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(71)(72) Applicant and Inventor: DAS, Shyam, C. [IN/US]; 7549 Orange Blossom Drive, Cupertino, CA 95014 (US).

(74) Agents: GEARY, William, C., III et al.; Lahive & Cockfield, 60 State Street, Boston, MA 02109 (US).

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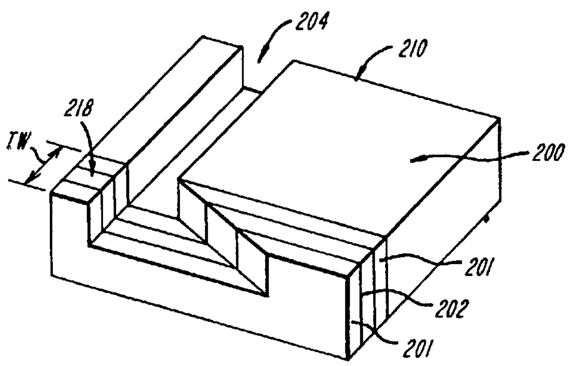

(57) Abstract

A metal in the gap (MIG) and thin film hybrid read/write head utilizes less magnetic material and thus possesses reduced inductance. The hybrid head is also less sensitive to throat height tolerances and better control is obtained over such geometrical parameters as gap and track. The hybrid head consists of an individual core (210), soft magnetic layer (201), non-magnetic layer (202), and C-cut (204). The hybrid head is manufactured by simplified, higher yielding techniques in a batch process.

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MIG AND THIN FILM HYBRID READ/WRITE HEAD

DESCRIPTION OF THE PRIOR ART

One of the advantages of thin film head technology is that several thousand devices can be fabricated on a wafer, then processed in rows to make sliders, all in a batch process. This utilizes complex technology but less man-power resources than MIG (metal-in-the-gap) technology. Thin film head geometrical definition of gap and track widths is well controlled due to use of photolithography and vacuum deposition techniques.

However, thin film process technology is quite complex. The large topography produced by hard-baked photoresist reduces batch yields due to degrading magnetics of the poles and changing stress in the films; also, there is some difficulty in forming narrow pitch coils over the large topography of the thin film head, as well as difficulty in defining well-aligned pole tips (or using track trimming). The photoresist insulation causes yield loss due to degradation of magnetics and varying throat height due to its shrinkage during subsequent hard-bake processes.

Yields in thin film head processing is also affected by cracking of uncured photoresist. Another in thin film head yield loss is due to its high throat height sensitivity. This requires a sophisticated electronic lapping guide process to improve the yield.

MIG heads of the prior art are simpler to fabricate, less sensitive in obtaining desired throat height, and resources are plentiful in this area. But its drawbacks are that the coils are wound manually one slider at a time and the sliders are also fabricated one at a time. This non-batch fabricating process requires a heavy man-power resource. Another disadvantage is that the geometrical control, e.g., for gap and track width, is poor. This limits MIG usefulness in high density disk drives. A further limitation in regard to use in high density disk drives is due to its high magnetic inductance.

It is therefore an object of the present invention to provide a MIG and thin film hybrid read/write head with reduced inductance and yet can be made in a batch processing manner.

SUMMARY OF THE INVENTION

The MIG and thin film hybrid read/write head disclosed herein combines the best of the thin film head technology with the best of the MIG technology to make high performing, high yield and lower cost heads. The invention utilizes the available MIG technology base and adds a batch process similar to the thin film head process. This new process is made simpler and high yielding by reducing the topography to make it a planar process. This new process does not require hard baked insulation, which further improves the yield.

The hybrid heads of the invention are less sensitive to throat height tolerances because they use MIG technology. The critical geometrical parameters, e.g., gap and track, are formed in a batch process using thin film head technology and in a planar topography, resulting in better geometrical control. Because of reduced magnetic material as compared to the prior art MIG head, this hybrid head has reduced inductance.

Another embodiment of this disclosure utilizes a MIG/thin film hybrid head for writing, and an MR head on the top of the write head for reading the data. In the prior art MR read/write head, the write head (trailing end of the slider, relative to the spinning media) sits on the top of the MR read head (at the leading end). The vertical distance between the read gap and the write gap determines the radius dependent skew for a rotary actuator. This distance increases when the write head is at the trailing end. This is because the transition is written closer to the trailing edge of the write pole.

Also, in the prior art of piggy-back MR read/write head the write head (trailing) follows the read (leading) head as the disk rotates. Therefore, this head cannot read the immediately written transition. However, in the MR read/write head disclosed herein, the inductive write head leads and the MR read head trails. That is, the MR head can read the immediately written transition. Furthermore, in the new MR read/write head the written transition is closer to the MR read gap, thus reducing the radius dependent skew effect for a rotary actuator. This is a more robust design because the write head is less sensitive to change in throat height due to application of MIG technology in making a write head. In the prior art MR read and inductive write head, the MR head is built first then the inductive write head is formed on the top of it.

Thus the MR read head is subjected to high temperature processes of thin film write head effecting the performance due to possible interdiffusion in between the layers. The new invention fabricates the write head first then the MR read head is formed, thus eliminating such adverse affects.

Thus embodiments of the presently disclosed invention teach a new and useful MIG and thin film hybrid read/write heads, and new and efficient methods of making same. The core fabrication and bonding with the slider is done in a batch manner. Magnetic stripes containing MIG type materials separated by glass bonding spacers are bonded on a slider-forming substrate. This bonding may be done at high temperature so that any subsequent temperature process does not effect the integrity of the bond. These magnetic stripes may be laminated MIG type material or ferrite with Sendust or high saturation material deposited thereon. Gap material and another layer of magnetic material may be deposited thereover. Then C- cuts are formed at specified intervals, with a ramp if necessary. Track width may be defined by mechanical grinding, if so desired. The C-cut is only part way into the magnetic stripe but the track definition may be had by removing all of the magnetic material from the track direction. All the slots and cavities may be filled with low melting glass or any non-magnetic material, and then lapped to planarize. This forms a C-core imbedded in the substrate with gap and pole-tips defined. Coil layers are formed on the planar surface separated by insulation (e.g., alumina or silicon dioxide type material). The insulating material is removed from the pole-tip and back closure regions. The top yoke (preferably of NiFe) is then formed to connect the top poletip and the back closure region of the yoke to form a complete magnetic circuit. This forms a high-quality, batch- produced inductive MIG type read/write head.

In an alternative embodiment, the bonded magnetic stripes are formed either by bonding the magnetic stripes as discussed above or by bonding a magnetic substrate on a slider- making substrate and cutting and removing the magnetic material to form the magnetic stripes.

The C-cut and ramp are formed by mechanical means. The C-cut slot is filled with low-temperature-melting glass or another non-magnetic material, and then lapped to planarize. Gap material and another layer of magnetic material is deposited. Now the poletip, back closure and alignment marks are patterned using photolithography, and the assembly is then etched to form track-width at least up to a portion into the bottom core. (Alternatively, this pattern may be made by masking with a removable type metal mask and then etching.) This makes an elevated poletip, back closure and alignment marks, all other regions being planar at lower level. Now coil layers are formed, separated by insulating material, e.g., alumina or silicon dioxide, on the planar surface.

Another embodiment of this invention is that the MR read head is formed on the top of the write head. Bars of core, preferably laminated MIG bars separated by glass bonding material at a specified interval, are bonded on the slider-forming substrate. The thickness of the magnetic material defines the track-width. The C-cut and ramp are formed by mechanical means. The C-cut slot is filled with low temperature melting glass or any other non-magnetic material, and is lapped to planarize. Gap material for the write head and a layer of Sendust is deposited, and annealed. The Sendust film is then patterned to form the top pole/bottom shield of the MR read head. The MR structure with leads are formed on this shield. The write coil is formed and the yoke portion of the write head along with the top shield are deposited. The rest of the steps of forming bonding pads and encapsulation are followed in a conventional manner.

In still another embodiment of the invention, a multi-turn yoke head is formed around a coil, with the lower pole being formed by embedding a pair of C-cut cores.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and further advantages of this invention may be better understood by referring to the following description in which common numerals are used to represent common parts, taken in conjunction with the accompanying drawing in which:

FIG. 1A is a perspective view of a C-cut single core, the track width being shown as the thickness of the laminated magnetic (Sendust) film.

FIG. 1B is a perspective diagram of a bar containing C-cut rows.

FIG. 2 is a perspective diagram of a slider-forming substrate showing the X-cut and Y-cut grooves.

FIG. 3 is a diagram showing magnetic stripes separated by glass bonding/spacer stripes.

FIG. 4 is a schematic of a slider-forming substrate and the magnetic substrates to be bonded together.

FIG. 5A is a schematic of a magnetic substrate and a slider-forming substrate bonded together. Magnetic material is removed in a row to form bonded magnetic stripes. C-cuts are made to form well positioned columns and rows of C-cut cores.

FIG. 5B is a cross-sectional view taken along line A-A' of FIG. 5A.

FIG. 6 is a diagram showing C-cut grooves on a wafer.

FIG. 7 is a schematic representation of an inductive head of the invention.

