Oct. 27, 1959 E. GESSNER 2,910,675

CORE ARRAY USING COAXIALLY SPACED CONDUCTORS

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FIG. 1

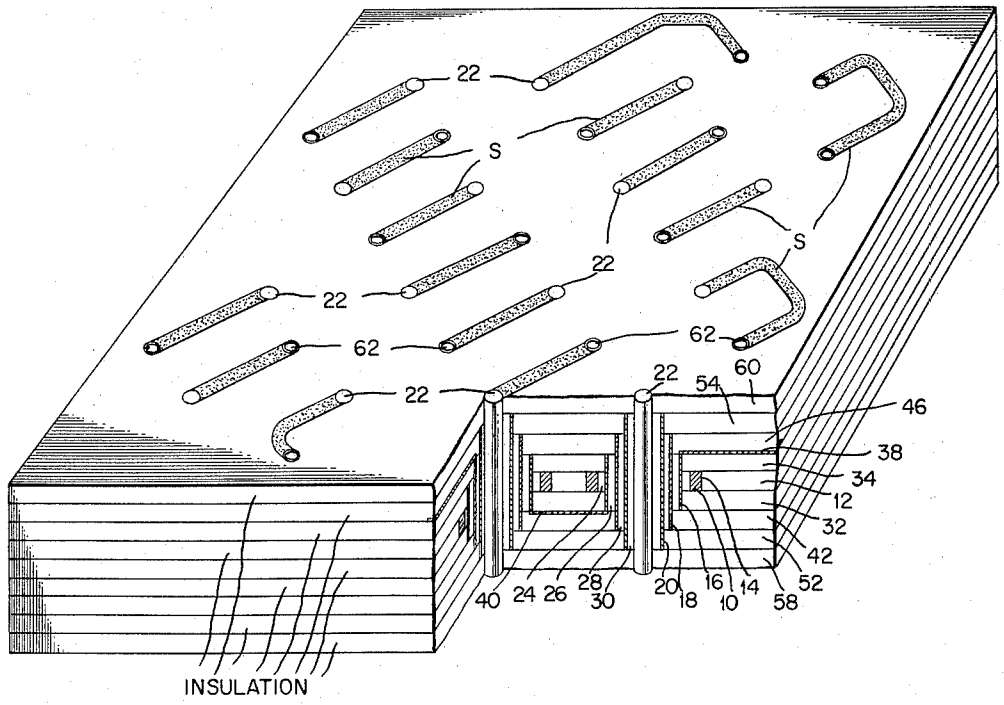
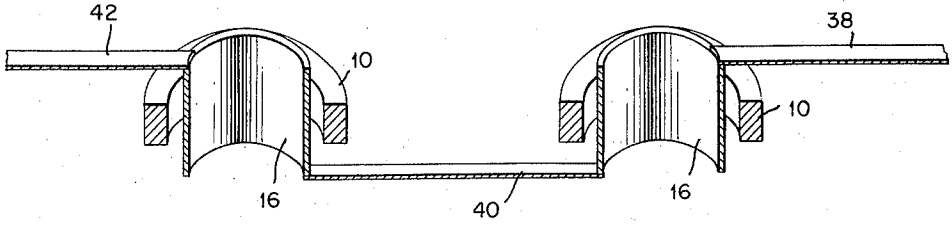


FIG. 2



INVENTOR
EUGENE GESSNER
BY Theodore M. Jones

ATTORNEY

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FIG. 4

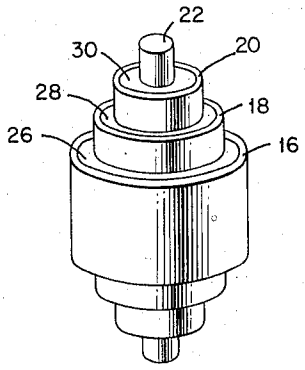
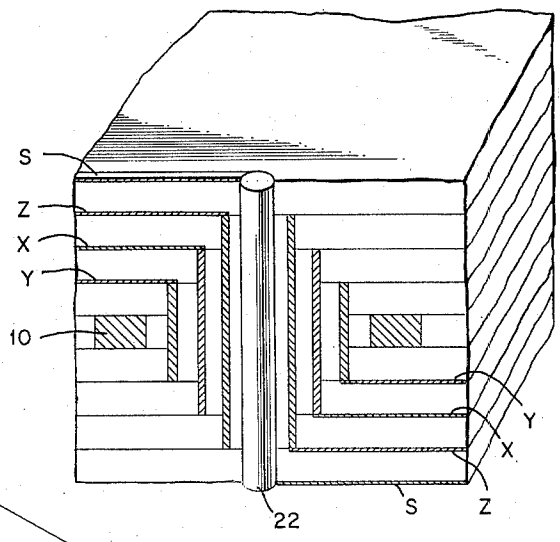


