

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 0 877 396 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.11.1998 Bulletin 1998/46

(51) Int Cl.⁶: **H01F 7/02**, H01F 41/02,
H01J 29/68

(21) Application number: **98303261.6**

(22) Date of filing: **27.04.1998**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **09.05.1997 US 854285**
09.05.1997 US 854284

(71) Applicant: **INTERNATIONAL BUSINESS
MACHINES CORPORATION**
Armonk, NY 10504 (US)

(72) Inventors:
• **Knickerbocker, John Ulrich**
Hopewell Junction, New York 12533 (US)

• **Knox, Andrew Ramsay**
Kilbirnie, Ayrshire KA25 7JZ (GB)
• **Rosenberg, Robert**
Peekskill, New York 10566 (US)
• **Humenik, James N.**
LaGrangeville, New York (US)

(74) Representative: **Ling, Christopher John**
IBM United Kingdom Limited,
Intellectual Property Department,
Hursley Park
Winchester, Hampshire SO21 2JN (GB)

(54) **Metal/ferrite laminate magnet**

(57) A metal/ferrite laminate magnet (100) has perforations forming apertures (125) in the magnet (100). The magnet is formed of outside metal plates (105) surrounding a sandwich of two layers of ferrite material (115). The outside metal plates (105) allow the perfora-

tions (125) to be made in the magnet (100) before sintering of the magnet (100) and maintain the alignment of the holes (125) during sintering. The metal plates (105) also provide the magnet (100) with mechanical robustness and rigidity and prevent cracking occurring between adjacent apertures (125).

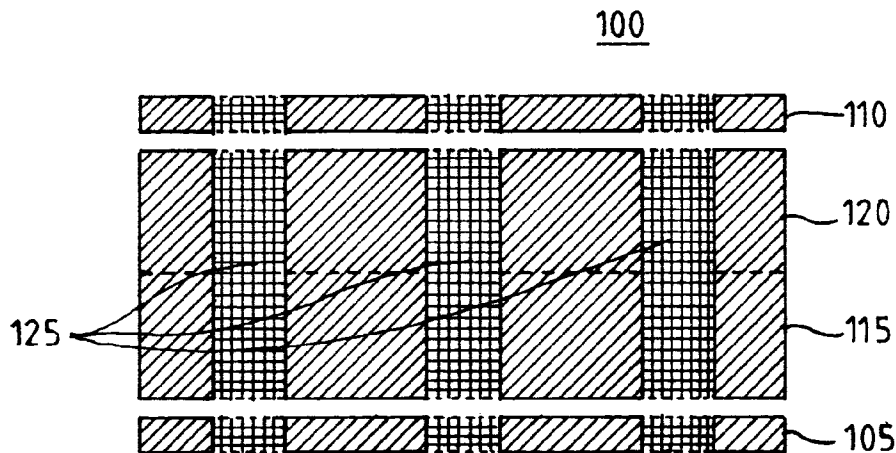


FIG. 1

EP 0 877 396 A1

Description

Field of the Invention

The present invention relates to a metal/ferrite laminate magnet having perforations and a process for manufacturing such a magnet. More particularly, the present invention relates to a magnet having a metal plate attached to a ferrite to maintain positional accuracy of perforations in the laminate and a process for fabrication of a large area laminate magnet with a significant number of perforated holes, integrated metal plate(s) and electrodes for electron and electron beam control.

Background of the invention

A magnetic matrix display is particularly although not exclusively useful in flat panel display applications such as television receivers and visual display units for computers, especially although not exclusively portable computers, personal organisers, communications equipment, and the like.

Conventional flat panel displays, such as liquid crystal display panels and field emission displays, are complicated to manufacture because they each involve a relatively high level of semiconductor fabrication, delicate materials, and high tolerances.

UK Patent Application 2304981 discloses a magnetic matrix display having a cathode for emitting electrons, a permanent magnet with a two dimensional array of channels extending between opposite poles of the magnet, the direction of magnetisation being from the surface facing the cathode to the opposing surface. The magnet generates, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam. The display also has a screen for receiving an electron beam from each channel, the screen having a phosphor coating facing the side of the magnet remote from the cathode, the phosphor coating comprising a plurality of pixels each corresponding to a different channel. There are grid electrode means disposed between the cathode means and the magnet for controlling the flow of electrons from the cathode means into each channel. The two dimensional array of channels are regularly spaced on an X-Y grid. The magnet area is large compared with its thickness.

The permanent magnet is used to form substantially linear, high intensity fields in the channels or magnetic apertures for the purpose of collimating the electrons passing through the aperture. The permanent magnet is insulating, or at most, has a small conductivity, so as to allow a field gradient along the length of the aperture. The placement of the beam so formed, on the phosphor coating, is largely dependent on the physical location of the apertures in the permanent magnet.

In operation, these electron beams are directed at a phosphor screen and collision of the electron beam with the phosphor results in light output, the intensity

being proportional to the incident beam current (for a fixed final anode voltage). For colour displays, three different coloured phosphors are used and colour is obtained by selective mixing of these three primary colours.

For accurate colour reproduction, the location of the electron beams on the appropriate coloured phosphor is essential. Some degree of error may be tolerated by using "black matrix" to separate the different phosphors. This material acts to delimit individual phosphor colours and also enhances the contrast ratio of the displayed image by making the display faceplate appear darker. However, if the electron beam is misplaced relative to the phosphor, initially the light output from the phosphor is reduced (due to loss of beam current to the black matrix) and this will be visible as a luminance non-uniformity. If the beam is subject to a more severe placement error, it may stray onto a different coloured phosphor to that for which it was intended and start to produce visible quantities of light output. Thus the misplaced electron beam is actually producing the wrong light output colour. This is called a purity error and is a most undesirable display artifact. For a 0.3mm pixel, typical phosphor widths are 67µm with 33µm black matrix between them.

It will be apparent that a very precise alignment is required between the magnet used to form the electron beams and the glass plate used to carry the phosphors that receive the electron beams. Further, this precise alignment must be maintained over a range of different operating conditions (high and low brightness, variable ambient temperature etc).

A number of other magnet characteristics are also important when considering application to a display:

1. It is generally accepted that the displayed image is formed by a regular array of pixels. These pixels are conventionally placed on a square or rectangular grid. In order to retain compatibility with graphics adaptors the magnet must thus present the electron beams on such an array.

2. In operation, the spacing between the grids used for bias and modulation of the electron beam and the electron source determines the current carried in the electron beam. Variations of this spacing will lead to variations in beam current and so to changes in light output from the phosphor screen. Hence it is a requirement that the magnet, which is used as a carrier for these bias and modulation grids, maintain a known spacing to the electron source. To avoid constructional difficulties, the magnet should be flat.