FIG. 8 is a cross-sectional representation of FIG. 7 along A-A'.

FIG. 9 is an air-bearing-surface (ABS) view (section along B- B') in FIG. 7.

FIG. 10A is a cross-sectional schematic showing C-cut grooves, gap layer, Sendust layer which is patterned and etched to form the top pole-tip of the inductive write head as well as the bottom shield of the MR read head.

FIG. 10B is a cross-sectional schematic of an MR read head sitting on the top of the inductive write head.

FIG 11 is a schematic of the ABS view of FIG. 10B.

FIG. 12 is a schematic of two c-cut cores, staggered and bonded together.

FIG. 13 is a schematic of a multi-turn yoke head formed around a coil according to the invention.

FIG. 14 A-F is a schematic of a multi-turn yoke head formed around a coil according to the invention.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENT

The invention may be formed as a MIG head or a ferrite head, as discussed below. As shown in FIG. 1(A, B), individual core 210, or bar 220, forms a laminated MIG core formed by depositing a soft magnetic layer, e.g, Sendust 201, separated by thin (0.1 micron) nonmagnetic material, e.g., alumina 202, on a substrate material 200. C-cut slots 204 are formed (and may be tapered, i.e., apex angled, forming a ramp). Alternatively, the core 210 and bar 220 are made of ferrite and Sendust type material is deposited after cutting C-cut 204. These cores 210 or bars 220 are bonded on a slider-forming substrate 230.

In one approach of FIG. 2, the substrate 230 has a series of partial X-cuts 231 and Y-cuts 232 at a well defined interval. The bar 220 is bonded in a slot 231 such that C-cuts 204 is in an exact alignment with the slot 232. A glass spacer stripe and bonding material (not shown), filling the C-cut 204 and aligning the reference surface 215 of one bar with respect to another on the substrate 230, is adjusted and fused to bond the bars on the substrate. After bonding, the substrate 230 may be lapped to planarize and expose the core surface 218 or a portion nearby. Alternatively, the bars 220 may be stacked and aligned with each other in reference to surface 215 on a slider-forming substrate and bonded and, ideally it is then lapped to planarize. This forms a planar wafer in which C-core bars are embedded, to form the bottom pole (yoke and tip). Now the gap material 235 (FIG. 8) is formed and then another layer 236 (FIG. 10A) of Sendust type material is deposited and annealed for later forming of the top pole tip. The second pole is formed as explained below.

For further processing, the Sendust material at corners 234, shown in FIG. 2, are etched away, exposing the reference surface 218, 215, or exposing alignment marks 233 which may have been defined in the previous steps. Subsequent layer masks may be aligned and processed accurately by using these references.

FIG. 3 is a diagram of magnetic stripes 301 (which may be laminated), separated by glass bonding spacers 305, and stacked on the slider-forming substrate 230, and fused to bond together. For a better bond integrity, glass may be deposited on the substrate 230 before stacking stripes 301 and spacers 305. The mating surfaces are lapped/polished to avoid any irregularities.

FIG. 4 and 5 are diagrams of another embodiment of this invention. A slider-forming substrate 299 is shown along with a magnetic substrate 300, e.g., formed of single crystal ferrite. Bonding material glass 289 is deposited on the mating surfaces of substrates 299 and 300 and fused at high temperature to bond them together. Substrate 299 may itself be magnetic, in which case the substrate 300 is not required.

In one approach, Sendust type or high saturation material 340 (forming the bottom pole), the gap material 235 and high saturation or Sendust type material 239 (for forming the top pole tip) are sequentially deposited on the magnetic substrate 300. Now rows 310 are formed by grinding all magnetic material from the spaces 320. The width of row 310 may be used to define the track width. Alternatively, the width of row 310 may be larger than the desired track width and then the final track width may be defined by photolithography and ion-milling processes in subsequent steps. C-cuts 330 are made part-way into the magnetic material 300. FIG. 6 shows such an array of C-cut cores, for example. The poletip region 290 and the back closure region 291 as defined. Coil layers 241 separated by alumina insulation 226 are formed and a magnetic yoke 242 (FIG. 7, 8), e.g., NiFe, is formed to complete the magnetic circuit.

In an alternative embodiment, the track width is defined by photo-patterning and ion milling. As has been discussed before, in reference to FIG. 7 and 8, the C-core 210 may be made of laminated magnetic film bars or magnetic stripes bonded on a slider-forming substrate 299 or by bonding the magnetic substrate 300 and forming magnetic stripes by mechanical means. Gap material 235 and a layer of preferably sheet Sendust material 236 (FIG. 10A) are deposited sequentially. Then C-cut 330 may be formed in these stripes, penetrating into the magnetic layer 300. The cavity or channel 320, 330 is then filled with low temperature melting glass and planarized (i.e. lapped).

To define the track width, in reference to FIG. 7 and 8, the mask pattern for poletip region 290, back closure region 291 and the alignment features 283 are formed, and ion-milled into the core 210 to a depth preferably equal to the throat height. This leaves a planar surface 360 except the projected surfaces 308, 307 and the alignment features 283. Now a multi-layer coil 241 separated by alumina insulation 226 may be formed. The back-gap closure gap material 227 may be removed in the previous steps. After insulation 226, preferably a NiFe top yoke 242 is plated in magnetic contact with portions 246 (top of top pole part 239) and 247 (top of back closure part 248). FIG. 9 schematically shows the ABS view of such head.

This fabrication process has several advantages. All the critical processes have been done essentially on a planar surface, unlike the conventional thin film head. For example, track definition by track trimming is done on a planar surface; coil layers 241 are on a planar surface; and the top yoke 242 are on planar surface. If desired, hard-baked photoresist may be used as an insulation material, but alumina type material is preferable.

Due to the large flux-conduction area provided by the MIG C-core described above, this head is less sensitive to throat height variations compared to conventional thin film heads. Also, pole tips 239 and 307 are made of Sendust which does not recess and smear as much as the NiFe poletips of the thin film heads. All these features together improve the process yield significantly, according to the new head technology disclosed herein.

Another embodiment of this invention is to make an MR read head on the top of the inductive head discussed above for the write purpose, as is schematically shown in FIG. 10B. A simpler approach of this is to form a C-core, preferably of laminated MIG, embedded in the wafer, as has been discussed above. After filling the cavity 330 with glass and planarizing, if the surface 309 is recessed with respect to the surface 307, then an additional thin layer of non-magnetic material (photoresist, alumina, nonmagnetic metal, e.g., copper or the like) is deposited and etched from the regions 307, 247, etc. This is to avoid wrap around of pole tip 239 in the region 309. After write gap 235 and Sendust sheet 236 (pieces 239 and 248 are formed from sheet 236) are deposited, with the help of alignment features 233 (FIG. 2), pattern 239 is formed in the layer 236 and etched to expose the surface 238.

Due to any reason, if there is any random misalignment in the positioning of one row with the other, using stepper technology of photopatterning and the reference surface 238, subsequent layer patterns can be accurately defined on the wafer with respect to the track-formed portion 225 of the bottom pole. After forming coil 241, insulating alumina 226 may be deposited and etched away from the surface at 247, and top at 239. Then the first MR read gap 248, MR film structure with its leads 240, and the second MR read gap 249, are deposited. Gap material is again etched from 246, 247 and coil contact regions 282, 280, 281 (FIG. 7) etc. are exposed. Then NiFe top yoke 242, top MR shield 245, and leads 280, etc. are plated. The rest of the steps to complete the head are performed in a conventional manner.

FIG. 11 is a schematic of the ABS view of the head schematically shown in FIG. 10B. As is shown, width (TW) of portion 225 defines the write track width. Since in laminated MIG, the thickness TW is controlled very accurately, a very narrow track write head can be made.

Thus a hybrid MIG/ thin film head for writing, and an MR head on the top of the write head for reading the data, is formed. In this new MR read/write head, the inductive write head leads, and the MR read head trails, relative to data on the spinning media. That is, the MR head can read the immediately written transition. Furthermore, in this new head the written transition is closer to the MR read gap, thus reducing the radius-dependent skew effect as in a typical rotary actuator. This a more robust design because the write head is less sensitive to changes in throat height due to application of MIG technology in making a write head.

In the new invention disclosed here, the write head is fabricated first and then the MR read head is formed, thus eliminating the adverse temperature affects on the multilayer, thin, sensitive, MR film structure.

In another embodiment of this invention, the head is formed by coupling the same coil layer multiple times with the yoke by folding the yoke multiple times with different segments of the coil. FIG. 12 shows C-core 410 separated by spacer 400 and bonded together with the C-core 411. FIG. 13 shows folding of the yoke multiple times with the same coil 241. Yoke 410 goes under the front segment 250 of the coil 241; yoke 442 goes over the back side 251 of the coil 241; yoke 411 goes under the back side 251 of coil 241; and yoke 443 goes over the front 250 of the coil 241. Thus the yoke links with the coil twice, thereby increasing the effective number of turns, for improved flux coupling.

Magnetization in the yoke segments have been defined such that flux travels essentially normal to magnetization to increase the head efficiency. The yoke segments 442, 443 may be made of ferrite material, plated NiFe, or any other soft magnetic material.