FIG. 3



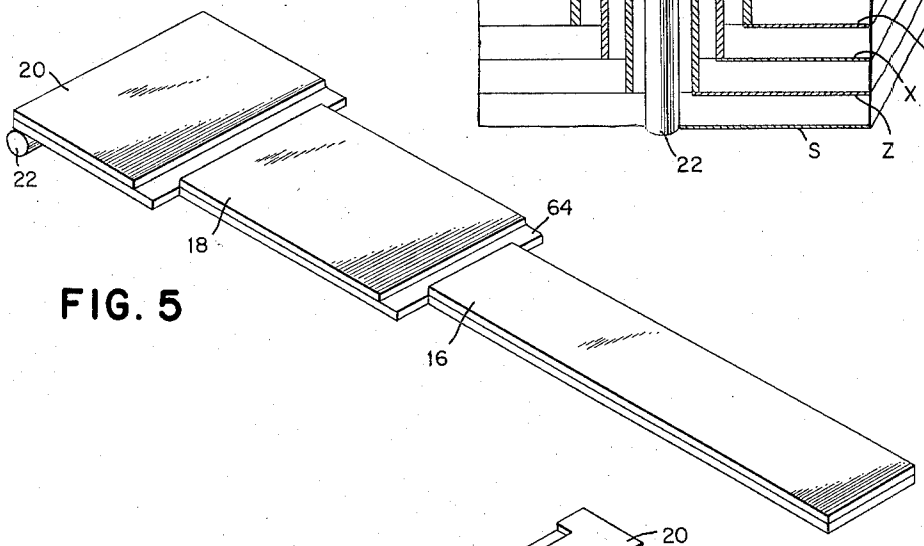
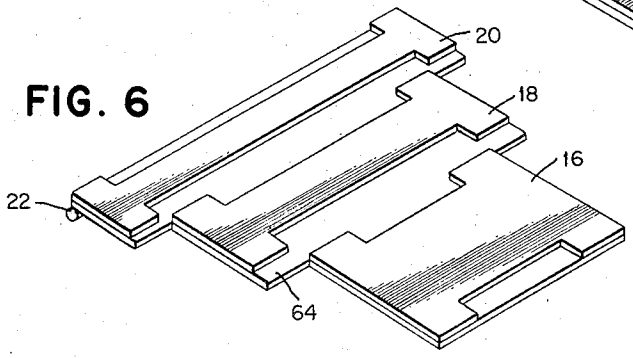


