April 15, 1969 E. A. LEDEEN 3,439,087

METHOD OF MAKING MEMORY CORE PLANE

Filed July 27, 1966 Sheet 1 of 2

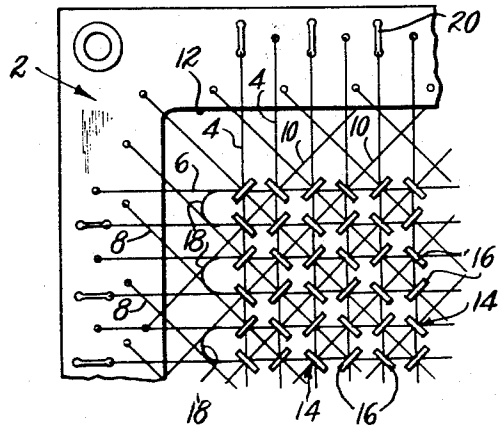


Fig. 1.

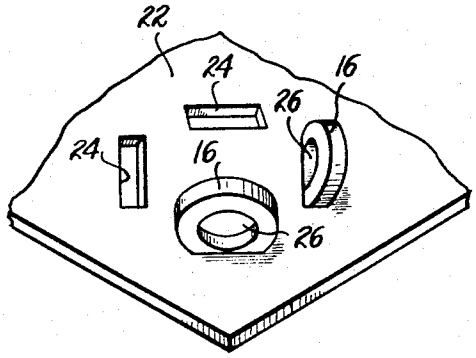


Fig. 2.

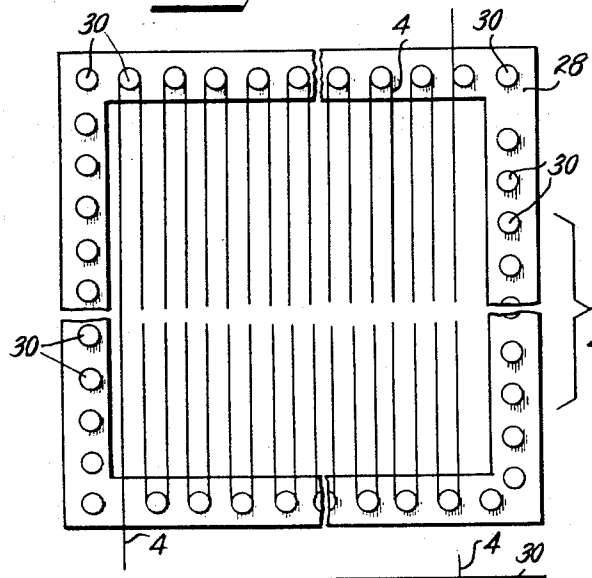


Fig. 3.

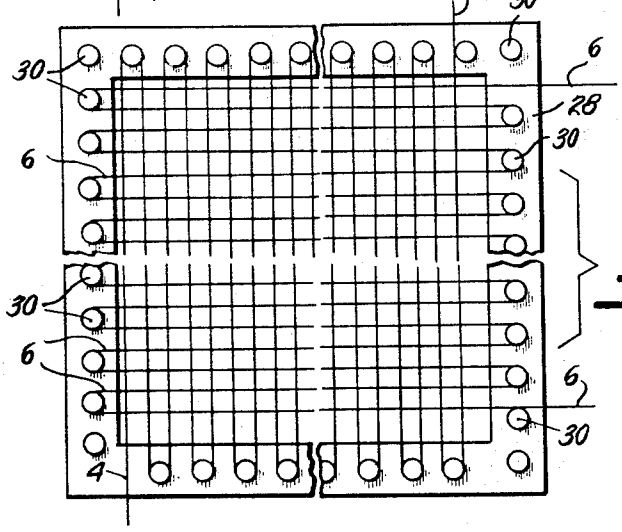


Fig. 4.