3. The display will be subject to mechanical forces, especially during shipment. The magnet must retain structural integrity over the allowable range of stresses it may encounter. A commonly accepted level is an equivalent acceleration of 30G

(294ms⁻²).

One further requirement is that since the magnet is to be used within the display, which is evacuated, it should not contain any organic components which may be released over the life of the display, so degrading the quality of vacuum or poisoning the cathode.

Finally, the magnet is magnetised in the direction of the apertures, that is the poles correspond to the faces of the magnet.

The manufacture of such a magnet that satisfies the above conditions is not possible by the use of previously known manufacturing methods. Certainly a magnet (ferrite, for example) of the desired size *without* apertures is readily obtainable but the presence of the apertures causes some problems.

If the apertures in the magnet are to be formed after the ferrite plate has been sintered, either laser or mechanical drilling may be used. However, the sintered ferrite is a very hard material and forming the apertures by this technique will be a costly and lengthy process - unsuitable for a manufacturing process.

Holes could be formed in the ferrite at the green-sheet stage before sintering by known punching/drilling methods. However, during sintering a number of problems arise:

1. The magnet plate will be subject to uneven shrinkage leading to the holes "moving" - an unequal radial displacement from their nominal positions.
2. The magnet itself is likely to "bow" such that it forms a section of a large diameter sphere.
3. Cracking is likely to occur between adjacent apertures due to the apertures acting as stress concentrators.
4. If, to obtain the desired aperture length, multiple thin sheets are stacked on top of one another, unequal shrinkage of individual sheets may lead to there being no "line of sight" through the apertures.

A further problem is that ferrite is a hard but not tough material and the presence of the apertures significantly reduces the mechanical strength of the plate. Thus, during shipment when large shocks may be encountered, complete mechanical failure of the magnet is a distinct possibility.

United States Patent 4,138,236 discloses a method of bonding hard and/or soft magnetic ferrite parts with an oxide glass. The oxide glass may be applied prior to or after prefiring or main firing. Finally, the ferrite parts are fused at temperatures in excess of the glass softening point.

United States Patent 4,540,500 discloses a low temperature sinterable oxide magnetic material pre-

pared by adding 0.1 to 5% by weight of glass to ferrite. In some situations, the sintering temperature can be reduced to about 1,000°C or less.

United States Patent 4,023,057 discloses a compound magnet for a motor stator having a laminated structure that includes thin, flexible magnets made from permanently magnetizable particles, such as barium ferrite, that are embedded in a flexible matrix, such as rubber. Various laminated arrangements are contemplated for producing more intense magnetic fields and thin metal spacers are used in most laminated structures to collapse the respective fields of the flexible magnetic components to increase the flux density at the resultant poles and to orient the permanent magnetic fields in the magnetic circuit of the motor.

Published Japanese Patent Application No. JP60093742 discloses a display having a focus electrode with a conductive magnetic body and a sputtered metal coating on one surface of the magnet body. The conductivity is required for the focusing electrode to perform its function. The coating is sputtered and so is a thin coating, not substantially adding to the mechanical structure of the magnet. Each of the holes in the magnet has a number of electron beams passing through it.

UK Patent Application 2315266 discloses a magnet-photosensitive glass composite and methods thereof.

However, the prior art does not disclose or teach the metal/ferrite laminate magnet and process thereof of the present invention.

Disclosure of the invention

Accordingly the invention provides a metal/ferrite laminate magnet comprising: a first ferrite sheet having a first surface and a second surface; a first metal plate having a first surface and a second surface, the first surface being attached to said first ferrite sheet over substantially the whole of a first surface of said first ferrite sheet; the first metal plate and the first ferrite sheet each having a plurality of apertures formed therein, extending from said first surfaces to said second surfaces, said apertures of said first ferrite sheet and said first metal plate being substantially aligned; a second ferrite sheet having a first surface and a second surface; a second metal plate having a first surface and a second surface, the first surface being attached to said second ferrite sheet over substantially the whole of a first surface of said second ferrite sheet; said second metal plate and said second ferrite sheet each having a plurality of apertures formed therein, extending from said first surfaces to said second surfaces, said apertures of said second ferrite sheet and said second metal plate being substantially aligned; and said first metal plate and said first ferrite sheet being joined to said second metal plate attached to said second ferrite sheet, such that the second surfaces of said first and second ferrite sheets abut and such that said apertures in said first and second ferrite

sheets are substantially aligned.

In a preferred embodiment in which deflection anodes are provided on one of the outer surfaces of the magnet the metal/ferrite laminate magnet further comprises a first insulating layer having a first surface and a second surface, the first surface being attached to said first metal plate, over substantially the whole of the second surface of the first metal plate; a first conductive layer, forming a set of deflection anodes, having a first surface and a second surface, the second surface being attached to said first insulating layer, over substantially the whole of a second surface of the first insulating layer; and said first insulating layer and said first conductive layer each having a plurality of respective apertures formed therein, each of the apertures corresponding to, and aligned with, a respective aperture in the first metal plate.

In a yet further preferred embodiment in which two sets of control grids are provided on the outer surface of the magnet opposing the deflection anodes the metal/ferrite laminate magnet further comprises: a second insulating layer having a first surface and a second surface, the first surface being attached to said second metal plate, over substantially the whole of the second surface of the second metal plate; a second conductive layer, forming a set of control electrodes, having a first surface and a second surface, the first surface being attached to said second insulating layer, over substantially the whole of the second surface of the second insulating layer; a third insulating layer having a first surface and a second surface, the first surface being attached to said second conductive layer, over substantially the whole of a second surface of the second conductive layer; a third conductive layer, forming a set of control electrodes, having a first surface and a second surface, the first surface being attached to said third insulating layer, over substantially the whole of a first surface of the third insulating layer; and wherein said second insulating layer, said second conductive layer, said third insulating layer and said third conductive layer each have a plurality of respective apertures formed therein, each of the apertures corresponding to, and aligned with, a respective aperture in the second metal plate.

In order to provide substantially linear, high intensity fields in the apertures for the purpose of collimating the electrons passing through the aperture, the first and second ferrite sheets are magnetised in the direction of the apertures so that the first surfaces of the first and second ferrite sheets form the opposing poles of the magnet.

Preferably, the plurality of apertures formed in the metal sheets and the ferrite sheets are arranged as a regular array so as to retain compatibility with existing graphics adapters.

Further preferably, to reduce stresses in the magnet, the thermal expansion coefficient of the ferrite sheets substantially corresponds to that of the metal plates.

In a preferred embodiment of the magnet the metal plates are stainless steel, which is magnetically transparent so as not to disturb the desired flux pattern from the magnet. In an alternative embodiment, the metal plates are soft iron having high permeability, which has the effect of shunting the magnetic field external to the magnet assembly, so limiting the collimating effect of the magnetic field to the apertures only. In a further alternative embodiment, the second metal plate is stainless steel and magnetically transparent and the first metal plate is soft iron and shunts the magnetic field external to the magnet assembly. This has the effect of forcing the field lines within the apertures at the end nearest the first metal plate to be normal to the metal plate surface, rather than to bend towards the outer edges of the magnet.