FIG. 5

FIG. 6

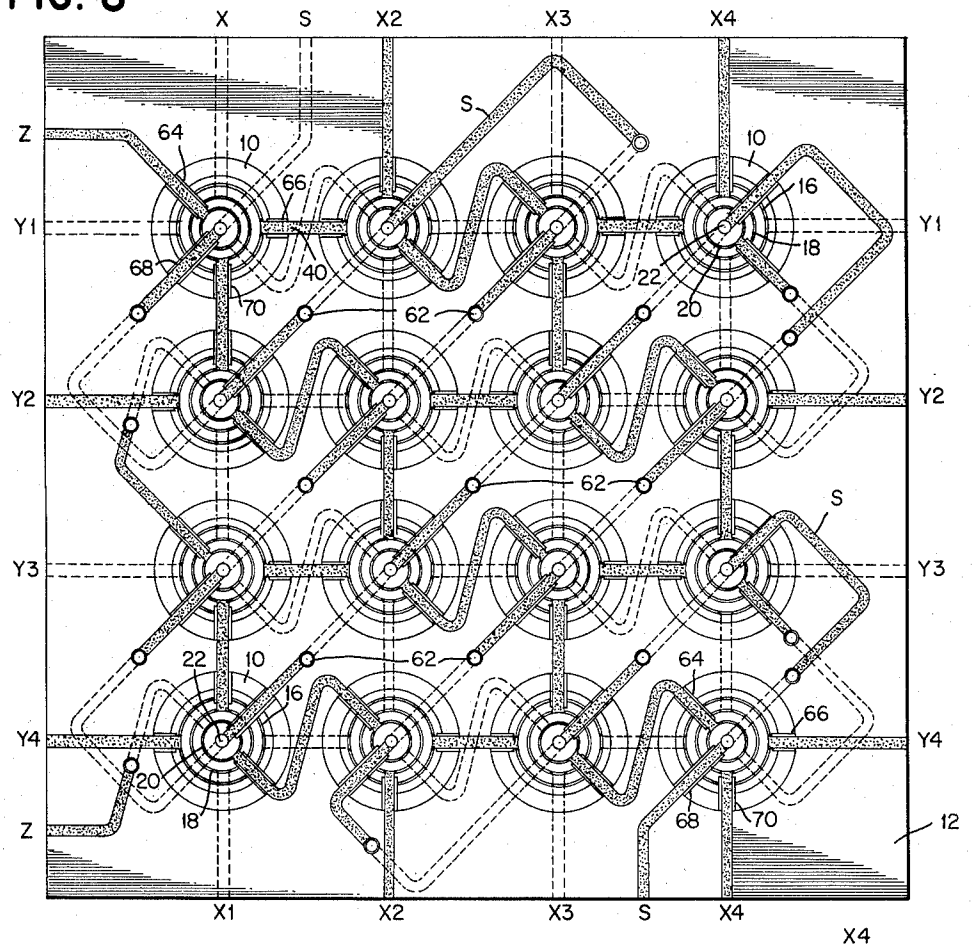


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CORE ARRAY USING COAXIALLY SPACED CONDUCTORS

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FIG. 8



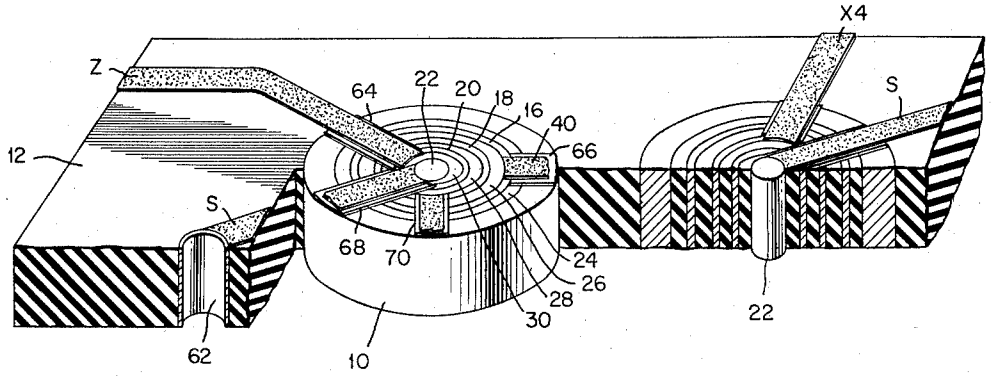


FIG. 7

United States Patent Office 2,910,675 Patented Oct. 27, 1959

2,910,675

CORE ARRAY USING COAXIALLY SPACED CONDUCTORS

Eugene Gessner, Towson, Md., assignor to International Business Machines Corporation, New York, N.Y., a corporation of New York

Application January 9, 1957, Serial No. 633,370

14 Claims. (Cl. 340—174)

This invention relates to magnetic core memory arrays and is directed more particularly to a structural arrangement adapted for automatic production of such arrays.

Magnetic core arrays are well known in the art and have the form of a lattice of magnetic cores in which the cores have two well defined extremes of magnetization for representing two values necessary to store binary numbers. A detailed explanation of the theory of operation of a typical array is described in the patent of E. W. Bauer and M. K. Haynes, Patent No. 2,889,550, filed July 14, 1954.