Yoke segment 442 is magnetically coupled to yoke segment 410 and 411 at parts 431 and 430 respectively. The yoke segment 443 is coupled to yoke segment 411 at part 432. In the fabrication process the C-cut cores 410 and 411 are bonded, and the cavities are filled and planarized. Gap material 235 and soft magnetic material 236 are deposited. To define the track width 420, the mask pattern for poletip region 290, back closure region 431, 430, 432 and the alignment features 283 are formed, and etched into the core 410 and 411 to a depth, preferably equal to the throat height. This leaves a planar surface 360 except the projecting surfaces 420, 430, 431, 432 and the alignment features 283. Now a multi-layer coil 241 separated by alumina insulation 226 is formed. After insulation 226, preferably a NiFe top yoke portions 442, 443 are plated in magnetic contact with parts 431, 430, 432.

As an example, a sequence of the fabrication process of making a folded yoke head is shown in FIG. 14. FIG. 14A shows magnetic stripes 310 bonded on the slider-making substrate 299. This may be formed by bonding magnetic substrate 300 with the slider-making substrate 299 and machining out portions 320 as has been discussed previously. As is shown in FIG. 14B, regions 451 are then machined to remove magnetic material. Then magnetic stripes 453 are bonded with the substrate 299 separated by spacer 400 from area 452, shown in FIG. 14C. Spacer 400 may be formed by depositing glass on 453 on the surface 401. Stripes 453 are bonded at an elevated level with respect to 452 such that when C-cut 330 are made in magnetic pieces 452, it removes all the magnetic material in regions 457 shown in FIG. 14D.

In order to make staggered pair of C-cut cores as is shown in FIG. 12, channels 454 are cut through magnetic stripes 453, removing magnetic materials therein. Also, C-cuts 330 and 461 are made. Since magnetic stripes 453 are bonded at an elevated level, when C-cuts 330 are made, it also removes all magnetic material from regions 457. Then C-cuts 461 are made. Remaining material 459 during making C-cut 461 will not have any adverse effect. This forms the staggered pair of C-cut cores shown in FIG. 12. The portion 455 will form a bottom pole-tip. The appendix 456 may be removed during the slider fabrication process if so desired.

Coil 241 may now be deposited around the projecting-out posts 431-432 as is shown in FIG. 14E. Coil 241 may be mechanically wound instead of depositing in the batch form by photolithography and plating techniques. The hand-wound coil has the advantage that the coil resistance is low. After winding the coil, the recessed regions may be filled with hardbaked photoresist, epoxy or alumina type material. Then top yoke parts 442 and 443 are formed to complete the magnetic circuit as per FIG. 14F. This yoke may be bonded ferrite, plated NiFe or any other soft magnetic material.

The foregoing description has been limited to specific embodiments of this invention. It will be apparent, however, that variations and modifications may be made to the invention, with the attainment of some or all of the advantages of the invention. Therefore, it is the object of the appended claims to cover all such variations as come within the spirit and scope of the invention. The invention is pointed out with particularity in the following claims.

What is claimed is:

1. A method of fabricating a magnetic storage device for writing and/or reading data in the form of magnetic flux onto and/or from a magnetic media which moves relative to the device, comprising the steps of

forming a C-cut core on a slider-forming substrate, and forming a head therefrom in a batch process.

2. The method of claim 1 further comprising the step of forming the substrate as a wafer for said batch processing.

3. The method of claim 2 further comprising the step of forming a coil and a second pole on the wafer.

4. The method of claim 3 wherein said forming includes forming a read/write inductive head or the write head of an MR read/write head wherein the head is a hybrid MIG/ thin film head.

5. A read/write head of a magnetic storage device, comprising

an inductive write head and an MR head, the MR head being formed on top of the write head.

6. The method of claim 1 including the step of forming the C-cut core on a wafer by

A. stacking magnetic stripes separated at a fixed regular distance on a slider-forming substrate,

B. bonding magnetic stripes on the slider-forming substrate,

C. making a C-cut in the stripes to form a slot, and

D. filling the slot with a non-magnetic material and planarizing.

7. The method of claim 1 including the step in which the C-cut core is formed as a wafer by

A. bonding a magnetic substrate with a slider-forming substrate,

B. cutting rows or channels to remove magnetic material to form bonded magnetic stripes on a slider-forming substrate,

C. making C-cuts in the stripes to form slots, and

D. filling the slots with a non-magnetic material and planarizing.

8. The method of claim 1 including the steps of

A. bonding a magnetic substrate with a slider-forming substrate,

B. depositing gap material,

C. depositing Sendust type magnetic material,

D. cutting channels to remove magnetic materials to form magnetic stripes,

E. making C-cut slots in the stripes at least part way into the first layer of the magnetic material,

F. filling the slots and planarizing,

G. forming at least one coil layer separated by insulation, and

H. forming the top pole connecting the front tip with the back closure to form a complete magnetic circuit.

9. The method of claim 1 further including the steps of

A. stacking magnetic stripes separated at a fixed regular distance on a slider-forming substrate,

B. bonding magnetic stripes on the slider-forming substrate,

C. making a C-cut in the stripes to form slots,

D. filling the slots with a non-magnetic material and planarizing,

E. depositing gap material and depositing soft magnetic material,

F. patterning the pole-tip structure to define track width and the back region structure and etching to form such structures,

G. depositing coil layers separated by insulation, and

H. depositing soft magnetic material magnetically connecting the tip region with the back closure to form a complete magnetic circuit.

10. A method of fabricating a magnetic storage device for writing and/or reading data in the form of magnetic flux onto and/or from a magnetic media which moves relative to the head comprising the steps of

fabricating a hybrid MIG and thin film type head by coupling a coil layer multiple times with a yoke by folding the yoke multiple times with different segment of the coil.

11. The method of claim 10 in which the coil is multi-layer.

12. The method of claim 10 in which the head is formed by

A. stacking magnetic cores separated by spacer material at a fixed regular distance on a slider-forming substrate,

B. bonding magnetic cores on the slider-forming substrate,

C. filling the slots with a non-magnetic material and planarizing,

E. depositing gap material and depositing soft magnetic material,

F. patterning a pole-tip configuration to define track width, a back region and an alignment pattern, and etching to form the patterns,

G. depositing coil layers separated by insulation, and

H. depositing soft magnetic yoke material magnetically connecting to form a complete magnetic circuit.

13. A magnetic storage head device for writing and/or reading data in the form of magnetic flux onto and/or from a magnetic media which moves relative to the head, comprising

a C-cut core on a slider-forming substrate forming a bottom pole, a gap material layer, a top pole-tip region and a back closure portion, the top pole tip region and back closure portion being formed of the same deposition sheet and coupled by a magnetic over layer, for forming a magnetic circuit.

14. The device of claim 13 comprising an inductive write head and a MR read head, wherein the MR read head is formed on the top of the inductive write head.

15. The device of claim 13 wherein the C-cut core comprises a stack of magnetic stripes separated at a fixed regular distance on a slider-forming substrate, the magnetic stripes bonded on the slider-forming substrate, and at least one C-cut is made in the stripes to form a slot, the slot being filled with a non-magnetic material.

16. The device of claim 13 wherein the C-cut core is formed as a magnetic substrate bonded on a slider-forming substrate, with rows or channels cut in the substrate to remove magnetic material to form bonded magnetic stripes on the slider-forming substrate, the stripes having a C-cut therein, and the slots of the C-cuts being filled with a non-magnetic material.

17. The device of claim 13 wherein a magnetic substrate is bonded with a slider-forming substrate, a gap material layer is formed thereover, Sendust magnetic parts (e.g., 290, 291, 283) are formed thereover, C-cut slots are formed in the stripes and the slots are filled and planarized, a coil layer and insulation formed thereover, with a top pole connecting the front tip with the back closure to complete the magnetic circuit.

18. The device of claim 13 further comprising a stack of magnetic stripes separated by bonding material spacer at a fixed regular distance on a slider-forming substrate.

19. The device of claim 18 further comprising bonded magnetic stripes on the slider-forming substrate, with C-cut slots in the stripes, the slots filled with a non-magnetic material, a soft magnetic material layer formed thereover, and a patterned pole-tip, back closure region and alignment pattern are formed thereat, with a coil layer separated by insulation thereover, and topped by soft magnetic material magnetically connecting the tip region with the back closure to complete the magnetic circuit.

20. The device of claim 13 further comprising a hybrid MIG and thin film type head, the head having a coil layer coupled multiple times with a yoke via folding the yoke multiple times with different segments of the coil.

21. A read/write head device of a magnetic storage apparatus, comprising an inductive write head and a MR head, the MR head being formed on top of the write head.

22. The device of claim 21 further comprising a substrate and a magnetic core embedded in the substrate.

23. The device of claim 22 in which the write track width is defined by the thickness of the magnetic core.

24. The device of claim 22 in which the embedded core defines the write track width.

25. The device of claim 22 in which the embedded core defines the write track width and is the leading pole of the write head.

