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METHOD OF MAKING MAGNETIC MATRICES AND RESULTING ARTICLE

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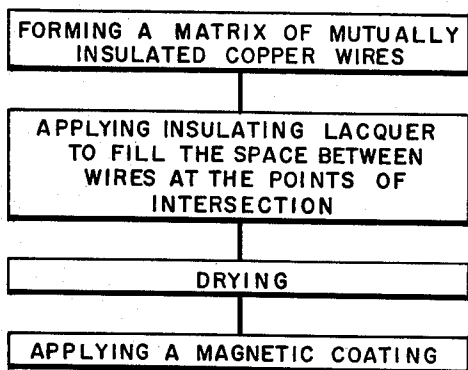


FIG. 1.

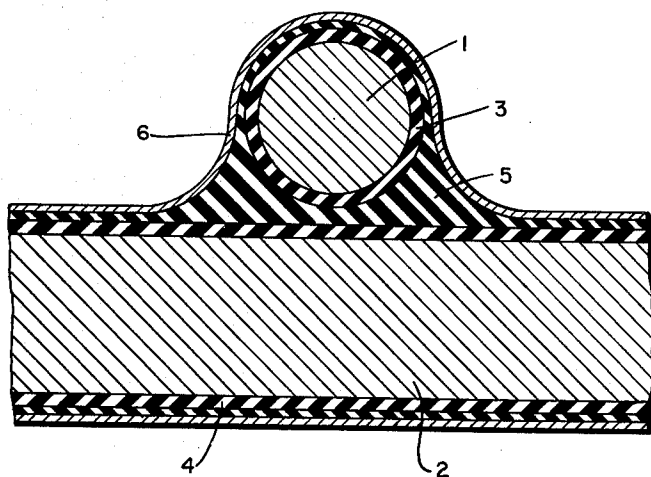


FIG. 2.

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METHOD OF MAKING MAGNETIC MATRICES AND RESULTING ARTICLE

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The present invention relates to a method of making magnetic matrices, and this application is a continuation-in-part of application Serial No. 790,383, filed February 2, 1959, and entitled "Method of Manufacturing Magnetic Core Matrices."

The aforementioned application relates to matrices for magnetically storing or switching impulse information and, more particularly, to a new method for manufacturing such matrices. To facilitate an understanding of the present invention, reference is made to the accompanying drawings in which FIGURE 1 is a flow diagram according to the process disclosed in application Serial No. 790,383, and FIGURE 2 is a cross section taken through an intersection of two wires forming part of a magnetic matrix according to the present invention.

The method by which a magnetic matrix according to application Serial No. 790,383 is made is illustrated by the flow diagram of FIGURE 1.

As is set forth in application Serial No. 790,383, matrices of this nature are extensively used in electronic calculators, information processing systems, distributors and similar systems. A standard matrix of this type, generally, comprises a planar grid arrangement of annular cores interlaced with reading, writing and inhibition wires. Its operation is well known and will not be described herein in detail, except to point out that the application of an input pulse drives the material of the core, which material has a generally rectangular hysteresis loop, into a saturated condition at one or the other end of its hysteresis loop, the polarity of the saturating current determining the direction of saturation.

These matrices operate satisfactorily, but they are expensive to manufacture, due to the time and care necessary in threading the wires through the minute openings in the cores. In addition, there is a great deal of breakage and waste in the wiring operation of cores which are already partially wired. For this reason, the manufacture of a matrix of, for instance, 32 x 32 cores, is uneconomical. Additionally, due to their structure and the type of handling required, there is a practical limit to the amount of additional miniaturization possible on such matrices.