Heretofore, magnetic core arrays of the type described have been assembled manually with the windings being threaded through the cores. This technique of assembly has become increasingly time consuming and expensive due to the requirements of greater capacity memory arrays and the tendency of using smaller sized cores.

Briefly stated, the novel article is a rigid array of cores in which the windings received in the core openings are constructed of coaxially spaced conductors insulated from each other and in which conductive areas are constructed to connect with the coaxially spaced conductors to form series linking circuits.

Accordingly, a first object of this invention is to provide an improved magnetic core array.

It is another object of this invention to provide an improved magnetic core array which lends itself readily to automatic manufacture in an economical and high speed process.

It is an object of this invention to provide an improved core array which eliminates the need for threading conductors through the core manually.

It is an object of this invention to provide an improved magnetic core array which is structurally compact and mechanically strong.

It is an object of the invention to provide an improved magnetic core array in which the cores are rigidly secured by a supporting member, windings received in the core openings are coaxially spaced conductors insulated from each other, and connecting circuitry joins coaxially spaced conductors in a predetermined pattern to form an operable array.

It is an object of this invention to provide an improved magnetic core array having a plurality of cores, a core-supporting member, a plurality of coaxially-spaced conductors insulated from each other and from the cores and individually linking the cores, printed circuit patterns connected to the coaxially spaced conductors to complete winding circuits for the cores, and insulating areas isolating each individual serial winding circuit of the printed circuit pattern and non-related coaxially spaced conductors.

It is an object of this invention to provide an improved magnetic storage element having a base member supporting a magnetic core and coaxially spaced conductors received in the core openings and electrically insulated from each other and from the core.

It is a still further object of this invention to provide

an improved magnetic storage element having a base member supporting a magnetic core with an opening therein and having a plug received in the core opening, the plug being constructed of coaxially-spaced conductors electrically insulated from each other and from the core.

Another object of this invention is to provide an improved method for assembling a magnetic core array.

It is another object of this invention to provide an improved process for fabrication of a magnetic core array.

It is an object of this invention to provide a process for fabrication of a magnetic core array having coaxially spaced conductors insulated from each other and in which conductive areas are constructed to connect with the coaxially spaced conductors to form series linking circuits.

It is an object of this invention to provide a process for fabrication of a plug having coaxially spaced conductors for insertion into the opening of a magnetic core.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Figure 1 is a perspective view, partly in section, of a major surface of a core array and further illustrates the winding arrangement of one embodiment of this invention.

Figure 2 is a diagrammatical view in perspective of a pair of cores and linking conductors arranged in accordance with the principles of this invention as illustrated in Figure 1.

Figure 3 is a perspective view of a section of the core array of the embodiment of Figure 1 showing core-linking conductors constructed according to the principles of this invention.

Figure 4 is a perspective view of a plug such as used in the embodiment of Figure 1 having coaxially spaced conductors constructed in accordance with the principles of this invention.

Figure 5 illustrates the arrangement of elements used in the construction of a single plug having coaxially spaced windings such as used in the embodiment of Figure 1.

Figure 6 illustrates a structural modification of the elements used in the construction of the plug shown in Figure 5.

Figure 7 is a portion of an array illustrating another embodiment of the invention.

Figure 8 is a view of a major surface of the embodiment of the core array illustrated in Figure 7 constructed in accordance with the principles of this invention.

Referring to Figure 1, a single plane of a typical three dimensional array has toroidal magnetic cores **10** arranged in rows and columns and linked by X windings, Y windings, a Z winding and an S winding. The Patent No. 2,889,550, of E. W. Bauer and M. K. Haynes, to which reference was made previously, describes the manner of electrically selecting a particular core in a core plane by the X and Y windings, the selection of a particular plane in a three dimensional array using the inhibit or Z winding, and the sensing of the magnetic change of a particular core using the S winding. A sheet of material **12** receives the magnetic core **10** in each of the openings **14**. Each core embraces coaxially spaced elements comprising conducting and insulating members wherein conductive cylinders **16**, **18**, and **20** are spaced about a rod **22** and are separated from each other and from the core by cylinders of insulating material **24**, **26**, **28**, and **30**.