26. The device of claim 22 wherein the embedded core is made of laminated magnetic film.

27. The device of claim 13 wherein at least one of the poles is formed by laminating magnetic films.

28. The device of claim 13 wherein the pole tips terminate with a gap between them at an air bearing surface (ABS), wherein at least one core is wider than the desired track width at the ABS, and wherein the pole tips around the gap are essentially of the same dimension for defining the track width.

29. The device of claim 13 wherein the pole tips terminate at an air bearing surface (ABS), and the pole tips at the ABS are formed of Sendust.

30. The device of claim 13 wherein at least one core is formed of laminated Sendust.

31. The method of claim 9 further comprising the step of etching the first pole at least to a depth equal to the throat height.

32. The method of claim 9 further comprising the step of making the embedded core of laminated soft magnetic film.

33. The method of claim 32 further comprising the step of making the thickness of the laminated embedded core wider than the desired track width.

34. The method of claim 32 further comprising the step of forming the magnetic film of Sendust.

35. The method of claim 31 further comprising the step of ion-beam etching.

36. A method of forming a read/write head of a magnetic storage device comprising

a. forming a core embedded in a substrate,

b. forming a C-cut in stripes to form a slot,

c. filling the slot with a nonmagnetic material and planarizing,

d. depositing write gap material, and removing the write gap material from the back closure region,

e. depositing a sheet of magnetic material,

f. patterning and etching the top of the magnetic material to form the top pole tip of the write head and the bottom shield of the MR head,

g. forming at least one coil and insulation layer.

h. forming a first read gap, a MR structure, and a second read gap, and

i. forming the top MR shield and yoke region connecting the back closure with the bottom shield.

37. The method of claim 36 further comprising the step of forming the bottom shield of Sendust film.

38. The method of claim 36 further comprising the step of making the embedded magnetic core of laminated magnetic film.

39. The method of claim 36 further comprising the step of determining the write track width via the thickness of the embedded core.

40. A method of forming a head having a coil layer coupled multiple times with a yoke, comprising

folding the yoke multiple times with different segments of the coil, whereby the folding of the yoke is accomplished by forming a staggered embedded core in the substrate.

41. The method of claim 40 further comprising the steps of

embedding a pair of magnetic cores adjacent to each other and separated by a nonmagnetic material, wherein one of the magnetic cores is at a different height than the other, such that while forming a C-cut in the magnetic core with larger height, the segment of the magnetic material of the other core in the path of the C-cut is removed

forming the C-cut in the core at higher elevation adjacent and parallel to the first C-cut for forming two adjacent magnetic posts separated from each other,

filling the slots with nonmagnetic material and planarizing, such that at least one layer of coil and insulation layers are formed, surrounding the adjacent magnetic posts, and

depositing a soft magnetic layer thereof, connecting a forward portion of one core with a rear portion of the adjacent core to complete the magnetic circuit.

42. The method of claim 41 further comprising the step of forming at least one core of laminated film.

43. The method of claim 40 further comprising the step of forming the pole tip at the ABS of core material wider than the desired track width, and then forming the desired track width by etching.

44. The method of claim 41 further including the step of separating the magnetic stripes with a bonding material spacer.

45. The method of claim 9 further including the step of separating the magnetic stripes with a bonding material spacer.

46. A magnetic storage head device for writing and/or reading data in the form of magnetic flux onto and/or from a magnetic media which moves relative to the head, comprising a C-cut core on a slider-forming substrate, forming a bottom pole, a gap material layer, and a top pole tip region and a back closure portion, the top pole tip region and back closure portion being formed of the same deposition sheet and coupled by a magnetic over layer, for forming a magnetic circuit, wherein the C-cut core comprises a stack of separated magnetic stripes separated at a fixed regular distance on a slider-forming substrate, the magnetic stripes bonded on the slider-forming substrate, and at least one C-cut is made in the stripes to form a slot, the slot being filled with a non-magnetic material, wherein yoke is defined having a plurality of coil layers separated from each other by insulating layers, having a magnetic layer formed thereover for forming a flux conducting magnetic circuit.

47. The device of claim 46 further comprising a hybrid MIG and thin film type head, the head having a coil layer coupled multiple times with a yoke via folding the yoke multiple times with different segments of the coil.

48. A method of forming a read/write head device of a magnetic storage apparatus, the head device formed on a wafer, the method comprising the step of forming at least one core embedded in the wafer.

