed so that only minimum surfaces have to be lapped. Also the lapping guide **32** is kept intact throughout both grinding operations (steps 200and 202) so that it can be subsequently used to control the lapping of poles **22**a to a specific throat height. Once the poles **22**a are lapped to near "zero throat" (step 204), a ramp (not shown FIG. **4**) is then lapped on each of the air bearing surfaces **18** which are formed by the just-mentioned throat lapping operation. Finally, a third grinding operation (step 206) is performed to relieve the area between the parallel rails **12** to form the recessed face **16**, and a slider **10** is thus fabricated. As mentioned above, the recessed area **16** thus formed, together with the air bearing surfaces **18** and ramps, are important structural features of a slider **10**.

The grinding and lapping step depicted in FIG. **4** are similar to those used in the prior single-row bar fabrication process. In particular, a lapping guide **32** is included in the central region of the head portion **40** in each unit **30** and is not removed by grinding until the throat lapping step is completed, as shown in FIG. **4**. This is because it is necessary to inspect each unit for throat height by viewing the lapping guide in that unit to ensure that a desired throat height has been attained. However, since the bar being lapped does not bow according to the FIG. **3** embodiment, it is no longer necessary to inspect all the throat heights during and after the throat lapping process. It follows that inclusion of a lapping guide in the central region of the head portion in every unit and its removal only subsequent to the throat lapping step are not necessary either.

FIG. **5** depicts an alternative grinding and lapping approach that may be incorporated into step **106** of FIG. **3** for fabricating sliders **10**. This process is made possible by elimination of the need to visually inspect each unit during and after the throat lapping process as discussed above.

The bar shown in FIG. **5** contains only one lapping guide at each end thereof (not shown). Two parallel rails **12** are readily formed in one single grinding operation (step 300), as compared to the FIG. **4** approach which uses three separate grinding operations (steps 200, 202, and 206). The bar can also be cut to divide all the units **30** therein from each other at this step. Lapping, step 302, is then performed to attain the desired throat heights by making use of the two lapping guides. After all poles **22**a on the bar have been lapped to the desired throat height, a ramp is lapped on each

of the air beating surfaces **18** (the step not shown). As shown in FIG. **5**, the part-off step, i.e.. separation of sliders **10**, is implemented before the throat lapping process although it can also be performed thereafter if desired.

A slider **10** fabricated following the procedure depicted in FIG. **5** is shown in FIG. **6**. Although there are minor structural differences between the sliders **10** shown in FIGS. **1** and **6**, both are functionally identical in their read/write performance.

Another embodiment of the present invention is schematically represented in FIG. **7** and will be described below with reference to FIGS. **1** to **6**.

In this embodiment, a superfluous section **35** of the wafer **26** is first sliced from the wafer **26** by a single cut **39** to expose one surface **15**a of the outermost bar **29** (steps 400 and 402). Note that removal of superfluous section **35**, unlike removal of section **34** (FIG. **3**), results in a slice surface **15**a which is distal from the poles **22**a. As a result, the sliced wafer **26'** is not ready to be processed. In order to expose a surface on which the poles **22**a terminate so that throat lapping and other processing steps can be performed, the sliced wafer **26'** is first bonded to a lapping fixture **50** via the slice surface **15**a (step 404). Before the bonding, the slice surface **15**a may be lapped to remove any stressed material, if necessary.

The outermost bar **29'** is then separated from the remainder of the sliced wafer **26'** by another slice cut **43** (steps 406 and 408). The single-row bar **29**, while fastened to the fixture **50**, now has a slice surface **15**b on which the poles **22**a terminate and which can be contoured following the approach of FIG. **4** or FIG. **5** to produce the sliders **10** as shown in FIGS. **1** and FIG. **6**, respectively (step 410). Finally, the sliders **10** thus fabricated are debonded from the lapping fixture **50** (step 412). The same process can be repeated until all bars in the wafer **26'** are fabricated into sliders **10**.

In the FIGS. **3** and **7** embodiments of the invention, the single-row bars are never bonded or clamped to a lapping fixture **50** when they are free-standing. That is, each bar remains an integral part of the wafer when it is fastened to the lapping fixture **50** on which it is processed into sliders. This prevents the bow that occurs when a free standing single-row bar is mounted on a fixture. As a result, the colinearity of the electromagnetic devices on the bar is maintinned during the fastening process.