A pair of plates **32** and **34** have a plurality of openings

therein such that each opening has a diameter sufficient to embrace the end of the cylinder **16** when the plates are positioned on opposing major surfaces of the sheet **12**. The Y conductor comprises a conductor **38** on the upper surface of the plate **34**, the cylinder **16**, a conductor **40** on the lower surface of the plate **32**, the cylinder **16** for the adjacent core in that row, and other elements of like construction arranged in a similar manner across the array. Figure 2 further illustrates the winding arrangement, and similar series Y windings link each core in all of the other rows. A pair of plates **44** and **46** have a plurality of openings therein of a diameter sufficient to embrace the ends of the cylinder **18** when the plates **44** and **46** are positioned adjacent the plates **32** and **34** respectively. The X conductors comprise the cylinders **18** and connecting conductors on the sheets **44** and **46** with each X conductor linking each core in a column of cores. In conformity with the usual practice in the art, X and Y conductors link individual cores in the same sense. In a similar manner, a pair of plates **52** and **54** are positioned adjacent the plates **44** and **46** respectively, embrace the ends of the cylinders **20**, and support connecting circuitry for the series Z windings. Similarly, a pair of sheets **58** and **60** are positioned adjacent the plates **52** and **54** respectively, embrace the ends of the rod **22**, and support the series S winding arranged according to the pattern shown on the sheet **60** and a pattern of like purpose on sheet **58** (not shown). A plurality of conductors **62** pass through openings in all of the sheets to complete the continuous S winding and pass current from one side of the plane to the other to preserve the sense of the S winding.

In Figure 1, it will be noted that the section as taken does not show all of the conductors which connect to the core-linking conductors. Accordingly, Figure 3 is merely an illustration of a general nature wherein all of the connecting conductors are rotated about the axis of the rod **22** until all can be shown in the same sectional plane to indicate that each coaxially-spaced conductor is connected to external circuitry to form the X, Y, Z and S windings.

In Figure 4, the coaxial plugs are fabricated by first arranging the elements of the structure according to Figure 5. A sheet of insulating material **64** such as the resin known by the trade name Mylar is cut in the shape of a series of rectangles of decreasing dimensions with the widths corresponding to the desired heights of the cylinders. The rectangular pieces of conductive material **16**, **18**, and **20**, are made from sheet such as annealed beryllium-copper or the like, and are cut according to the desired dimensions of the cylinders and cemented or otherwise secured to the sheet. Next the rod **22** is positioned under the sheet near the end of conductor **20**, and the insulating sheet **64** and conductors are rolled counterclockwise about the rod. After the plug is first formed in this manner, it may be heated and compressed in a mould to fuse the plug into a uniform and unitary structure as shown in Figure 4. Such a plug may be built having the largest diameter less than 0.030 inch for insertion into the openings of very small cores used at the present time having 0.050 inch outside diameter with openings 0.030 inch in diameter and a thickness of 0.15 inch. While particular dimensions have been mentioned in this regard, it is to be understood that other sized plugs and cores may be used and those described are not to be considered limiting.

Plugs may be constructed in accordance with the invention having coaxially spaced conductors which are not complete cylinders. Such cores may be constructed by the method just described using conductors having the shape of "I" as shown in Figure 6. The cut-away portions reduce the possibility of electrical short circuits between conductors and reduce the inter-conductor capacitance.

While certain materials have been mentioned for use as the conductive elements in the foregoing description of the plugs, the elements **16**, **18**, and **20** may be first painted upon the sheet **64** using conductive paint. Then the conductive areas are plated to the thickness desired, and the plug formed in the manner described. Also, the plugs may be constructed by cutting the cylinders **16**, **18** and **20** from metal tubes of conductive material, placing the tubes around the rod **22** in a supporting jig, and extruding a nonconductive plastic material into the spaces between the cylinders. Such a method of construction is adaptable to automatic manufacture.

Referring now to Figure 1, the insulating cylinder **24** between the cores **10** and the Y conductors **16** may be formed as a strip and attached to the conductor **16** before insertion of the plug in the core opening or it may be formed by spraying or painting an insulating material within the core openings before insertion of the plug.