49. The method of claim 48 further comprising the step of making the embedded core of laminated soft magnetic film.

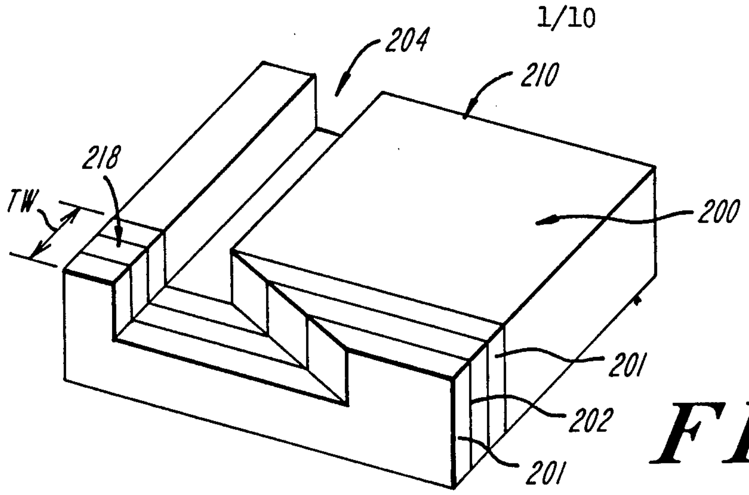

FIG. 1A

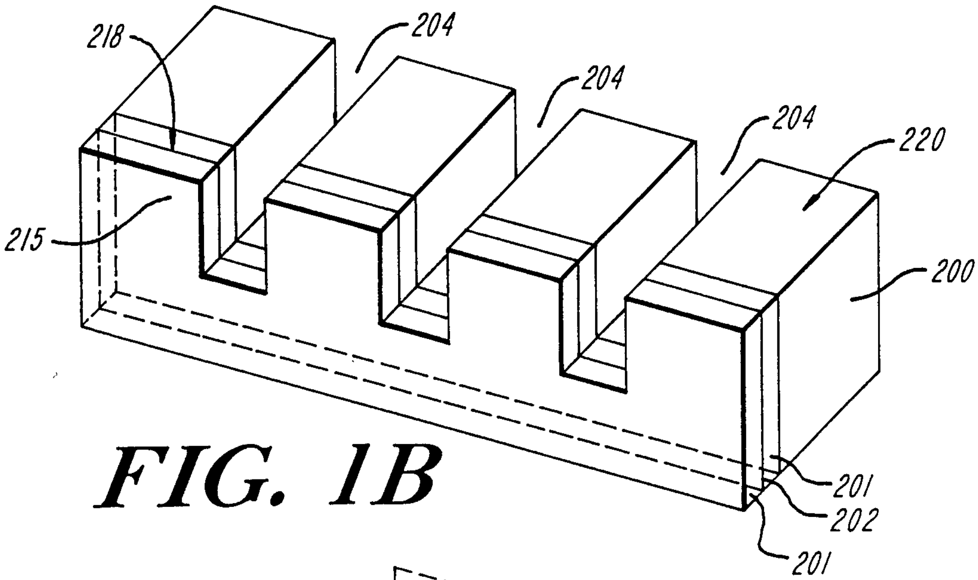

FIG. 1B

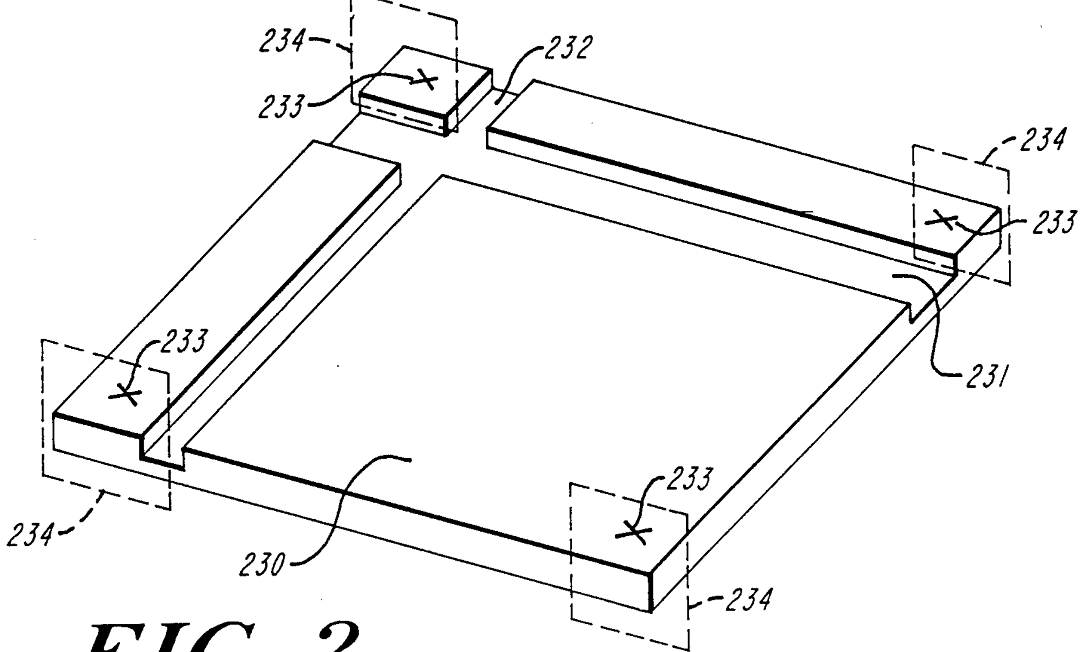

FIG. 2

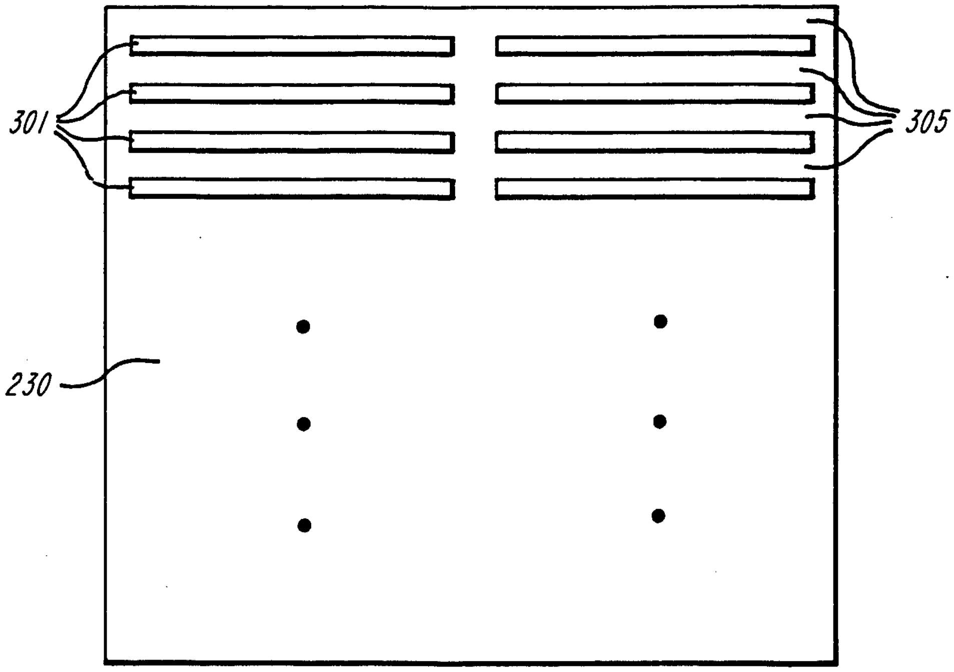

FIG. 3

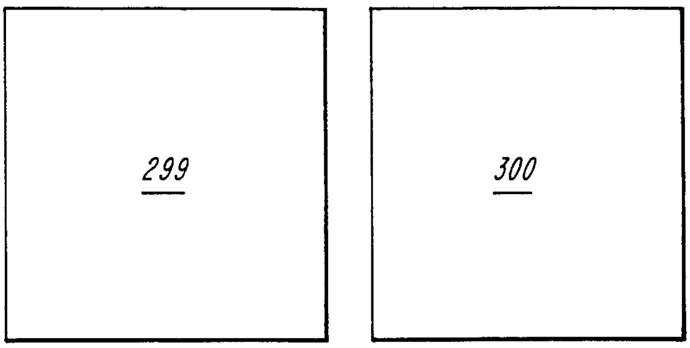

FIG. 4

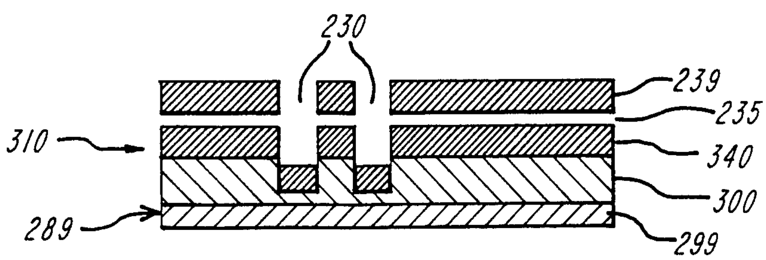

FIG. 5B

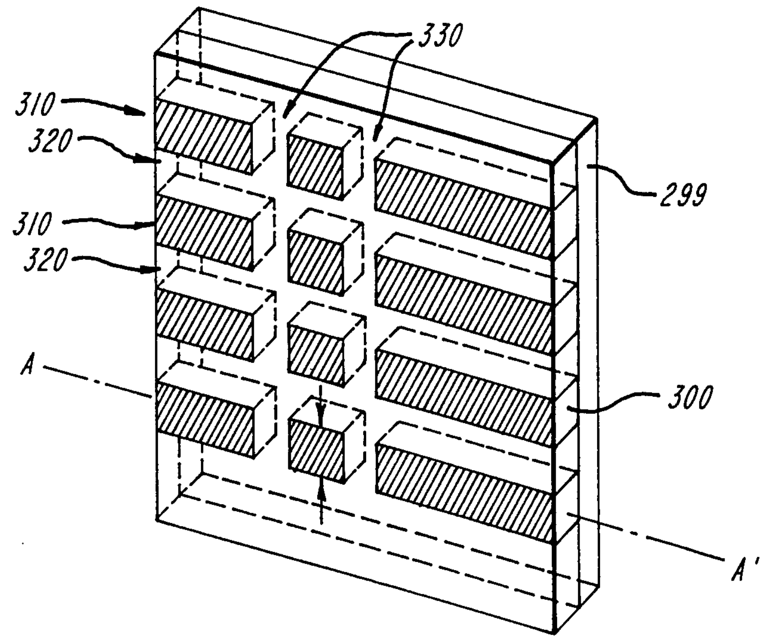
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FIG. 5A

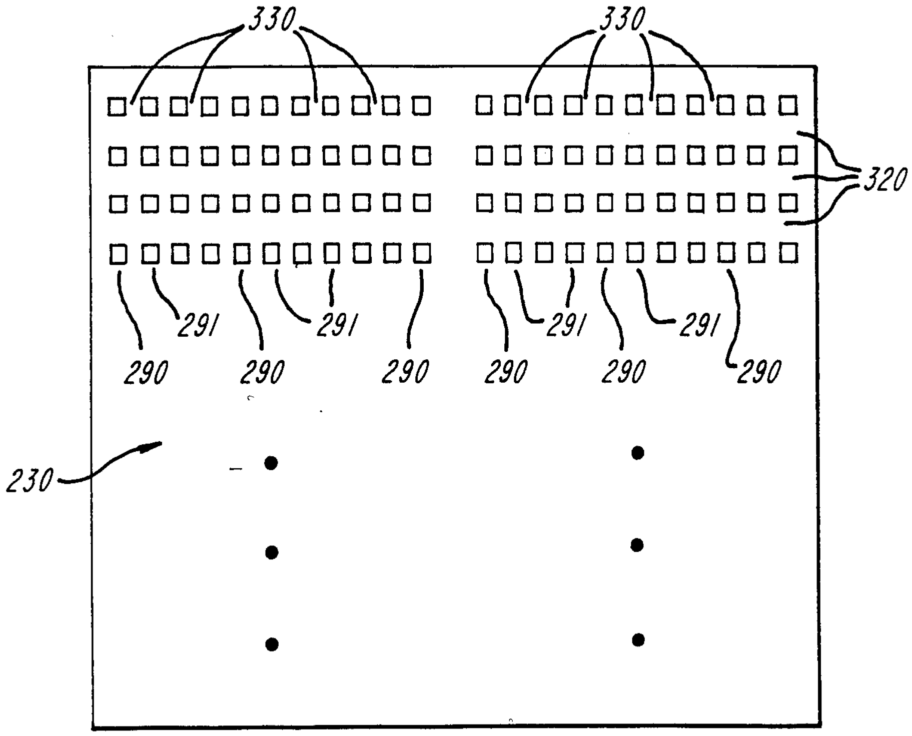
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FIG. 6