The wirer **26** used in the FIGS. **3** and **7** embodiments of this invention contains on its top face electromagnetic devices **22** of identical orientation (see FIG. **2** and description thereof). By contrast, the two further embodiments as illustrated in FIGS. **9** and **11** are implemented with wafers **52** and **62** (FIGS. **8** and **10**), respectively, where the electrumagnetic devices **22** on each row are oriented in a direction which is opposite to that of the adjacent row(s).

More specifically, as shown in FIGS. **8**, **8**A and **8**B, the top two rows **54**a and **54**b of electromagnetic devices **22** of a wafer **52** have devices **22** arranged with the poles **22**a on row **54**a face those on row **54**b, with a "street" **56** disposed between the two rows **54**a and **54**b. The "street" **56**, unlike rows **54**a and **54**b which contain electromagnetic devices **22**, is void of any functional elements. As will be explained below, it serves to provide tolerance in slicing the double-row bar **54** into two single-row bars **54**a and **54**b, and also serves to provide some thickness which greatly contributes to the solution of the bow problems associated with processing of single-row bars. A "street" with a thickness 61% that of a single-row bar has been found to be satisfactory for both purposes.

For the wafer **52** shown in FIG. **8**, the same row-street-row pattern is repeated **16** times. As a result, **16** identical double-row bars **54** can be obtained by properly slicing the wafer **52**. For each double-row bar **52** sliced from the wafer **51**, the poles **22**a on both rows and **52**b remain embedded and are thus not ready to be lapped.

FIG. **9** shows how the wafer **52** in FIG. **8** is processed. In the first step (step 500), a double-row bar **54** is bonded simultaneously, via the slice surfaces **14**, to two lapping fixtures **50**a and **50**b. The double-row bar **54** is then sliced, along the "street" **54**, into two singlerow bars **52**a and **52**b (step 502). The two single-row bars **52**a and **52**b remain fastened to the fixtures **50**a and **50**b, respectively, after the slice cut. Provision of the street **56** minimizes the likelihood that the poles are inadvertently damaged during this slice cut. With the poles exposed by the slice cut, the grinding and lapping processes of FIG. **4** or FIG. **5** are then followed to contour each single-row bar **52**a or **52**b to form sliders **10** of FIG. **1** or FIG. **6** (step 504). Finally, the individual sliders **10** are debonded from the fixtures **50**a and and **50**b (step 506).

The structure of a wafer **62**, which can be used in the FIG. **11** embodiment, is shown in FIGS. **10**, **10**A and **10**B. The electromagnetic devices **211** on the top two rows of the wafer **62** are arranged so that the poles **22**a on the top row **64**a are distal from those on the second row **64**b, and vice versa. A "street" **66** similar to that provided in wafer **52** in FIG. **9** spaces the two rows **64**a and **64**b apart for the purposes stated above. Repetitions of the same row-street-row pattern on the wafer **62** enable one to produce a plurality of identical double-row bars **64** by repeated slice cuts. Each double-row bar **64** thus produced has poles **22**a that terminate on both slice surfaces **14**a and **14**b. As Shown in FIG. **11**, a double-row bar **64** is bonded to a lapping fixture **50**a via one of its slice surfaces **14**a (step 600). The slice surface **14**a may first be lapped to remove stressed material prior to the bonding, if necessary. The exposed slice surface **14**b of the double-row bar **64** is then mechanically processed following the steps of FIG. **4** or FIG. **5**, except that the part-off operation is not performed (step 602) In the next two steps **604** and **606**, the processed slice surface **14**b is bonded to a second lapping fixture **50**b, and the unprocessed surface **14**a is debonded from the first fixture **50**a. The unprocessed slice surface **14**a is now exposed and subjected to the gnnding and lapping processes (step 608). The part-off cuts are then made in such a way as to extend both rows **64**a and **64**b, so that the sliders on both rows **64**a and **64**b are divided (also, step 606).

Finally, a slice cut along the "street" **66**, followed by debonding from the second lapping fixture **50**b, releases the individual sliders **10** (step 610).

Note that in contrast the prior fabrication methods in which a single-row bar ts bonded to a lapping fixture, both the FIG. **9** and FIG. **11** embodiments bond a double-row bar to one or two lapping fixtures, followed by a slice cut of the double-row bar into two single-row bars. This approach essentially eliminates the bow problems associated with the mechanical processing of a free-standing single-row bar.