In a yet more preferred embodiment, the ferrite sheet has a bulk electrical resistance of between $10^7 \Omega/\square$ and $10^9 \Omega/\square$. This high, but finite, resistance provides a leakage path for the charge left by electron collisions and positive ion collisions with the aperture walls.

The invention also provides a process of forming metal/ferrite laminate magnet, comprising the steps of:

- (a) forming at least one opening in a metal sheet having a first surface and a second surface,
- (b) securing at least one ferritic layer to said first surface of said metal sheet,
- (c) securing at least one dielectric layer to said second surface of said metal sheet,
- (d) forming an opening through said ferritic layer and said dielectric layer, such that at least a portion of said opening overlaps a portion of said opening in said metal sheet, and thereby forming said metal/ferrite laminate magnet.

Brief description of the drawings

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a magnet according to a first embodiment of the present invention having a pair of metal layers with two ferrite sheets therebetween;

Figure 2 shows a magnet according to a second embodiment of the present invention having a pair of metal layers with a ferrite sheet therebetween;

Figure 3 shows a magnet according to a first embodiment of the present invention having deflection anodes and control electrodes formed thereon;

Figure 4 shows a magnet according to a third embodiment of the present invention having a single metal layer attached to a ferrite sheet;

Figure 5 shows a magnet according to a third embodiment of the present invention wherein the single metal layer faces the incoming electron beams; and

Figures 6-12 illustrate one process of manufacture of the preferred embodiment, specifically the laminated metal/ferrite magnet, of this invention.

Detailed description of the preferred embodiments

Figure 1 shows a magnet 100 which consists of magnetic material 120,115 built with two metal plates 105,110 sandwiching the magnetic material 120,115. Apertures 125 are formed in the magnetic material layers 120,115 and in the metal plates 105,110. The metal plates may be a magnetically transparent material such as stainless steel or they may be a metal with a high permeability, such as soft iron.

In each of the figures 1 to 5, the layers are shown with a small separation between them for the purposes of clarity, however, the layers are actually substantially in contact with each other without gaps between them.

The process for forming the preferred magnet is:

Step 1 - Cut the metal plate 105 to size. In the alternative, the plate 105 could be formed by a roll operation;

Step 2 - Etch the apertures 125 in the metal plate;

Step 3 - Attach the magnetic material 115 (which is in the form of a ferrite greensheet) to one side of etched metal plate 105;

Step 4 - Punch apertures 125 in the magnetic material 115 using the etched holes in the metal plate 105 as guides;

Step 5 - Repeat steps 1 to 4 for a second metal plate 110 and ferrite greensheet 120;

Step 6 - Align the assembly created at step 4 with that created at step 5;

Step 7 - Sinter the sandwich 100 including the magnetic material 115,120 using a conventional sintering method; and

Step 8 - Align the magnetic field perpendicular to the magnet 100 surface to magnetise the magnet assembly.

The above structure provides a steel/ferrite laminate magnet with the desired mechanical properties. For each half of the structure, the aperture length is typically in the range $2.0\times \rightarrow 4.0\times$ the diameter, with the steel substrate being of the order of $50\mu\text{m}$ thick. For a magnet with $100\mu\text{m}$ diameter apertures, the aperture length is approximately $400\mu\text{m}$, giving a magnet thickness of $500\mu\text{m}$ and for $200\mu\text{m}$ diameter apertures, the aperture length may increase to 1.2mm , giving a magnet thickness of 1.3mm . Note that these figures represent the maximum aperture aspect ratio and that this may not necessarily be required for satisfactory beam colli-

mation.

The stainless steel plates used on the outside faces of the magnet are magnetically "transparent" so as not to disturb the desired flux pattern from the magnet. The plates also serve to maintain flatness of the magnet under mechanical loads caused by assembly, thermal cycling or by operation of a hot cathode where temperature variations can be neutralised by the thermally conductive metal.

It is possible to use metal plates with high permeability e.g. soft iron. These will have the effect of "shunting" the magnetic field external to the magnet assembly, so limiting the collimating effect of the magnetic field to the apertures only. Outside the apertures, the electron beam is then influenced only by electrostatic fields associated with normal display operation. The electron beam will still be influenced by magnetic fields generated external to the display. The permeable metal plate will not correct for high external fields, but will provide some correction.

The magnet is to be used with electron beams passing through the apertures. Despite the collimating effect of the magnetic field, there is bound to be some collision of stray electrons and positively charged ions with the aperture walls. If the magnetic material were to be a perfect insulator, electron collisions would result in the deposition of a negative charge on the aperture walls and positive ion collisions would result in the deposition of a positive charge on the aperture walls. This in turn would lead to a reduction in the potential at the walls, so disturbing the electrostatic field pattern and hence the electron beam. In the limit if sufficient charge were deposited, the potential would fall so much as to exclude any further electrons from entering the aperture and the display would cease to function until this charge was removed.

To circumvent this problem, the magnetic material has an additive which provides a high but finite resistance, typically in the range $10^7 \rightarrow 10^9 \Omega/\square$. Thus there is a leakage path for the charge left by any electron collisions or any positive ion collisions with the aperture walls. However, the resistance is sufficiently high to allow the correct potential gradient across the aperture without dissipating excessive power, which would lead to possible thermal problems within the magnet itself.

Other ceramic materials (in particular, glass) are added to the base ferrite to act as a binder and to modify the thermal expansion coefficient of the ferrite/glass laminate to closely match the metal plate(s). Similarly, dielectric and electrode materials should have thermal expansion coefficients near or matched to the metal plates. For the ferrite/glass composite, increasing the percentage of glass per volume decreases the final obtainable magnetic field strength. Calculation suggests that up to one-third of the ferrite may be replaced before the collimating action of the field is degraded sufficiently to cause a problem with the operation of the display. This corresponds to a magnet field strength of about 2000

gauss. In conventional usage this percentage of binders, etc. is not required. An increase in the magnetic field strength required could be achieved with alternate materials, such as one of the rare earths, if required. A suitable rare earth material is Samarium Cobalt.

A further benefit of the laminate structure is that the steel plates on the outside of the magnet are highly electrically conductive. They thus form equipotential surfaces on each side of the magnet apertures. In so doing, a highly uniform field across the display is to be expected. Apart from the field uniformity, the etched holes in the steel plate also "shield" the magnet aperture walls from the collision of stray electrons.

Computer simulations show that the most likely place for a collision to occur is at the aperture entrance, before the full collimating effect of the magnetic field has exerting its influence. In this region, the electrons are passing through the steel layer and thus, since it is a conductor, collisions will not be a problem, manifesting itself as a negligibly small current flowing in the bottom plate.