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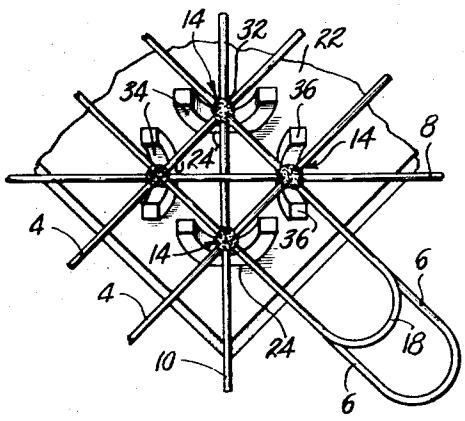


Fig. 5.

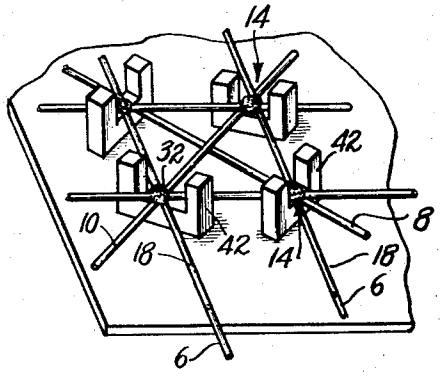
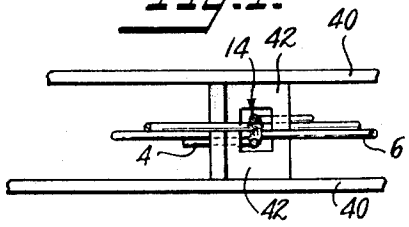


Fig. 6.

Fig. 7.



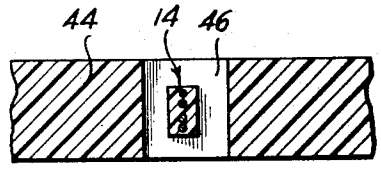
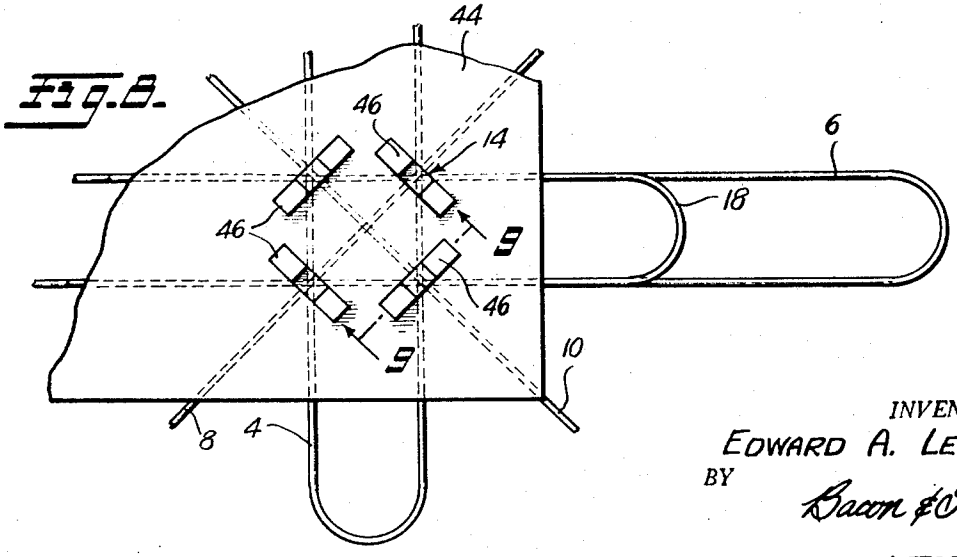


Fig. 9.

Fig. 8.



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METHOD OF MAKING MEMORY CORE PLANE

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U.S. Cl. 264—255 4 Claims

ABSTRACT OF THE DISCLOSURE

A core plane for a memory device is formed by arranging wires in a holder in the desired grid formation having a plurality of intersections. The grid is then invested in a mold material and annular cavities are formed in the material around each intersection. The cavities are then filled with magnetic material to form a memory core around each intersection.

This invention relates to the making of a core plane for a memory device, of more or less conventional form, for use in computers.