Specifically, the degree that an object bows in the presence of an external deflection force is determined by both the thickness of the object and the magnitude of the force. That is, the degree of bow is proportional to the magnitude of the deflection force and inversely proportional to the cube of the object's thickness. Therefore, the resistance of an object to bowing rises very rapidly with the increase in thickness. For example, a double-row bar, which contains a "street" with a thickness 61% of a single-row bar, is 2.61 times as thick as

a free-standing single-row bar, and the bow of this double-row bar will only be 2.61^{-3}, or 5.6%, that of a single-row bar for the same deflection force.

Similarly, in both FIGS. **3** and **7** embodiments, a sliced wafer, which is very much "thicker" than a single-row bar, is always fastened to a lapping fixture as the initial step in processing the wafer into sliders. As a result, any bow is essentially negligible. Even when only one last single-row bar remains on the sliced wafer for mechanical processing, the "thickness" of this reduced sliced wafer, which consists of the superfluous section **34** or **35** and the last single-row bar, is still much greater than that of a freestanding single-row bar.

Despite their operational differences, there is one single concept which underlies all the four embodiments as illustrated in FIGS. **3**, **7**, **9**, and **11**. That is, it is critical not to process a free-standing single-row ban at all times. In other words, one should always have a single-row bar anchored to a relatively rigid and thick object so that the single-row bar becomes highly unlikely to bow, both before and after it is fastened to a lapping future for mechanical processing.

The present invention is to embrace all head assembly fabrication processes which are covered by the concept discussed above., namely, a single-row bar does not bow, or only bows very slightly, if a relatively rigid and thick object is anchored thereto. Thus, although the foregoing description bas been limited to specific embodiments of this invention, it will be apparent, however, that variations and modifications may be made, with the attainment of some or all of the advantages of the invention.

For example, the relatively rigid and thick object to which a single-row bar is anchored, as taught in this invention, can be any suitable material, including an unprocessed wafer. As another example, while fabrication of thin film head sliders for a magnetic disk drive system is disclosed herein, the similar process can also be used to manufacture head assemblies to be used in a magnetic tape drive system. Therefore, it is the object of the appended claims to cover all such variations and modifications as come within the true spirit and of the invention.

What is claimed is:

1. A process for the fabrication of electromagnetic head assemblies from a bar on a first surface of which a plurality of electromagnetic devices are provided as a single row and with like orientation, the bar being integral along a second surface with an adjacent substrate portion, which fabrication process comprises the steps of:

anchoring the [first surface] *substrate portion* to a fixture,

while the [bar] *substrate portion* is anchored [along the first surface], forming head assemblies along *a third surface of* the bar, *the third surface being opposed to the second surface;* and

separating the individual head assemblies.

2. The process defined in claim **1** wherein the adjacent substrate portion is anchored to a fixture with a side surface of the bar, which is opposed to the second surface, exposed [for said] *to facilitate thereon* mechanical operations *that form the head assemblies.*

3. The process defined in claim **2** wherein the adjacent substrate is a wafer.

4. The process defined in claim **2** wherein the adjacent substrate is a second bar identical to the first bar.

5. The process defined in claim **1** further comprising the step of severing the bar from the adjacent substrate portion to expose the second surface of the bar for the mechanical operations.

6. The process defined in claim **5** wherein the adjacent substrate is a wafer.

7. The process defined in claim **5** wherein the adjacent substrate is a second bar identical to the first bar.

8. A process for the fabrication of electromagnetic head assemblies from a wafer comprising rows of electromagnetic devices formed thereon, each row and the underlying portion of the wafer being a bar of head assembly units, which fabrication process comprises the steps of:

anchoring [the bar] *at least a portion of the wafer* to a fixture with a side surface *of a bar* exposed, *the wafer portion being thicker than the bar;*

while the [bar] *wafer* is anchored, forming head assemblies along the side surface of the bar; and,

severing the individual head assemblies from the wafer.

9. The process defined in claim **8** further comprising the steps of:

removing the wafer from the fixture after the severing step,

anchoring the wafer to the fixture with a side surface of another bar exposed,

while the bar is anchored, forming head assemblies along the side surface of the bar,

severing the individual head assemblies from the wafer, and,

repeating the foregoing steps until all bars in the wafer have been processed.

10. The process defined in claim **8** wherein the wafer is anchored to a fixture followed by its severance from the fixture to expose a side surface of the bar for chanical operations.