To summarize the construction of array in accordance with the foregoing description, the openings **14**, **62** (and others if required for converting circuitry) are formed in the sheet **12**, and then the cores are deposited in the openings **14**. If desired, a bonding agent may be applied to the sheet and cores to hold the cores in position. The insulators **24** are formed by coating the core openings with an insulating material, followed by insertion of the individual plugs in each core opening. Then, the sheets **32** and **34** are positioned, each covering a respective one of the opposing major surfaces of the sheet **12**. The Y circuitry for the conductors **16** is now developed on the sheets **32** and **34** by any method for depositing the predetermined pattern arrangement of conductive areas known in the art such as metal spraying, photographic electrodeposition, or other like process. Subsequently, the sheets **44** and **46** are placed upon the sheets **32** and **34** respectively, and the X circuitry is developed on the accessible major surfaces of the sheets **44** and **46** to connect the conductors **18** in series circuits for each column. In like manner, the sheets **48** and **50** are positioned and the Z conductors constructed. Similarly, the sheets **52** and **54** are positioned and the S conductors constructed with this construction including the forming of the conductors **62**.

It is pointed out that the sheet **12** may be of wax, resin, or like material which can be removed in any suitable way, as for example, heat or chemicals after fabrication of the array. The cores are retained in position by the plugs after removal of the sheet **12**. With the sheet **12** removed the cores may be cooled by convection.

While the width of the insulating sheets **32**, **34**, **44**, **46**, **48**, **50**, **52**, and **54** are shown to be approximately the thickness of the cores, in practice the sheets could be quite thin depending only upon the insulating properties of the material used. Accordingly, the insulating sheets may be formed by alternate coatings of insulating material, and the metallic connecting X, Y, Z and S conductors.

Figure 7 shows a portion of an array illustrating another embodiment of the invention having a single plane of a three dimensional array of magnetic cores in which the coaxial conductors are of equal length. A single sheet **12** contains the cores, and an insulating material is applied to selected portions of the sheet and plugs to isolate connecting circuitry from the cores and other core-linking conductors. One of these portions is illustrated as an area **64**, which is an insulating coating applied over the plug to insulate the Z winding from the core **10** and the conductors **16** and **18**. Similarly, other coated areas are illustrated by the areas **66**, **68**, and **70** to insulate the Y, S, and X circuitry respectively. Such coated areas for each core may be applied through a template and thereafter X, Y, Z and S connecting circuitry may be simultaneously constructed by depositing the predetermined pattern arrangement of conductive areas by methods well known in the art. Accordingly, all connecting circuitry is applied in one step rather than

in successive steps of alternately constructing layers of insulation and conductive patterns.

The array shown in part in Figure 7 is illustrated in plan view in Figure 8. It will be noted from Figure 8 that each of the various conductors may be exposed on the major surfaces of the arrays in this embodiment; whereas, in the embodiment of Figure 1, all conditions except the last formed are not exposed.

The particular pattern of linking cores using X, Y, Z and S conductors to form an array as above described is but one of many feasible winding configurations, and the particular form shown in Figures 1 and 7 is not to be considered as limiting the invention since the construction taught is applicable to many circuit arrangements.

The terminus of each X, Y, Z and S conductor may be arranged to connect to external circuitry to allow coupling to external apparatus for a two-dimensional array or to interconnecting groups of single planes to provide a three-dimensional memory unit.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a magnetic storage element, the combination, comprising a toroidal magnetic core having an opening therein, coaxially spaced conductors insulated each from the others and from said core and passing through said opening, and circuits connected to at least one of said coaxially spaced conductors.

2. In a magnetic memory device, the combination, comprising a plate of insulating material having a plurality of openings therein, a plurality of magnetic cores arranged in an array and individually received in said openings, coaxially spaced conductors individually linking said cores, means insulating said conductors one from the other and from said cores, a plurality of layers of insulating material adjacent said plate, and electrically conductive regions on said insulating layers connecting said coaxially spaced conductors to define circuits linking groups of said cores.

3. In a magnetic memory device, the combination, comprising a plate having a plurality of openings therein, a plurality of toroidal magnetic cores arranged in an array and individually received in said openings, coaxially spaced conductors individually linking said cores, means insulating said conductors one from the other and from said cores, a plurality of layers of insulating material adjacent said plate, and electrically conductive regions on said insulating layers connecting said coaxially spaced conductors to define circuit linking groups of said cores.