The general structure and manner of use of memory core planes is well known to those skilled in the art and need not be described in detail herein other than in broad and general terms. Such a core plane customarily comprises an open rectangular framework having a grid of wires extending across the opening thereof, said wires intersecting at a multiplicity of locations, there being generally about four wires intersecting at each location. The device further includes annular, or doughnut shaped magnets surrounding each intersection, with all the wires at that intersection passing through the center opening of the magnet. Many such core panes are employed in a single computer, in some cases hundreds, and each core plane may include over 4,000 small annular magnets arranged in an area about 3" square. At present these core planes are constructed almost entirely by hand, which renders their cost quite high and their production slow and tedious.

Customarily, a support plate is provided having a multiplicity of slots therethrough each of a size to receive and support one of the annular magnets on edge. The slots are arranged in accordance with the desired pattern of magnets in the core plane and a mass of the magnets is first placed on the plate and the same vibrated while suction is applied to the bottom of the plate through the slots. Thus, a magnet will eventually drop into each slot and be held upright therein by the suction, whereupon the excess magnets can be removed, leaving only those necessary for the particular core plane. Thereafter and while the cores are thus held on the support plane, working with microscopes or other high magnification apparatus, the wires are laboriously hand threaded through the core elements and secured to the frame to complete the memory core plane.

According to the present invention the grid of wires is first formed without the memory cores in place and means are provided to hold the grid in a self-supporting condition. Thereafter, the magnets are assembled or constructed around the various intersections of the grid in a manner capable of machine operation and without requiring tedious manual threading of the wires through the individual cores.

Various methods of assembling the magnets about the grid intersections will be described in detail.

It is, therefore, the primary object of this invention to provide a method of making memory core planes which eliminates substantially all hand labor and thereby reduces the cost of the core planes and increases the speed of production thereof.

Other and additional objects and advantages of the invention will become apparent to those skilled in the art as the description proceeds with reference to the accompanying drawings wherein:

FIG. 1 is a fragmentary enlarged plan view of a portion of a finished core plane;

FIG. 2 is a perspective view, on an enlarged scale, of a corner portion of a support plate as already used in constructing core planes and as used in one form of the present invention;

FIGS. 3 and 4 are plan views of a jig for assembling the wire grid according to one form of the present invention;

FIG. 5 is an enlarged perspective view illustrating a step in one form of the method of the present invention;

FIG. 6 is a view similar to FIG. 5 but illustrating a mold plate used at one step in a further method according to the invention;

FIG. 7 is a side view of the structure of FIG. 6 with a second mold plate in position;

FIG. 8 is a fragmentary enlarged plan view of a portion of an intermediate product of the invention produced by the apparatus of FIGS. 6 and 7; and

FIG. 9 is a further enlarged sectional view taken along the line 9—9 of FIG.8.

FIG. 1 illustrates a corner portion of a conventional memory plane comprising a suitable open rectangular frame **2** conventionally made of insulating material, such as fiberboard. A plurality of wires **4**, **6**, **8** and **10** are arranged in grid formation in the opening **12** of the frame **2**. The wires **4** and **6** define a rectangular grid parallel to the sides of the frame **2** whereas the wires **8** and **10** define a rectangular grid with the wires oblique to the sides of the frame **2**. Each of the sets of wires **4**, **6**, **8** and **10** are in superposed layers over the other sets of wires and are arranged so that wires of the grids intersect at a multiplicity of intersections one of which is identified generally by numeral **14**. Usually four wires pass through the annular magnet **16** at each intersection and are commonly known as "read," "write," "sense" and "inhibit" wires. The fourth wire may be provided by a wire **18** parallel to and overlying each wire **6**, as shown. The ends of the wires are secured to the frame **2** and electrically connected to suitable terminals **20** whereby the completed memory plane may be slidably positioned in a computer structure wherein the terminals **20** make electrical contact with suitable contacts in the apparatus. As previously stated, the wires described and the annular magnets **16** are quite small, sometimes the magnets **16** are of a diameter considerably less than $\frac{1}{32}$ of an inch and over 4,000 such magnets may be provided on each frame **2** occupying a space about 3" square.