Figure 2 shows a second embodiment 200 of the present invention. In this embodiment a single ferrite sheet 120 is used, together with a top metal plate 110 and a bottom metal plate 105. In this context bottom means the surface of the magnet facing the cathode or source of electrons and top means the surface of the magnet facing the phosphor screen. This embodiment does not allow the formation of such high aspect ratio apertures, but it allows for a cheaper and simpler construction. The benefits of maintaining positional accuracy of the apertures during manufacture are still achieved.

One of the differentiating features of a Magnetic Matrix Display is the mechanical simplicity of the display construction. A major contributor to this simplicity is the use of the magnet as the carrier for the grid electrodes used to operate the display.

Figure 3 shows a laminate magnet according to the present invention. The magnet structure 100 corresponds to that of figure 1. Additionally, since the outer surfaces of the magnet assembly are highly conductive steel plates, there is a thin insulating layer 310, which is typically 50µm thick, between the steel plate 110 and the deflection electrode 305. The deflection electrode 305 is a deflection electrode as described in UK patent application 2304981 referred to earlier in this description.

Similarly, control electrodes 320 and 330 are located on steel plate 105, being separated from the steel plate 105 by an insulating layer 315 and from each other by a further insulating layer 325. Each of the insulating layers 315,325 is typically 50µm thick.

Figure 4 shows a third embodiment 400 of the present invention. In this embodiment only a single metal plate 110 is used, which will reduce the overall strength compared to the first and second embodiments described in figures 1 and 2 respectively, but the cost

and complexity of manufacture will be reduced. The cathode or electron source is located below the magnet and the electrons enter the apertures 125 in the direction shown by arrows 405.

Figure 5 shows a variation 500 of the third embodiment shown in figure 4, in which the single metal plate 105 is on the other side of the ferrite, that is, the plate is located on the side which faces the cathode or electron source. The electrons enter the apertures 125 in the direction shown by arrows 505.

Figures 6-12 illustrate one process of manufacture of the laminated metal/ferrite magnet 100, of this invention. Figure 6 shows a rolled metal sheet 605, which is preferably capable of withstanding oxidizing atmospheres of up to about 1000°C. Onto this metal sheet 605, is applied a photoresist 606, that is exposed and developed to produce a pattern of holes 607, in the resist 606. The metal sheet 605, and the developed photoresist 606, are then placed in an etchant that attacks the metal only in the area not protected by the resist 606. This produces the desired array of holes 125, in the metal sheet 605, creating the perforated metal sheet 705, as clearly seen in Figure 7.

The photoresist 606, is then stripped from the metal sheet 705. The etched metal sheet 705, can now be inspected to ensure that all holes 125, are present and that the dimensional and positional tolerances of the holes are met.

For some applications the metal sheet 705, may have to be prepared to enhance the adhesion between it and the subsequent ferritic layer and/or dielectric layer. This could be accomplished by the deposition of or formation of selected adhesion promoting metals or oxides on one or both surfaces of the metal sheet 705. However, one could also use a suitable adhesive to secure the ferritic layer and/or dielectric layer to the metal sheet 705.

A ferritic layer 815, is formed by combining ferritic material with a glass powder, organic binders, solvents and vehicles to produce a slurry capable of being cast into thin ferritic sheets. The technology used to produce these thin ferritic sheets 815, is similar to the one used to prepare conventional multilayer ceramic greensheets. After drying, the cast sheets are cut to the proper size to form a ferritic layer 815, which are to be used for further processing.

In similar fashion, a dielectric layer 813, is formed by processing dielectric material(s) into a slurry and casting them to form thin dielectric greensheets 813. After drying, these cast sheets are also cut to the proper size to form the thin dielectric greensheets 813, which are to be used for further processing. The dielectric layer 813, can be formed by alternative techniques, such as, for example, oxidation of the surface of the metal sheet 705.

As shown in Figure 8, a laminate structure is formed by combining the etched metal sheet 705, with the thin dielectric greensheet 813, on one side and the thin fer-

rite greensheet 815, on the other side, to form a primary "green" laminate structure 809. It is preferred that the laminate structure 809, is secured so that there is no movement between the various layers. This securing can be done by the simultaneous application of heat and/or pressure to all three components or layers of the laminate structure 809, or by adhesively bonding the layers to the metal sheet 705.

After the primary "green" laminate structure 809, has been formed, holes are produced in the ferritic greensheet 815, and dielectric greensheet 813, using the pre-existing etched holes 125, in the metal sheet 705, as a guide. The holes formed in the greensheet components of the laminate structure 809, can be made by myriad mechanical, laser, or electron beam techniques known to those skilled in the art. This is shown in Figure 9, where a primary "green" laminate structure 809, has been perforated with holes 125, that have been produced in the ferritic greensheet 815, and dielectric greensheet 813, creating a punched ferritic greensheet 915, and a punched dielectric greensheet 913, that combine with the metal sheet 905, to form a perforated primary green laminate 919.

A plurality of perforated primary "green" laminate structures 919, may be combined into a secondary "green" laminate structure 1029. This would be accomplished by the reapplication of heat and/or pressure to the components or by the use of an organic adhesive. In this step care must be taken to ensure the alignment of the holes 125, in the various substructures.

The secondary "green" laminate structure 1029, is thermally processed in a manner that drives off or decomposes the organic constituents that may be present in the structure 1029. This thermal process also coalesces the particles that are used to make up the ferritic and dielectric layers, it binds the ferritic layer 915, and the dielectric layer 913, to the metal sheet 905, and bonds the ferritic layers 915, to each other, as more clearly shown in Figure 10. Please note that for the purpose of clarity through holes 125, have not been shown in the laminated structure 1029, of Figure 10.

The thermal processing of the secondary "green" laminate 1029, is preferably done at a temperature less than that which will cause permanent deformation of the metal sheet 915. The glass phase added to the ferrite powder will enhance the sintering of the structure.

An alternative way of making the sintered laminate structure 1029, is illustrated in Figure 11, where the structure 809, as shown in Figure 8, is stacked to create a structure 1159. The stacked and laminated structure 1159, is similar to the laminate structure 1029, except that only holes 125, have been formed in the metal sheet 905, and that there are no holes 125, in the ferritic layer 915, or the dielectric layer 913. This structure 1159, is then partially sintered to create a structure 1159, which is essentially free of any organic material and is also partially densified. This partial densification of the laminated structure 1159, should be such that a mechanical

means could be used to form holes through the dielectric layer 913, and the ferrite layer 915. One way to form the hole 125, would be by using a media blast or pressurized impinging medium 1156. Care should be taken that the laminated structure 1159, is not damaged in any way. One way to avoid any damage to the laminated structure 1159, would be to secure a metal or coated metal-type plate 1151, having openings 1155, that correspond to the openings 125, to the side of the laminated structure 1159, that is being hit with the impinging medium 1156. The metal-type plate 1151, could also have a polymer or rubber backing 1153, having openings 1155. Particles from the media blast 1156, that pass through the openings 1155, hit the particles in the vicinity of the openings 125, and that results in the expulsion of particles 1157, thus creating openings 125, in both the dielectric layer 913, and the ferrite layer 915, resulting in a laminated structure 1029, that has through openings 125. The laminated structure 1029, having through openings 125, can now be fully sintered, if it has not been done so.