4. In a magnetic memory device, the combination, comprising an insulating plate having a plurality of openings therein, a plurality of toroidal magnetic cores arranged in an array, and individually received in said openings, coaxially spaced conductors individually linking said cores, means insulating said conductors one from the other and from said cores, a plurality of layers of insulating material adjacent said plate and electrically conductive regions on at least one of said insulating layers connecting said coaxially spaced conductors to define circuits linking groups of said cores.

5. A magnetic memory device comprising a plurality of magnetic cores arranged in a planar, spaced relationship, each of said cores having an opening therein, a plurality of coaxially spaced conductors in said openings of each of said cores, and conductive circuits interconnecting corresponding ones of said coaxially spaced conductors associated with each of said magnetic cores.

6. A magnetic storage element comprising a toroidal magnetic core having an opening therein and a plug received in said opening comprising coaxially spaced conductors, and insulators alternately disposed.

7. An array of magnetic cores comprising, in combination, a plate of insulating material having a plurality of spaced openings therein, said cores received in said openings and supported thereby, a plurality of coaxially spaced conductors insulated from each other and individually linking said cores, and printed circuit patterns on said plate surfaces connected to said coaxially spaced conductors and forming winding circuits for said cores, and a layer of insulating material between each individual winding circuit of said printed circuit patterns and non-related coaxially spaced conductors.

8. In a magnetic memory device, the combination, comprising a plurality of magnetic cores; means mounting said cores in spaced relation to form an array; a plurality of coaxially spaced conductors individually linking said cores; means insulating said conductors one from the other, from said cores; a plurality of layers of insulating material adjacent said mounting means; and electrically conductive regions on insulating layers connecting said coaxially spaced conductors to define circuits linking groups of said cores.

9. In a magnetic memory device, the combination, comprising a plurality of magnetic cores, insulating means supporting said cores in spaced relation to form an array, a plurality of coaxially spaced conductors individually linking said cores, means insulating said conductors one from the other and from said cores, a plurality of layers of insulating material adjacent said insulating means, and electrically conductive regions on said insulating layers connecting said coaxially spaced conductors to define circuit linking groups of said cores.

10. In a magnetic memory device, the combination, comprising a first plate of insulating material having a plurality of openings therein, a second plate of insulating material having a plurality of openings therein, a plurality of magnetic cores supported in spaced relation between said inner surfaces of said first and second plates, a plurality of coaxially spaced conductors individually linking said cores, means insulating said coaxially spaced conductors one from the other and from said cores, a plurality of regions of insulating material at the ends of said coaxially spaced conductors, and electrically conductive regions on the outer surfaces of said first and second plates and on said regions of insulating material connecting said coaxially spaced conductors to define circuit linking groups of said cores.

11. In a magnetic memory device, the combination, comprising a first plate of insulating material, a second plate of insulating material, a plurality of magnetic cores supported in spaced relation between the inner surfaces of said first and second plates, a plurality of coaxially spaced conductors individually linking said cores, means insulating said coaxially spaced conductors one from the other and from said cores, a plurality of layers of insulating material adjacent the outer surfaces of said first and second plates, and a plurality of electrically conductive regions between said layers of insulating material connecting said coaxially spaced conductors to define circuit linking groups of said cores.

12. In a magnetic memory device, the combination, comprising a first plate of insulating material, a second plate of insulating material, a plurality of magnetic cores supported in spaced relation between the inner surfaces of said first and second plates, a plurality of plugs having coaxially spaced conductors individually linking said cores, a plurality of layers of insulating material adjacent the outer surfaces of said first and second plates, and a plurality of electrically conductive regions between said layers of insulating material connecting said coaxially

spaced conductors to define circuit linking groups of said cores.

13. A magnetic storage element comprising a magnetic core having an opening therein and a plug received in said opening having a plurality of coaxially spaced conductors and means insulating said conductors from each other and from said core.

14. In a magnetic storage element, the combination, comprising a toroidal magnetic core having an opening therein, a plurality of coaxially spaced conductors

received in said opening, means insulating said conductors from each other and from said core, and circuits connected to at least one of said conductors.

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