The customary manner of assembling the device of FIG. 1 includes the use of a support plate **22** (FIG. 2) provided with slots **24** therethrough of a size to receive and hold the annular magnets **16** on edge with one magnet at each position corresponding to the desired positions of the intersections **14**. To position the magnets **16** on the plate **22**, a mass of the magnets is dumped on the plate and the latter is then vibrated while suction is applied to the bottom thereto. Thus, a magnet **16** will find its way into each slot **24** and will be held therein by the suction, in the upstanding position shown in FIG. 2. While so holding the magnets in place, the plate **24** may be positioned within the opening **12** of the frame **2** and the wires then laboriously threaded by hand through the central openings **26** of the magnets **16** and secured to the frame **2** as shown in FIG. 1.

According to one form of the present invention, the device is assembled as follows:

A rectangular jig **28** (FIGS. 3 and 4) is provided with upstanding pegs or pins **30** and about which a first layer

of wire 4 is sinuously wound, as shown in FIG. 3. Thereafter, a second layer of wire 6 is sinuously wound on other pegs in a layer overlying the wire 4 and at right angles thereto to thus form the rectangular grid first described with reference to FIG. 1. Thereafter, the diagonal grid comprising wires 8 and 10 (not shown in FIGS. 3 and 4) are wound on the jig either on the same pegs 30 or additional pegs. The pegs or pins 30 are so positioned that the grids will form the intersections 14, previously described, at the desired locations. It is to be understood that the use of the jig 28 is not essential since all of the wires may be threaded on and secured to the frame 2 in the first instance to define the grid of wires or the wires may be arranged to form the grid in any other suitable manner. In the case where the grid is formed separate from the frame 2, after completing the positioning of all of the wires therein, the grid is preferably treated to be self-supporting, such as by spraying a light adhesive thereon to at least temporarily bond the wires together at the intersections so that the grid may be removed from the jig and comprise a self-supporting mat or grid of wires. Such adhesive material is shown at 32 in FIGS. 5 and 6. If the grid of wires is first and initially formed directly on the frame 2, such adhesive is unnecessary since the grid is thus self-supporting.

The support plate 22, previously described, is then used but instead of positioning completely annular magnets 16 thereon, in the manner described, the plate 22 and the slots 24 thereof is employed to support generally U-shaped bodies 34 (see FIG. 5) of magnet material. The bodies 34 are arranged and oriented in the slots 24 with their open sides facing upwardly and with their legs 36 extending in an upward direction. Thereafter, the self-supporting grid of wires is placed over the assembly in the manner shown in FIG. 5 with the intersections 14 lying within the U-shaped bodies 34, that is, with the intersections being between the upstanding legs 36. Thereafter, a plate similar to the plate 22 is loaded with bridging pieces, not shown, with the bridging pieces being held thereon by suction in the manner already described so that the second plate may be positioned over the plate 22 of FIG. 5 with the bridging pieces spanning the legs of each of the bodies 34 and engaging the ends of those legs. Suitable adhesive material is applied to the ends of the legs 36 and the bridging pieces are thus secured thereto to define a generally annular magnet surrounding each intersection 14. After curing the adhesive, the suction may be relieved from both the plates and the latter removed, leaving the core plane assembled.

FIG. 5 shows the bodies 34 as being of generally semicircular shape and the bridging pieces may also of semicircular shape identical to the bodies 34. However, the bodies 34 may be rectangular, U-shaped or any other suitable configuration and the bridging pieces may be straight bars. Obviously, any desired shapes may be employed so long as they complement each other so that when assembled, they define a completely annular magnet. By "annular" magnet applicant refers to a magnet completely surrounding an intersection 14, whether the magnet be of truly circular shape or of other configuration having an opening for the wires.