11. The prooess deemed in claim **10** further comprising the steps of:

anchoring the wafer to the fixture with a side surface of another bar exposed, and,

repeating all the steps of claim **9** until all bars in the wafer have been processed.

12. A process for manufacturing electromagnetic head assemblies from a fabricated wafer which contains on one surface electromagnetic devices arranged in rows in identical orientation, said process comprising the steps of:

removing a part of the wafer to expose the surface on which the poles of the electromagnetic devices in a first row terminate,

fastening the wafer to a fixture in such a manner so that the exposed surface is susceptible to mechanical processing,

lapping and grinding the exposed surface so that a desired throat height of the poles and a desired contour of the row are attained,

parting the processed row into individual head assemblies, and,

removing the head assemblies from the remainder of the wafer by a slice cut, thereby generating a smaller wafer with an exposed surface on which the poles of the electromagnetic devices on a row adjacent to the first row terminate.

13. The process defined in claim **12** wherein the last three steps are repeated.

14. The process defined in claim **12** wherein the partial wafer is fastened to the future by bonding.

15. The process defined in claim **12** wherein the partial wafer is fastened to the fixture by clamping.

16. The process defined in claim 12 wherein the wafer is bonded to a lava substrate before it is fastened to the fixture via the lava substrate. and the lava substrate is debonded from the head assemblies formed as the last step of the process.

17. A process for manufacturing electromagnetic head assemblies from a fabricated wafer which contains on one surface electromagnetic devices arranged in rows in identical orientation. said process comprising the steps of:

removing a part of the wafer to expose the surface of one row, which surface being distal from the poles of the electromagnetic devices on the row;

fastening the wafer to a future via the exposed surface of the row,

separating the remainder of the wafer from the row, thereby leaving exposed the surface of the row on which the poles terminate and generating a smaller wafer;

lapping and grinding the newly exposed surface of the row so that a desired throat height of the poles and a desired contour of the row are attained,

parting the processed row into head assemblies, and, removing the head assemblies from the fixture.

18. The process defined in claim 17 wherein the fastening step and all steps subsequent thereto are repeated.

19. A process for manufacturing electromagnetic head assemblies from a fabricated wafer which contains on one surface electromagnetic devices arranged in rows, the electromagnetic devices on a given row being in one orientation while those on the adjacent row being in an opposite orientation, said process comprising the steps of:

slicing the wafer in such a manner to produce a plurality of identical double-row bars each having the poles of the electromagnetic devices on one row face those on the other row and further having two slice surfaces created by the slice, fastening one double-row bar onto a first fixture via a first slice surface and onto a second fixture via a second slice surface,

separating the fastened double-row bar into two identical fastened single-row bars by a slice cut to expose the surfaces of the two single-row bars on which the poles exterminate,

lapping and gnnding the exposed surface of the two single-row bar so that a desired throat height of the poles and a desired contour of the two single-row bars are attained,

parting the two processed single-row bars into head assemblies, and,

removing the head assemblies thus formed from the first and the second fixtures.

20. The process defined in claim 19 wherein there is a street between any two given adjacent rows of electromagnetic devices.

21. A process for manufactunng electromagnetic head assemblies from a fabricated wafer which contains on one surface electromagnetic devices arranged in rows, the electromagnetic devices on a given row being in one orientation while those on the adjacent row being in an opposite orientation, said process comprising the steps of:

slicing the wafer in such a manner to produce a plurality of identical double-row bars each comprising a first and a second single-row bars, the first singlerow bar having the poles of the electromagnetic devices thereon distal from those on the second single-row bar and each single-row bar having a slice surface created by the slice;

fastening one double-row bar onto a first fixture via the slice surface of the first single-row bar with the slice surface of the second single-row bar remaining exposed,

lapping and grinding the exposed slice surface of the second single-row bar so that a desired throat height of the poles and a desired contour of the second single-row bar are attained,

fastening the double-row bar onto a second fixture via the processed slice surface of the second singlerow bar,

removing the first fixture from the processed second single-row bar, thereby exposing the slice surface of the first single-row bar;

lapping and grinding the newly exposed slice surface of the first single-row bar so that a desired throat height of the poles and a desired contour of the first single-row bar are attained.

transversely parting and longitudinally slicing the processed double-row bar into head assemblies, and,

removing the head assemblies from the second fixture.

22. The process defined in claim 21 wherein there is a street between any two given adjacent rows of electromagnetic devices.

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