The formation of a matrix from a perforated plate of ferrite having a rectangular hysteresis loop is also known. The matrix is completed by threading the necessary wires through the perforations in the plate. This kind of matrix represents a certain technical advance over that formed of individual annular cores, because it is stronger than the more conventional matrix. Also, the wiring may be applied to the perforated sheet by photo-engraving techniques, but the expense of such a method can be justified only when the matrices are to be mass-produced. The holes in the perforated plate may be made smaller than the openings in the individual cores, thus reducing the amount of energy necessary to produce saturation and ensuring more positive action. This latter result is of great advantage when the matrix is fed by transistors. Further, since the holes may be smaller, the spaces between the holes may be smaller, thus reducing the size of the entire matrix over that of one formed of individual cores. However, threading the necessary wires through the perforations, especially the small ones, is still the greatest disadvantage of the matrix

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formed from a sheet of ferrite. In addition, it is necessary to form a large number of tiny perforations in a ceramic material without chipping and without otherwise damaging the sheet. This requires extreme care and expensive punches and dies.

Application Serial No. 790,383 further sets forth that another known method of manufacturing a magnetic core matrix is by pressing the necessary wiring into the surfaces of a perforated sheet of ferrite. This method results in a matrix in which the wires are in intimate contact with the ferrite material, still further reducing the amplitude of the pulse necessary to saturate the core material; but it is extremely difficult to produce such a matrix. The ferrite which forms the material of the sheet is a ceramic material and, as most ceramic materials, it must be fired at extremely high temperatures. Pressing the wires into a sheet formed from powdered ferrite does not produce the rectangular hysteresis loop necessary for producing the storage and switching characteristics desired in the matrix. Therefore, the material must be fired and this means that the wires imbedded in the material being fired must be covered with a heat-resistant material which will not disintegrate during firing and which will not interfere with the operation of the matrix after it is formed. In addition, the heat-resistant covering must be thin to allow for the placement of the necessary wires in the small spaces provided. But even with these precautions, it is virtually impossible to sinter the material to provide the necessary magnetic characteristics without destroying the wires.

Accordingly, it was an object of the invention disclosed in application, Serial No. 790,383, to provide a new and improved method for the manufacture of a magnetic storage and switching matrix having superior operating characteristics without encountering the difficulties of the prior art methods.

It was another object of the invention disclosed in application Serial No. 790,383 to provide a new method of forming a magnetic storage matrix by spraying or sputtering from a gaseous or vapor phase a layer of ferrite upon a network of insulated wires in such a manner that at least the intersecting points of the wires are completely and intimately covered by the magnetic material.

It was a further object of the invention disclosed in application Serial No. 790,383 to provide a means for coating the wires to assure that the final coating is smooth and continuous and to avoid excessive material between the intersecting points of the wires, the coating being applied by dipping, for example. A lacquer which is temperature-resistant, such as a silicone lacquer, may be used as a bath for the wires.

Spraying of molten metals and ceramic substances on bases which cannot be subjected to high temperatures has been known. Suitable spray guns are available for this purpose, these guns using the material to be sprayed in the form of wires, rods or powder, and introducing the material into a flame. In this manner, copper is sprayed on ceramic surfaces and zinc is applied to paper in the manufacture of capacitors, for example, without harming the base material. It is also possible to spray quartz which, if properly performed, results in a remarkably compact and homogeneous layer, even though the base material is heated to a relatively low temperature, such as the paper in the manufacture of paper capacitors mentioned above.

When compared with a sheet pressed from ferrite powder, the density of ferrite sprayed or sputtered according to the present invention is so high, that no substantial internal demagnetization takes place through the pores. Thus, the desired magnetic properties are obtained and retained. Furthermore, the wire forming the network, or wire fab-

ric, on which the ferrite is deposited, is not harmed in any way, particularly if they are coated with a layer of temperature-resistant insulating material prior to spraying. A silicone lacquer may be used for this purpose, and it may be applied by dipping or in any other suitable manner.

In addition, it is possible to form the wire cloth in conventional machines in the size and shape finally needed, in a frame if desired, with terminals attached for connection. After coating with an insulator, the fabric can be pressed or otherwise be placed on the top surface of a sheet of the sintered ferrite and a layer of ferrite sprayed or sputtered over the entire matrix, forming a tight bond between the ferrite and the wire mesh. In any case, the sputtering or spraying may be performed in an appropriate atmosphere or in a vacuum. The wire fabric and the sintered ferrite base may be cooled during the sputtering or spraying by any suitable means, such as refrigerated gas, to prevent the destruction of the wire or of the insulating coating. The wire mesh and, consequently, the entire matrix may be made in the form of a long band and desirable lengths may be cut therefrom, or it may be made in three dimensions rather than in the conventional planar form. Since the ferrite material may be sprayed on objects of any shape, it is possible to make the matrix according to the invention in application S.N. 790,383 in any geometrical form desired, so that matrices may be custom made to fit into limited spaces of odd shapes.