An alternative method is illustrated in FIGS. 6 through 8. The self-suporting grid of wires shown in FIG. 6 may be formed in either of the manners already described. This alternative method employs a lower mold plate 40 to which are secured upstanding generally U-shaped mold devices 42 fixed thereon in the arrangement shown. The grid of wires is positioned on this lower mold structure in the manner shown in FIG. 6 and an identical or similar mold structure is inverted and placed over the assembly of FIG. 6 so that the mold devices 42 abut to define a generally annular mold form surrounding each of the intersections 14. This assembly is shown in side view in FIG. 7. While the parts are thus held in this position, a suitable investment material 44 is poured between the plates 40 to completely embed the grid of wires and to surround the mold devices 42. That material may be either a settable plastic material or a high temperature wax or the like. After the investment material is solidified, the mold plates 40 and their attached mold devices 42 are withdrawn from opposite faces thereof leaving the grid of wires embedded in the investment material 44. The spaces from which the mold devices 42 were removed define a generally annular cavity 46 (see FIG. 9) surrounding each of the intersections 14. The resulting structure is shown in plan in FIG. 8 and in section in FIG. 9. Generally U-shaped portions of the magnet cores may then be supported on a plate 22 in the manner already described and assembled to the structure of FIGS. 8 and 9 with the legs of the magnet extending into the cavities 46 from one side thereof and complementary magnet portions are then positioned in the remaining part of the cavities 46 from the other side thereof, preferably by employing such a support plate as already described with reference to FIG. 5. The magnet portions are adhesively bonded together to define a complete annular core magnet surrounding each intersection 14. If the investment material 44 is a cured plastic, it may be left in place in instances where such a completely embedding structure is desired. If such embedding of the final product is not desired, the investment material is preferably a high temperature wax or the like so that, after completion of the annular core magnets, the wax material may be melted and removed from the structure, leaving the assembled core plane of FIG. 1.

A further alternative method employs the same initial steps as described with reference to FIGS. 6 to 9 to produce the mold structure of FIGS. 8 and 9 but instead of assembling the core magnets from solid complementary portions, the magnets are molded in place as follows.

A cover plate of glass or the like is secured to one face of the investment material 44 to close one side of the cavities 46. It is to be noted that normally the cavities 46 open to both faces of the investment material 44. With one side of the cavities 46 thus closed, each cavity is filled with a slurry of magnet-forming material comprising particles of such material in a suitable bonding carrier.

When all of the cavities are filled, the slurry is cured to solid form and the annular magnets are thus completed. In this form also the investment material 44 may be either left in place or removed as described, depending upon the desired end product.

In each form of the method, the wire grid is first formed with the wires intersecting at the desired locations and the generally annular magnets are assembled around those intersections by arranging discrete portions of the magnet to define the annular structure and then securing the portions to each other. In some instances, the magnet portions thus arranged are solid, shaped bodies complementing each other to define the annular structure whereas in the last described form of the method, the discrete bodies are random particles in a bonding carrier.

I claim:

1. The method of making a core plane for a memory device, comprising the steps of: arranging wires to define a substantially planar grid of wires having a plurality of multiwire intersections; holding said wires in the form of said grid; embedding at least portions of said grid in mold forming material, and forming a generally annular mold cavity in said material and around the wires at each of said intersections; filling said mold cavities with a slurry of magnet forming particles; and curing said slurry to solid form to form a generally annular memory core about each of said intersections.

2. The method defined in claim 1 wherein said step of holding said wires in the form of said grid comprises applying an adhesive to said grid to at least temporarily bond said wires together at said intersections.

3. The method defined in claim 1 including the further step of removing said material after curing said slurry to solid form.

4. The method of making a core plane for a memory device, comprising the steps of: arranging wires to define a substantially planar grid of wires having a plurality of multiwire intersections; holding said wires in the form of said grid; embedding at least portions of said grid in mold forming material, and forming a generally annular cavity in said material and around the wires at each of said intersections with said cavity having an exterior opening on each side of said grid; placing at least two complementary solid magnet portions in said cavity, said portions being shaped to fit together to form a generally annular memory core of the size and shape of said cavity; said placing step comprising placing said complementary portions in said cavity, from respectively opposite sides of said grid, to fill said gravity.

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29—604; 264—221, 272, 277