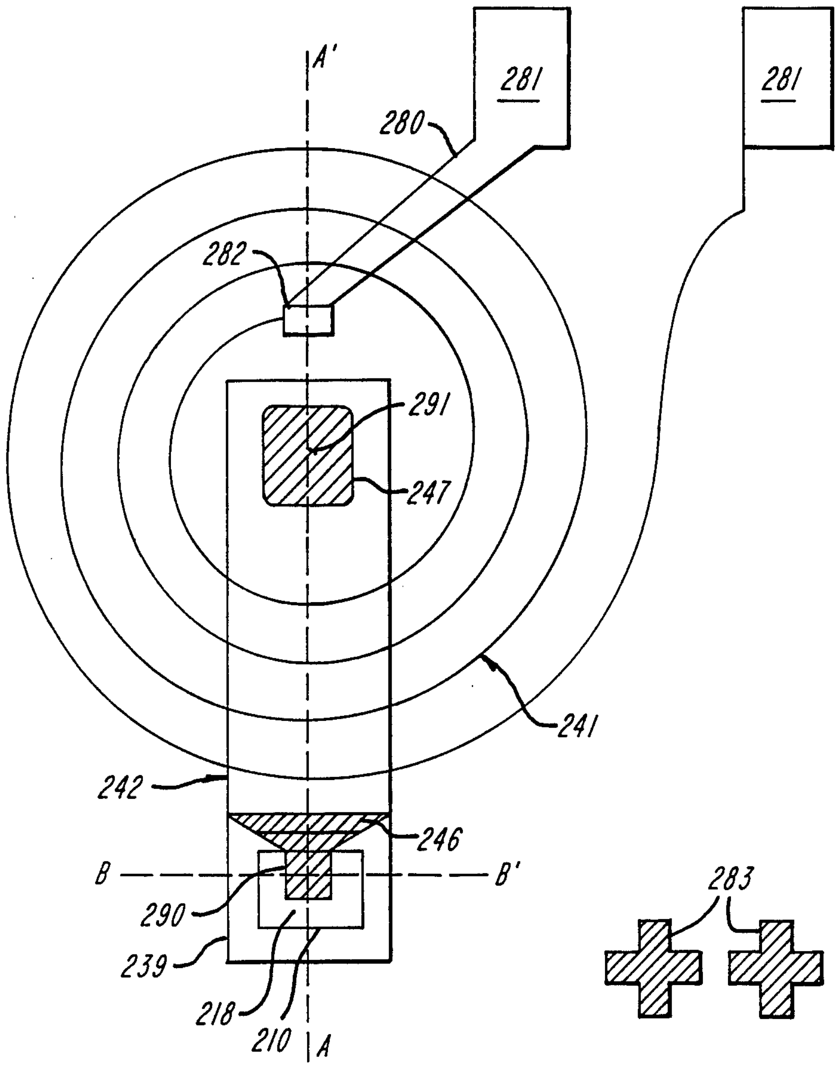
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FIG. 7

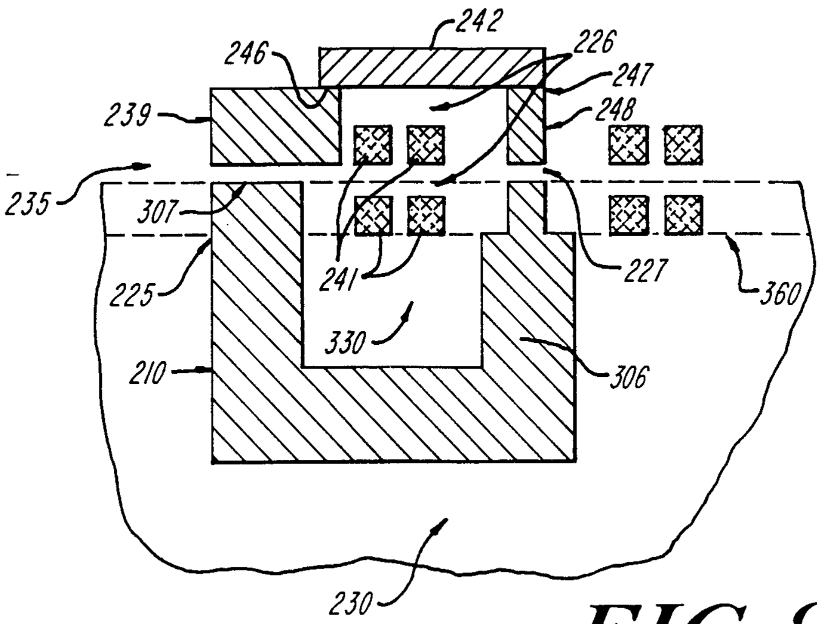
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FIG. 8

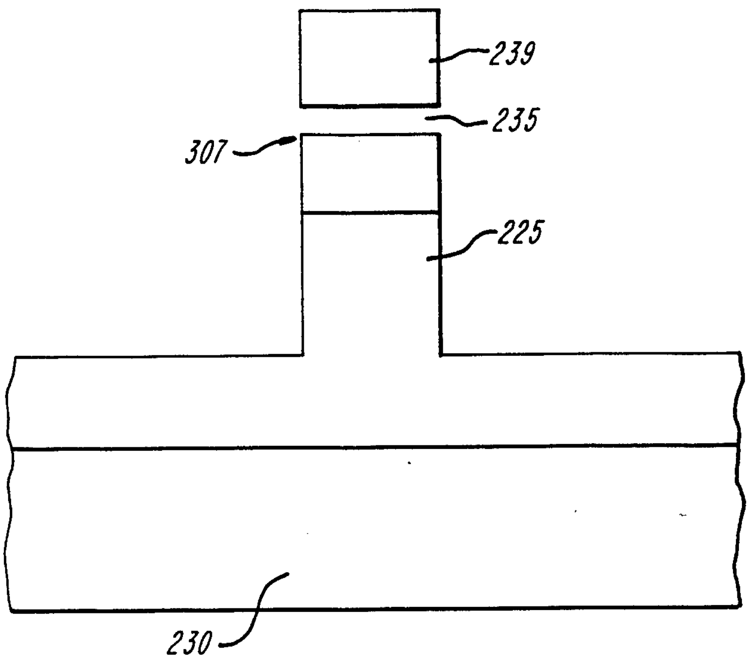
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FIG. 9

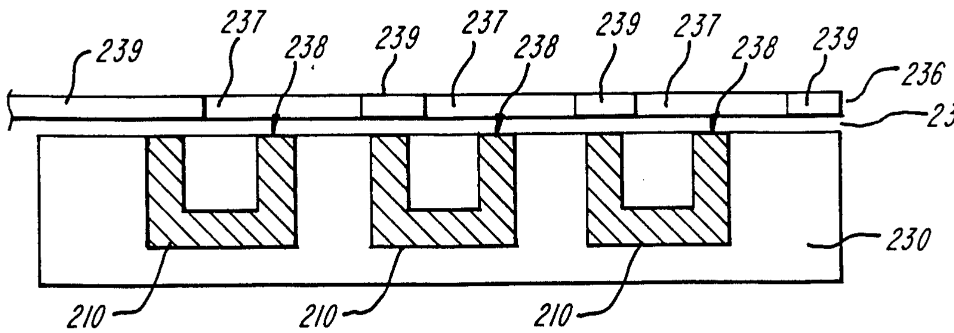
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FIG. 10A