After the sintered laminate structure 1029, has been formed, the deflection electrode 305, and the control electrodes 320 and 330, are applied to or formed on the structure, as clearly shown in Figure 12.

These electrically conductive metal patterns, such as, metal patterns 320, 330 and 305, may be applied by any of a number of techniques that include the screen printing of metal pastes, the photo or mechanical patterning of applied metal layers, or the application of a pre-patterned metal decal. Depending on the techniques used to apply the metal patterns, a subsequent heat treatment of the laminate structure may be required.

In order to form the metal patterns 320 and 330, it is preferred that after the application of the initial metal pattern say 320, to the surface of the sintered laminate structure 1029, a second set of control grid electrodes 330, may be applied orthogonally to the first set 320 or 330, because it does not matter if grid electrode 320, is formed first or the grid electrode 330, is formed first. However, prior to the application of the second set of control grid electrodes, a dielectric layer 315, may be deposited onto the first set of electrodes, lets say electrode 320, to isolate one electrode from the other electrode. This dielectric layer 315, may be applied in the form of an adhesively bonded greensheet, it may be made into a slurry that is sprayed onto the surface, or it may be applied using conventional thin film deposition techniques, which are well known in the art.

Depending on the technique used to apply the dielectric layer 315, the sintered laminate 1029, may have to be subjected to another heat treatment to coalesce the powders of the dielectric layer. Imperative in this step is that the holes 1241, 1243 and 125, forming the pixel hole 1270, in the structure not be altered by the application of the dielectric layer 315. Once the dielectric layer 315, has been applied to the surface of the sintered laminate, over the first set of control grid electrodes, the

second set of control grid electrodes may be applied orthogonally to the first.

The application of these metal features would utilize any of the techniques previously described for the application of surface metallization.

However, it should be noted that all of the metal and dielectric features could be applied in an unsintered pre-patterned form to the sintered laminate. A second sintering would then bond these features to the initial laminate structure.

After the final sintered laminate has been produced, it would be subjected to electrical test, physical inspection, and finally the polarizing of the ferritic layers 915, to produce the necessary magnetic field. It should be appreciated that polarization of the ferritic layers 915, can take place before or after assembly of the magnet laminate in a device. Furthermore, the polarization of the ferritic layers 915, can also take place at elevated temperatures.

One advantage of the magnet laminate of the present invention is that the openings 125, or the pixel wells 1270, do not have to be perfectly aligned in order for an electron beam to pass through the pixel wells 1270.

The metal plate(s) 905, that is part of the magnet laminate provides numerous advantages. For example, the metal plate avoids charging and acts as a stray electron sink. It provides mechanical strength to the magnet laminate. It provides thermal stress gradient reduction. The metal plate(s) provide dimensional stability. They are used for the process registration for the hole formation. For some applications the metal plate(s) 905, could also be used as a mask for the formation of phosphors on the glass plate.

Claims

1. A metal/ferrite laminate magnet (100) comprising:

a first ferrite sheet (115) having a first surface and a second surface;

a first metal plate (105) having a first surface and a second surface, the first surface being attached to said first ferrite sheet over substantially the whole of a first surface of said first ferrite sheet;

the first metal plate and the first ferrite sheet each having a plurality of apertures (125) formed therein, extending from said first surfaces to said second surfaces, said apertures of said first ferrite sheet and said first metal plate being substantially aligned;

a second ferrite sheet (120) having a first surface and a second surface;

a second metal plate (110) having a first surface and a second surface, the first surface being attached to said second ferrite sheet over substantially the whole of a first surface of said second ferrite sheet;

said second metal plate and said second ferrite sheet each having a plurality of apertures (125) formed therein, extending from said first surfaces to said second surfaces, said apertures of said second ferrite sheet and said second metal plate being substantially aligned; and

said first metal plate and said first ferrite sheet being joined to said second metal plate attached to said second ferrite sheet, such that the second surfaces of said first and second ferrite sheets abut and such that said apertures in said first and second ferrite sheets are substantially aligned.

2. A metal/ferrite laminate magnet (100) according to claim 1 further comprising:

a first insulating layer (310) having a first surface and a second surface, the first surface being attached to said first metal plate (110), over substantially the whole of the second surface of the first metal plate;

a first conductive layer (305), forming a set of deflection anodes, having a first surface and a second surface, the second surface being attached to said first insulating layer, over substantially the whole of a second surface of the first insulating layer; and

said first insulating layer and said first conductive layer each having a plurality of respective apertures (125) formed therein, each of the apertures corresponding to, and aligned with, a respective aperture in the first metal plate.

3. A metal/ferrite laminate magnet (100) according to claim 2 further comprising:

a second insulating layer (315) having a first surface and a second surface, the first surface being attached to said second metal plate (105), over substantially the whole of the second surface of the second metal plate;

a second conductive layer (320), forming a set of control electrodes, having a first surface and a second surface, the first surface being attached to said second insulating layer, over substantially the whole of the second surface of the second insulating layer;

a third insulating layer (325) having a first surface and a second surface, the first surface being attached to said second conductive layer, over substantially the whole of a second surface of the second conductive layer;

a third conductive layer (330), forming a set of control electrodes, having a first surface and a second surface, the first surface being attached to said third insulating layer, over substantially the whole of a first surface of the third insulating layer; and wherein

said second insulating layer, said second conductive layer, said third insulating layer and said third conductive layer each have a plurality of respective apertures formed therein, each of the apertures (125) corresponding to, and aligned with, a respective aperture in the second metal plate.

4. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the first (115) and second (120) ferrite sheets are magnetised in the direction of the apertures (125) so that said first surfaces form the poles of the magnet.

5. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the plurality of apertures (125) formed in said first metal plate (105) and said first ferrite sheet (115) are arranged as a regular array.

6. A metal/ferrite laminate magnet (100) according to any preceding claim wherein said regular array is a square array.

7. A metal/ferrite laminate magnet (100) according to any preceding claim wherein said regular array is a rectangular array.

8. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the thermal expansion coefficient of the first (115) and second (120) ferrite sheets substantially corresponds to that of the first (105) and second metal (110) plates.

9. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the first (105) and second metal (110) plates are stainless steel.

10. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the first (105) and second metal (110) plates are soft iron.

11. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the first metal plate (105) is soft iron and the second metal plate (110)

is stainless steel).

12. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the aperture (125) diameter is approximately 100µm, the first (105) and second (110) metal plates are each approximately 50µm in thickness and the first (115) and second (120) ferrite sheets are each approximately 200µm in thickness.

13. A metal ferrite laminate magnet (100) according to any preceding claim wherein the aperture (125) diameter is approximately 200µm, the first (105) and second (110) metal plates are each approximately 50µm in thickness and the first (115) and second (120) ferrite sheets are each approximately 600µm in thickness.

14. A metal/ferrite laminate magnet (100) according to any preceding claim wherein the ferrite sheet has a bulk electrical resistance of between $10^7\Omega/\square$ and $10^9\Omega/\square$.

15. A process of forming a metal/ferrite laminate magnet (100), comprising the steps of:

(a) forming at least one aperture (125) in a metal plate (105) having a first surface and a second surface,

(b) securing at least one ferritic layer (115) to said first surface of said metal plate,

(c) securing at least one dielectric layer (310) to said second surface of said metal plate,

(d) forming an opening through said ferritic layer and said dielectric layer, such that at least a portion of said opening overlaps a portion of said opening in said metal plate, and thereby forming said metal/ferrite laminate magnet.

16. A process as claimed in claim 15, wherein said at least one aperture (125) in said metal plate (105) is formed by the application of at least one photoresist (606) on said metal plate, exposing and developing said photoresist to form a pattern of apertures and subsequently etching said metal plate to form said at least one aperture in said metal plate.

17. A process as claimed in claim 15, wherein said at least one aperture (125) in said metal plate (105) is formed by a laser beam, an electron beam or mechanical means.

18. A process as claimed in claim 15, further comprising mixing ferritic material with glass particles, organic binders and solvents to form a ferritic slurry; mixing,

casting and drying said ferritic slurry, into a ferritic green sheet; and blanking said ferritic green sheet into said at least one ferritic layer.

19. A process as claimed in claim 15, further comprising mixing dielectric material to form a dielectric slurry; mixing, casting and drying said dielectric slurry, into a dielectric green sheet; and blanking said dielectric green sheet into said at least one dielectric layer. 5
20. A process as claimed in claim 15, wherein at least one electrically conductive metal is secured adjacent to said aperture (125). 10
21. A process as claimed in claim 15, further comprising securing at least one anode means (305) on said perforated face of said magnet (100). 15
22. A process as claimed in claim 15, further comprising securing at least one control electrode means (320, 330) on said face of said magnet (100) remote from said face carrying an anode means (305). 20
23. A process as claimed in claim 15, wherein said aperture in said ferritic layer (115) is formed by partially sintering said ferritic layer and using a pressurized impinging medium (1156) to open at least one hole. 25
24. A process as claimed in claim 15, wherein two of said metal/ferrite laminate magnets are secured to each other such that said metal plate (105) sandwiches said ferritic material (115) and said dielectric material is on the opposite sides. 30
25. A process as claimed in claim 15, further comprising mixing ferritic material with glass particles, organic binders and solvents to form a ferritic slurry, and wherein said ferritic slurry is deposited onto said metal plate (105) using at least one spray. 35
26. A process as claimed in claim 15, further comprising mixing dielectric material to form a dielectric slurry, and wherein said dielectric slurry is deposited onto said metal plate (105) using at least one spray. 40
27. A process as claimed in claim 15, further comprising heating said metal plate (105) to at least 300°C and depositing dry ferritic powder material onto said heated metal plate until at least one coating of said ferritic material (115) is formed on said metal plate. 45
28. A process as claimed in claim 15, further comprising heating said metal plate (105) to at least 300°C and depositing dry dielectric powder material onto said heated metal plate until at least one coating of said dielectric material is formed on said metal plate. 50
29. A process as claimed in claim 15, wherein at least 55

one surface of said metal plate (105) is oxidized to form at least one dielectric layer.

30. A process as claimed in claim 15, wherein said aperture (125) in said metal plate (105) is used to form corresponding holes in subsequent components of said laminate magnet (100), and wherein all of said correspondingly formed holes are held in registration with said hole in said metal plate.