Thus, the method of manufacturing magnetic core matrices according to the invention disclosed in application S.N. 790,383 has at least the following advantages:

(1) The wire mesh or fabric of the matrix can be readily made on machines which are now used for making wire cloth, and it is possible to make the wire network on a frame with necessary terminals in the sizes needed for a particular purpose, or in larger sheets from which the desired size and shape sheet may be cut. Such method is more economical than the threading of wires through individual cores or perforations.

(2) The signal wires of the matrix which are used for reading, writing, etc., are coated directly with the ferrite material and are not merely placed within an opening in the material, as in the threaded matrices. Therefore, it is possible to operate the matrices formed by the method of the invention disclosed in Serial No. 790,383 with smaller than conventional pulses, allowing the system to be driven by transistors and other small current devices.

(3) The points of intersection of the wires in the matrix formed according to the invention disclosed in Serial No. 790,383 may be closer together than in more conventionally formed matrices, thus reducing the size of the overall matrix. This decrease in size of the matrices is becoming increasingly important, as they are more generally used in computing and control systems.

(4) It is possible to repair a magnetic storage matrix made in accordance with the invention disclosed in application Serial No. 790,383, whereas it was necessary to discard conventional matrices with damaged elements. This results in a great saving in time and material.

In summation, application Serial No. 790,383 shows a method of making a magnetic storing or switching matrix in which a magnetic layer or coating is sputtered from molten state or is vaporized from gaseous state, i.e., it is deposited by evaporation onto a preformed wire system composed of insulated wires arranged in the form of webbing or netting in such a manner, that at least the storing or switching points of intersection of the wires are completely surrounded by the magnetic layer being applied.

The present invention has as its object the provision of an improvement of the method disclosed and claimed in application Serial No. 790,383, and is based on the consideration that the thickness of the applied magnetic layer is of substantial importance insofar as the switching time of the matrix is concerned.

It is known that the process of magnetic reversal of magnetic layers applied by deposition of vapor can take place faster than normally by a factor of several orders of magnitude if the coating is maintained at certain very small layer thicknesses, such as several tenths of a micron (1 micron being equal to 10^{-3} mm.). Thus, the process of magnetic reversal can, with the magnetic layer being of the proper thickness, take place during a time interval of, for example, 10^{-9} seconds. The physical cause for this phenomenon may well be based on the fact that the elemental magnetizing vectors, in case of such small layer thicknesses, lie substantially parallel to the plane of the layer and change their direction under the influence of exterior magnetic fields mainly by coherent rotation processes.

The aforementioned improvement is based on the realization that the method disclosed in application Serial No. 790,383 is especially suitable for applying such very thin magnetic layers, and that this method is substantially improved by practicing it in such a manner, that such a thin layer is applied. Thus, according to the improved feature, the magnetic layer is applied in such small thicknesses that the magnetic reversal takes place substantially exclusively by coherent rotation processes parallel to the plane of the layer.

As stated above, the layer is of the order of several tenths of a micron, and may be within the range of 0.05 to 1.0 micron. A layer thickness of approximately 0.2 micron has been found to be particularly suitable to obtain the desired result.

It is known that the magnetic reversal process in such extremely thin layers of suitable magnetic material, such as certain iron-nickel alloys, follows a substantially rectangular hysteresis loop after a magnetic field annealing step, i.e., after a transitory exposure to constant magnetic fields accompanied by moderate heating as, for example, to several hundred degrees centigrade, such as approximately 300° C. Inasmuch as the magnetic reversal can at the same time take place exceptionally rapidly, as set forth above, it is desirable, in the case of storing or step-switching input signals which must be handled very rapidly, to subject the extremely thin magnetic layer applied to the preformed wire matrix to magnetic field annealing.