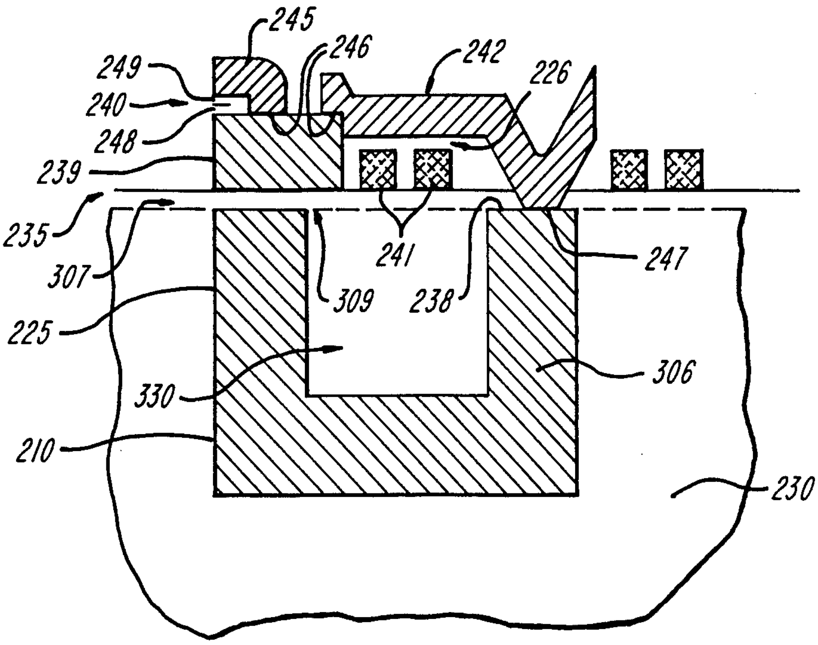

FIG. 10B

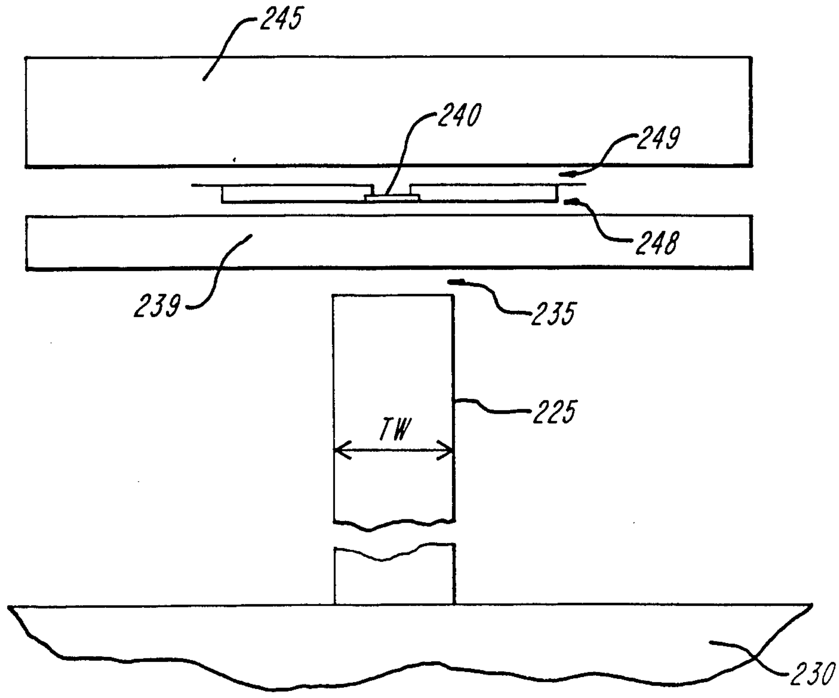

FIG. 11

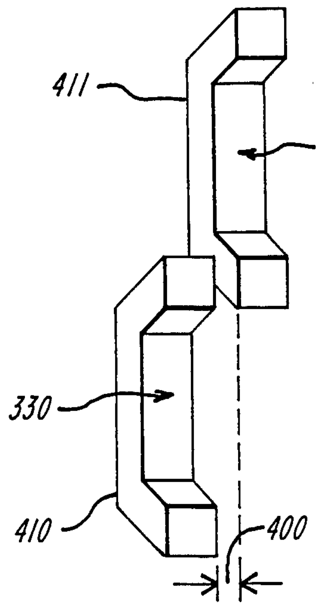

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FIG. 12

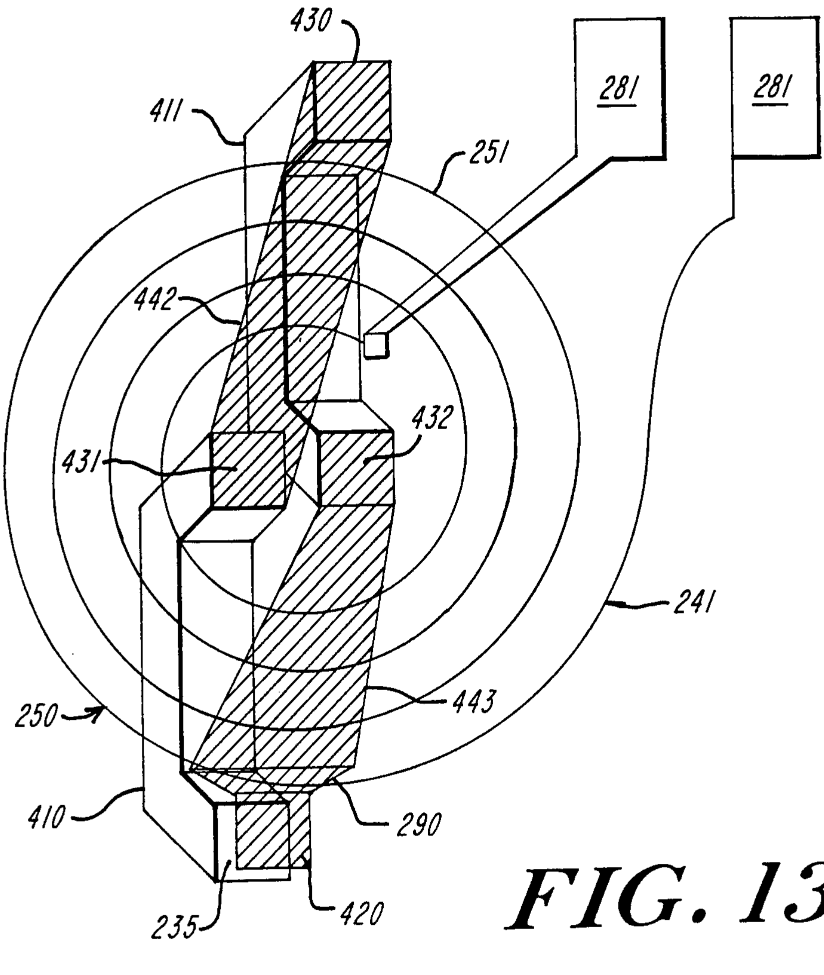

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FIG. 13

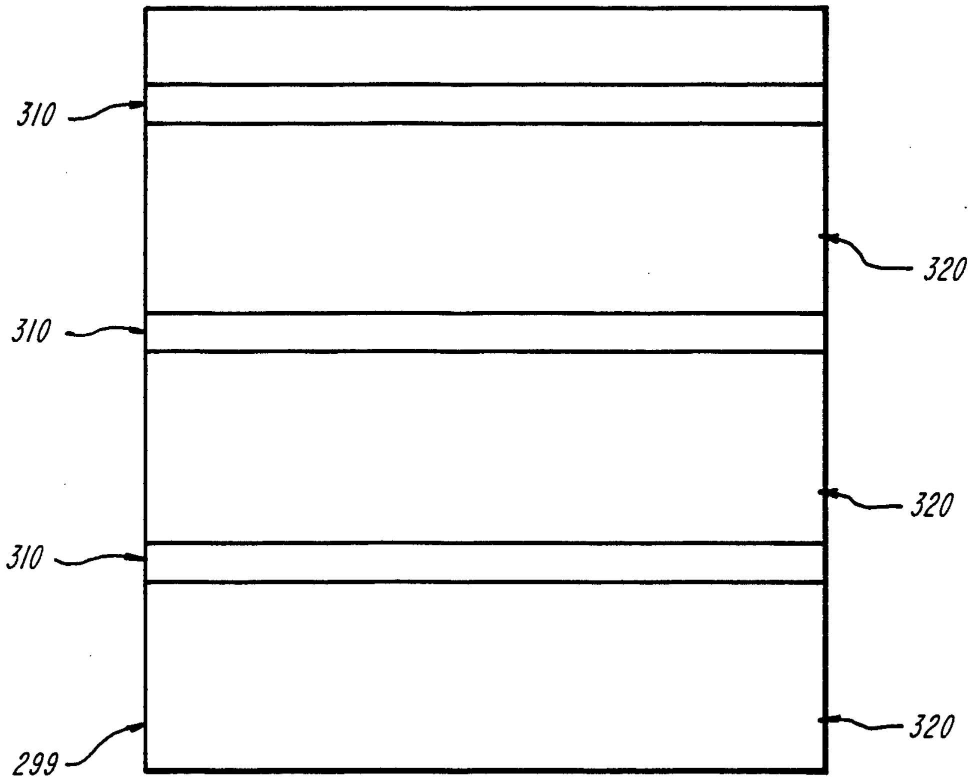

FIG. 14A

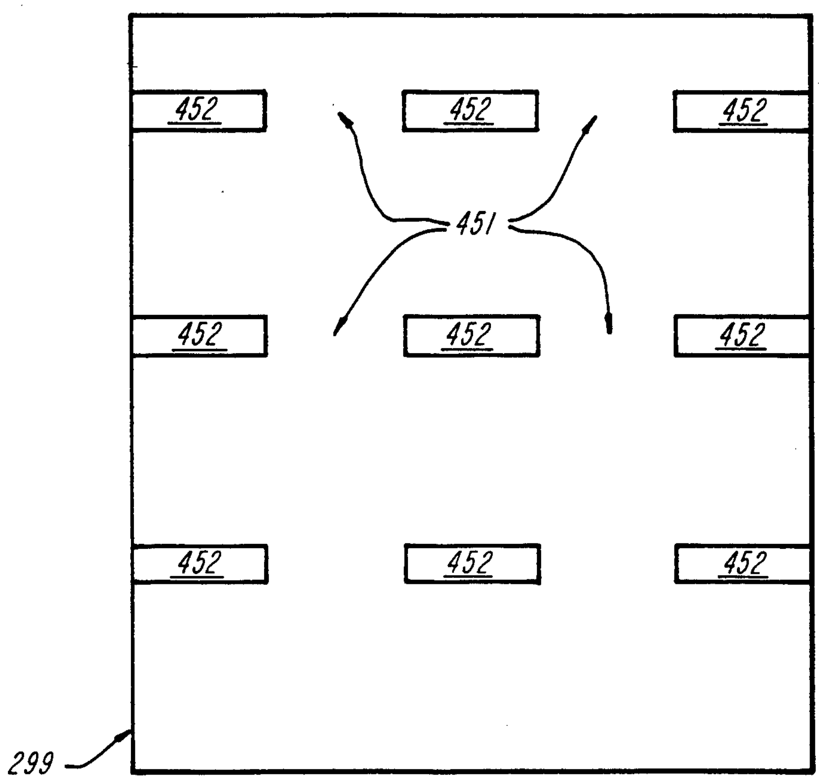

FIG. 14B

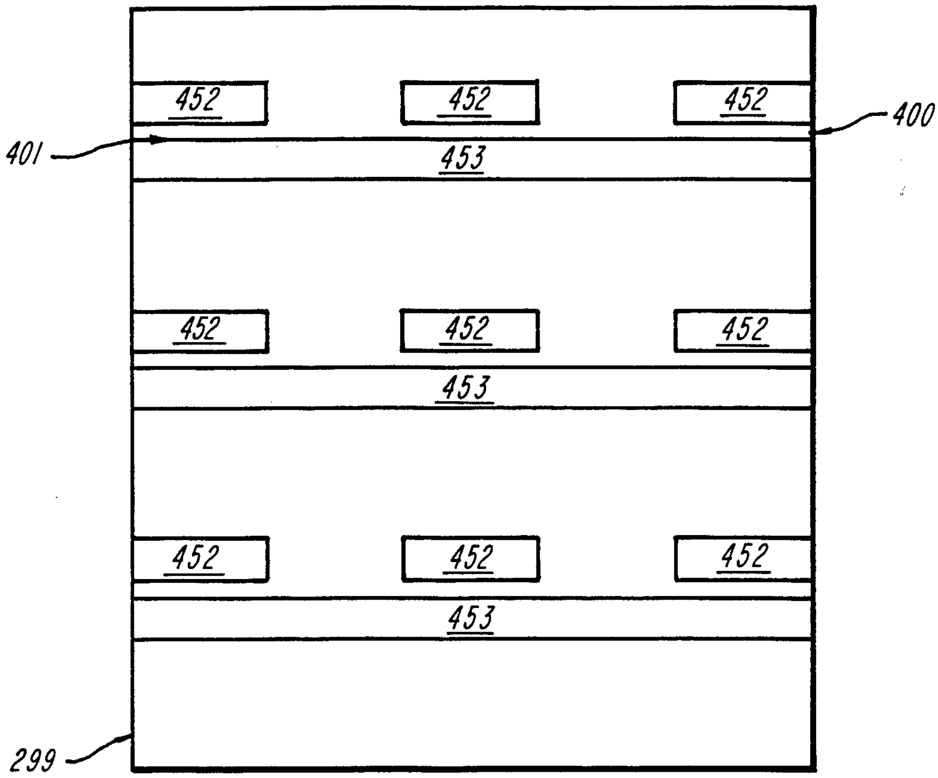

FIG. 14C

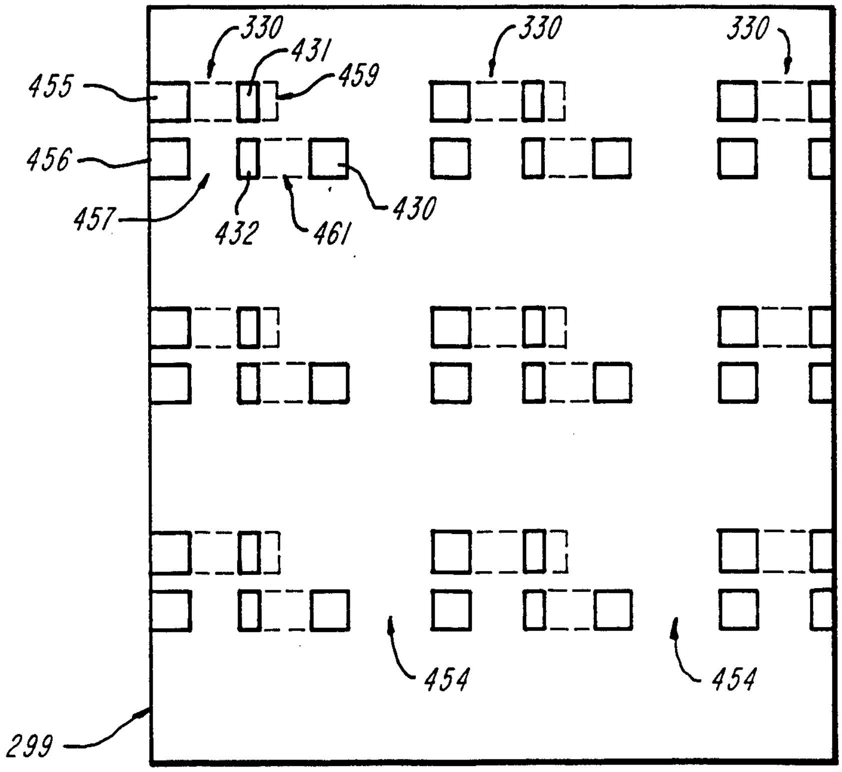

FIG. 14D

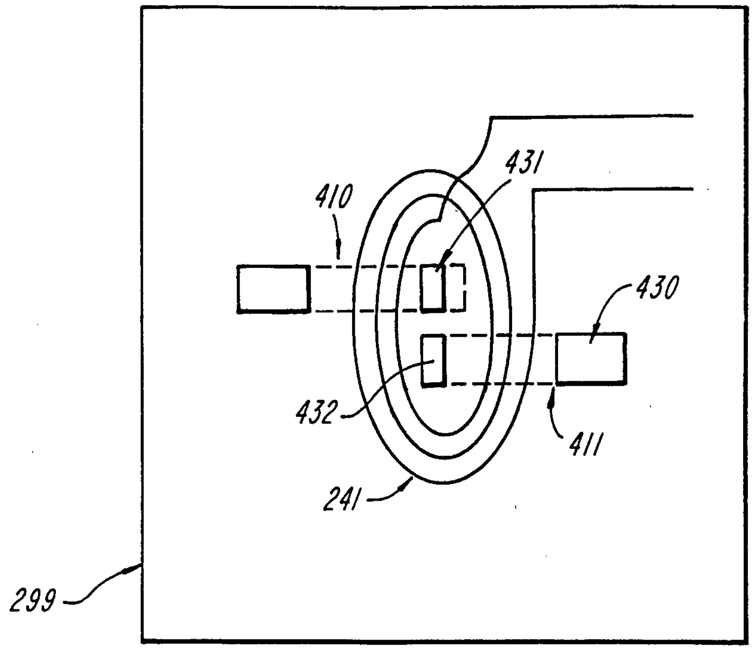

FIG. 14E

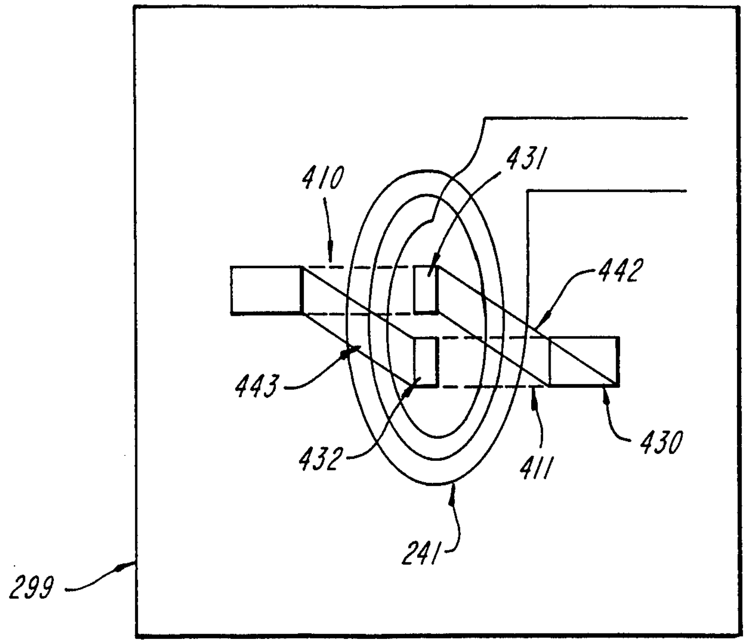

FIG. 14F

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/02620

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :G11B 5/127, 5/33, 5/23, 5/147
US CL :360/113, 119, 126
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 360/113, 119, 126, 110, 122; 29/603; 324/252; 365/8, 157, 158

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS; search terms: mig, metal in the gap, mr, magnetoresistive, mgneto resistive, mig\thin film, sendust, inductive write head.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---------- Y	US, A, 5,093,980 (Maurice et al) 10 March 1992, col. 2, lines 9-30, Figs. 1-4.	1-3 ---------- 4, 6-9, 12-20, 28-39, 45-47
Y	US, A, 4,874,922 (Vadnais et al) 17 October 1989, col. 5, Fig. 4.	6-9, 15-20
X --------- Y	US, A, 3,908,194 (Romankiw) 23 September 1975, col. 3, lines 53-68 and col. 4, Figs. 5, 6, 9.	5, 21, 22 ------------- 4, 8-20, 23-39, 45-47

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date		
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 April 1994	06 MAY 1994

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	DAVID OMETZ
Facsimile No. N.A.	Telephone No. (703) 308-1296

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/02620

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,059,278 (Cohen et al) 22 October 1991, col. 5, lines 50-61, Fig 1.	10-12, 20
X --------- Y	US, A, 5,084,957 (Amin et al) 04 February 1992, cols. 4-5, Figs. 1 and 2.	40, 43, 48, 49 ------------- 23-30, 39, 47
A	US, A, 4,967,298 (Mowry) 30 October 1990, Fig. 6.	5, 21-27