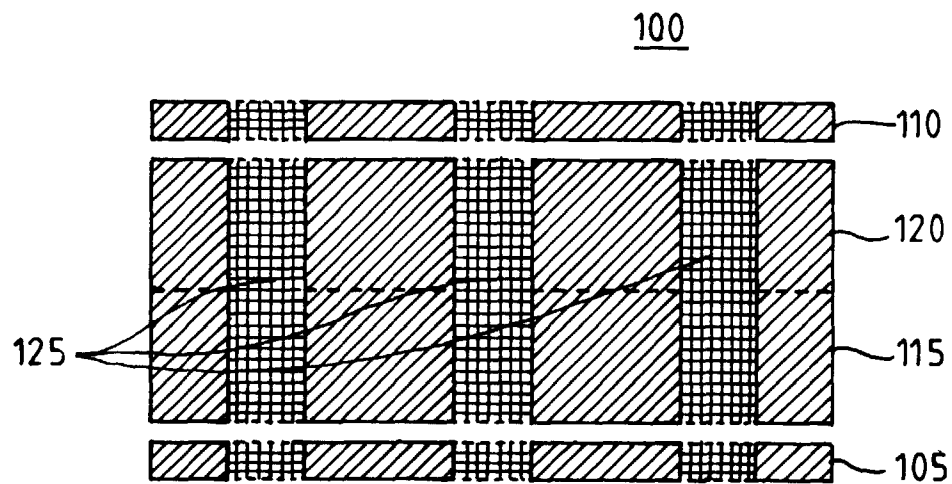


FIG. 1

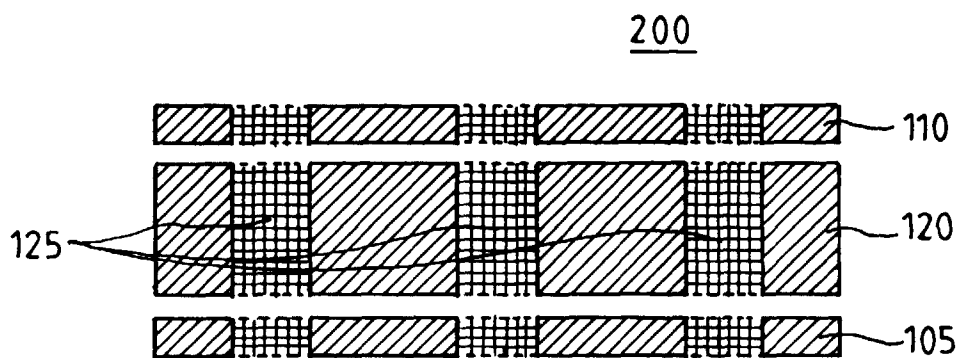


FIG. 2

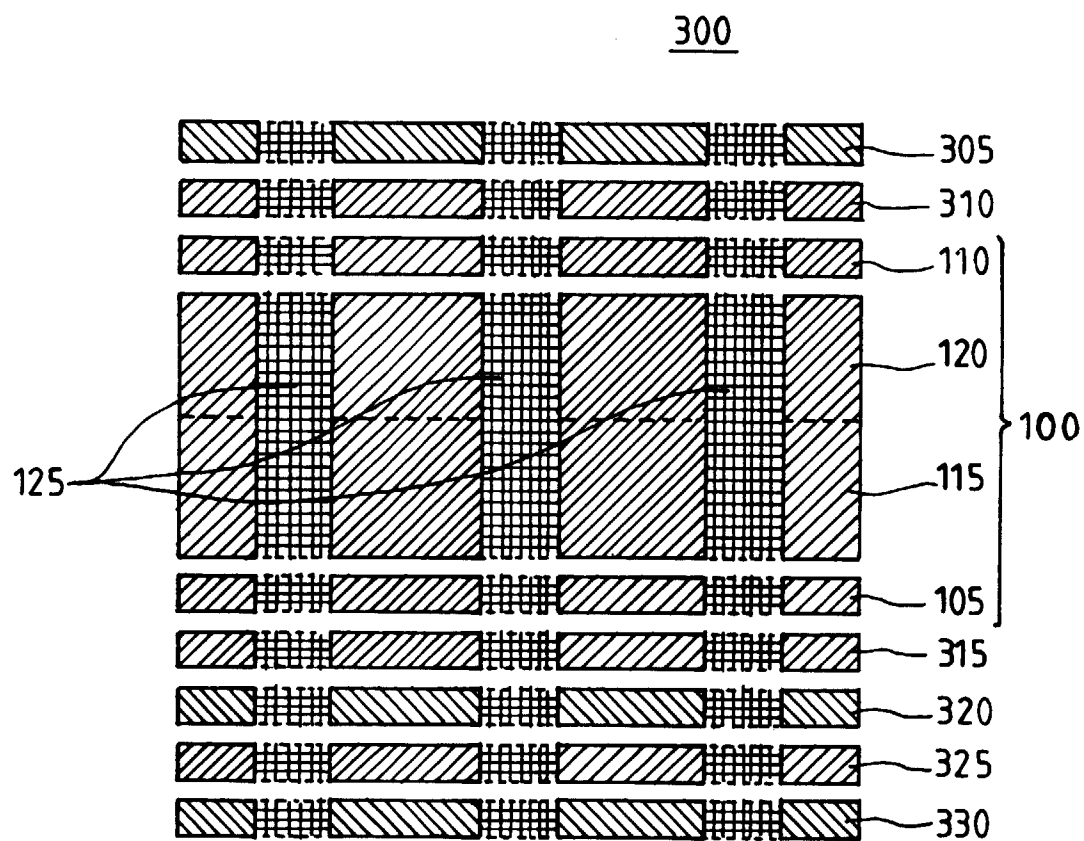


FIG. 3

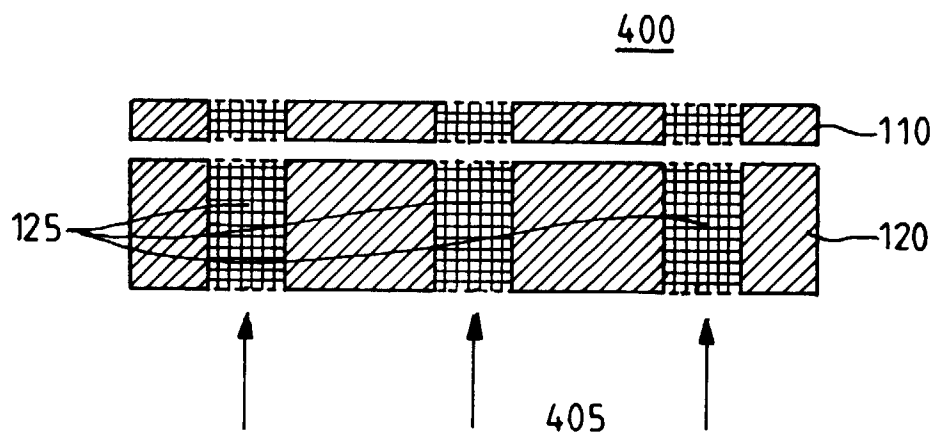


FIG. 4

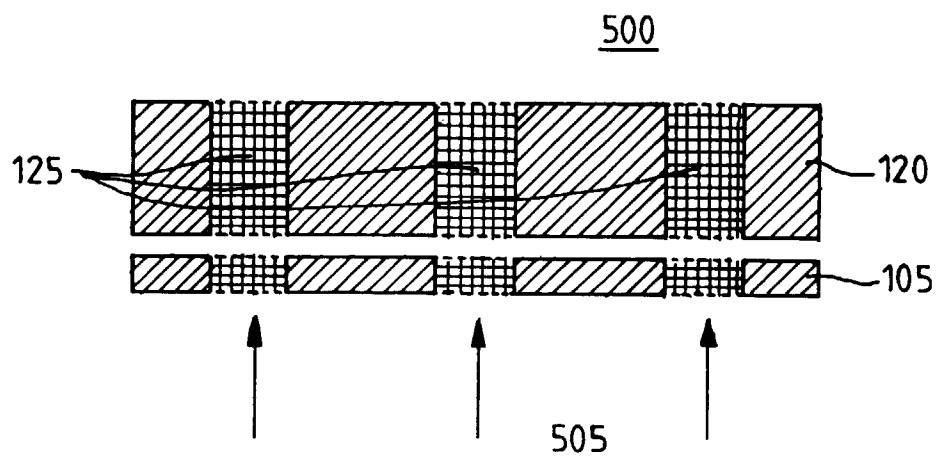


FIG. 5

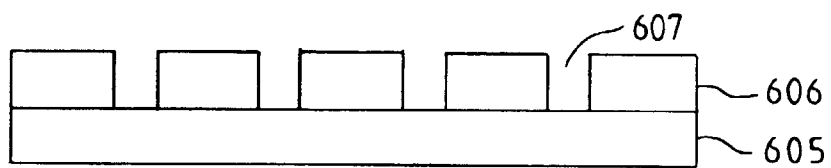


FIG. 6

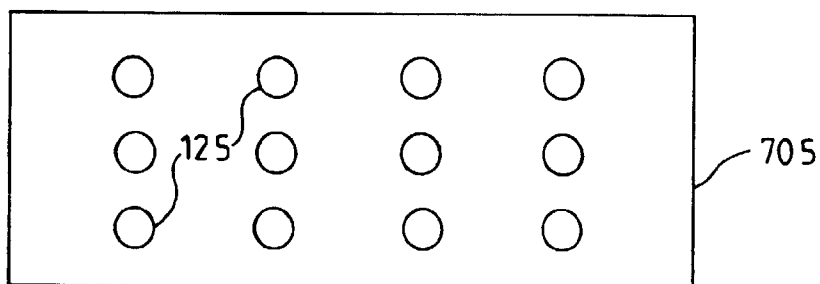


FIG. 7

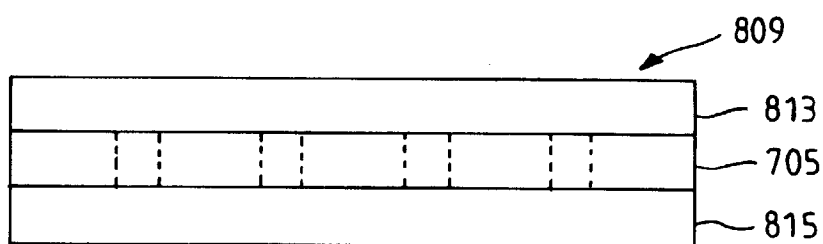


FIG. 8

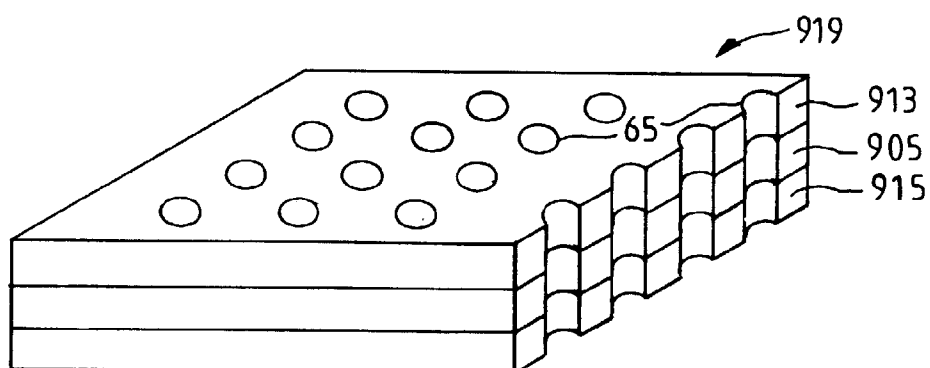


FIG. 9

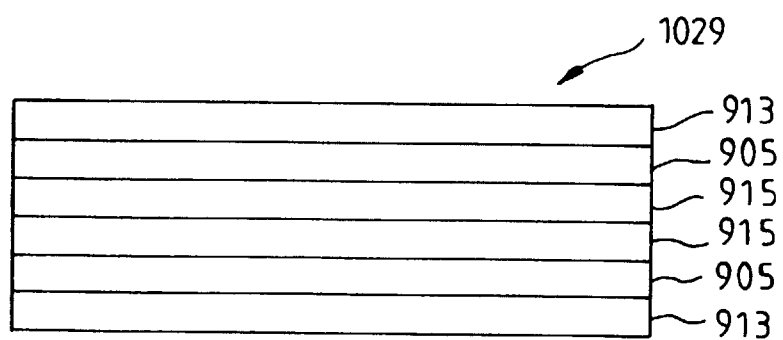


FIG. 10

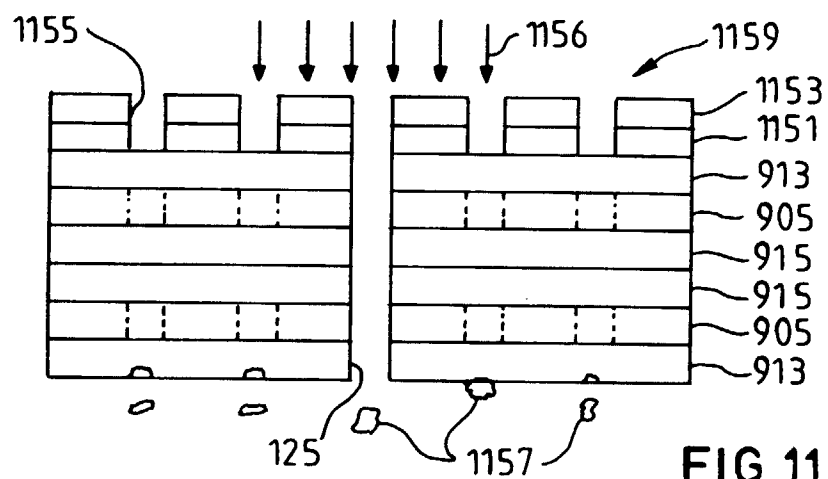


FIG. 11

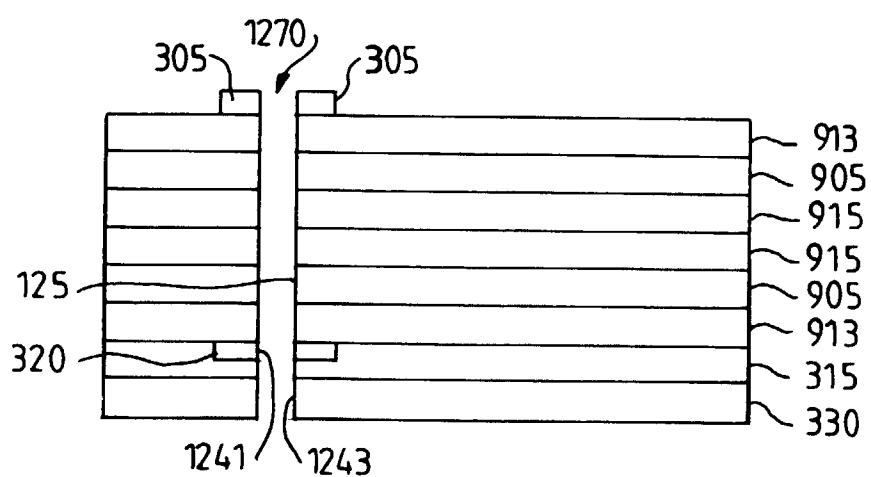


FIG. 12



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 3261

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,A	GB 2 304 981 A (IBM) 26 March 1997 * page 14, paragraph 3; claims 1-6,11-13,18,20,37-42; figure 5 * ---	1,2,4,5,15,18,22	H01F7/02 H01F41/02 H01J29/68
A	GB 1 041 315 A (ASSOCIATED ELECTRICAL INDUSTRIES) * page 1, line 19 - page 2, line 76; claims 1,3 * ---	1,5	
A	EP 0 530 125 A (FERROPERM COMPONENTS APS) 3 March 1993 * column 2, line 19 - column 3, line 11; claim 1; figure 1 * -----	1,15	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01F H01J
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 28 August 1998	Examiner Decanniere, L
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P/MC01)