The magnetic field annealing can take place during or after the application of the magnetic layer. The magnetic field required for this purpose can be produced in any suitable manner, as for example with the aid of one or more of the matrix windings. In this way, the layer encompassing the points of intersection of the matrix can be given a magnetic directional bias, i.e., a preferred direction, which is selected so as to correspond to the intended use of the matrix.

In order to increase the generally very weak magnetic reversal signals of such thin layers, the same can be formed by applying a plurality of superimposed very thin partial layers, in which case insulating layers may, if desired, be applied between the individual partial layers.

The extremely thin magnetic layers or partial layers can advantageously be applied by depositing the magnetic material by evaporation or by precipitating it from a solution. The material may, for example, be a ferrite or iron-nickel alloy. The precipitation can be carried out without current as, for example, in a manner similar to the known so-called Canigen method for applying nickel coating. This method is described in U.S. Patents Nos. 2,532,283 and 2,532,284.

FIGURE 2 is a cross section taken through an intersection of two wires forming part of a magnetic storage or switching matrix according to the present invention, and shows mutually perpendicular wires 1 and 2, surrounded by insulation 3 and 4, respectively, the space between the intersecting wires being filled by insulating lacquer and the magnetic coating covering the network being indicated at 6.

I claim:

1. In a method of making a magnetic storing or switching matrix wherein a magnetic coating is applied to a preformed network of mutually insulated wires in such a manner that at least the storing or switching points of intersection of the wires are surrounded by the applied magnetic coating, the improvement of making the magnetic coating of a thickness of between 0.05 and 1.0 micron.

2. In a method of making a magnetic storing or switching matrix, the step of applying to a preformed network of mutually insulated wires a magnetic material for covering at least the points of intersection of the wires with a coating of a thickness of between 0.05 and 1.0 micron.

3. In a method of making a magnetic storing or switching matrix, the step of applying to a preformed network of mutually insulated wires a magnetic material for covering at least the points of intersection of the wires with a coating of a thickness of between 0.05 and 1.0 micron and simultaneously subjecting the magnetic coating being applied to magnetic field annealing.

4. In the method defined in claim 3, wherein at least one of the matrix windings is used for subjecting the magnetic coating to said magnetic field annealing.

5. In a method of making a magnetic storing or switching matrix, the steps of applying to a preformed network of mutually insulated wires a magnetic material for covering at least the points of intersection of the wires with a coating of a thickness of between 0.05 and 1.0 micron, and thereafter subjecting the magnetic coating to magnetic field annealing.

6. In the method defined in claim 5, wherein at least one of the matrix windings is used for subjecting the magnetic coating to said magnetic field annealing.

7. In a method of making a magnetic storing or switching matrix, the step of applying to a preformed network of mutually insulated wires a magnetic material for covering at least the points of intersection of the wires with a plurality of superposed partial layers of a thickness of between 0.05 and 1.0 micron.

8. In a method of making a magnetic storing or switching matrix, the step of applying to a preformed network of mutually insulated wires magnetic material as well as insulating material for covering at least the points of intersection of the wires with a coating composed of alternating layers of magnetic material of a thickness of between 0.05 and 1.0 micron and layers of insulating material.

9. In a method of making a magnetic storing or switching matrix, the step of depositing a magnetic material by evaporation onto a preformed network of mutually insulated wires for covering at least the points of intersection of the wires with a coating of a thickness of between 0.05 and 1.0 micron.

10. In a method of making a magnetic storing or switching matrix, the step of precipitating a magnetic material from a solution onto a preformed network of mutually insulated wires for covering at least the points of intersection of the wires with a coating of a thickness of between 0.05 and 1.0 micron.

11. A magnetic storage or switching matrix comprising a network of mutually insulated wires having at least at the storing or switching points of intersection of the wires a magnetic coating of a thickness of between 0.05 and 1.0 micron.

12. A matrix as defined in claim 11 wherein the thickness of said coating is approximately 0.2 micron.

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