Oct. 4, 1966 R. G. SKOGSTAD ETAL 3,276,104

METHOD OF FORMING STIFFENED ENDS ON FINE INSULATED THREADING WIRES BY METAL COATING

Filed Oct. 27, 1961

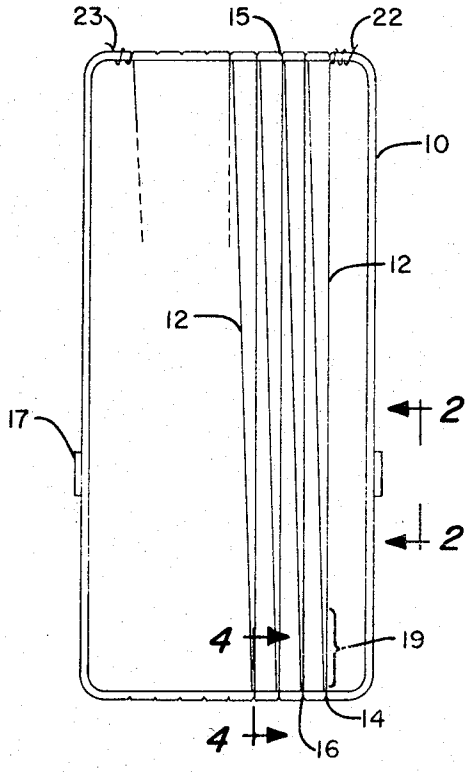


Fig. 1

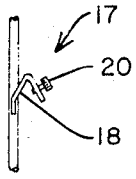


Fig. 2

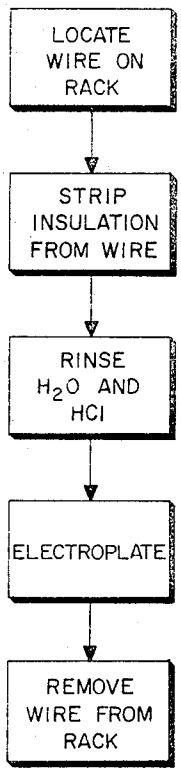


Fig. 3

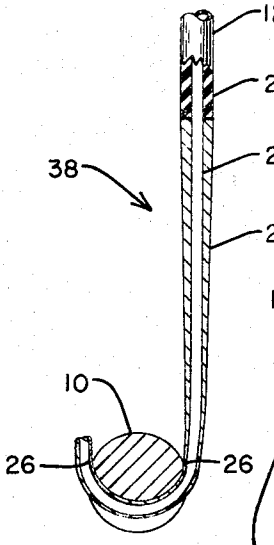


Fig. 4

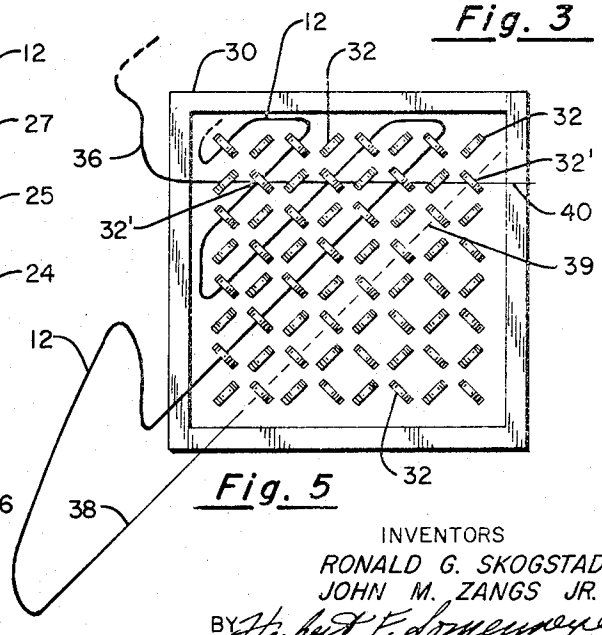


Fig. 5

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United States Patent Office

3,276,104
Patented Oct. 4, 1966

3,276,104

METHOD OF FORMING STIFFENED ENDS ON FINE INSULATED THREADING WIRES BY METAL COATING

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Filed Oct. 27, 1961, Ser. No. 148,058
3 Claims. (Cl. 29—155.5)

The present invention relates generally to the assembly of magnetic core matrices of the type utilized in digital computers, and more specifically to a method for preparing the wires used therein to facilitate the assembling of such matrices.

A conventional magnetic core matrix or memory plane consists of an electrical arrangement of a plurality of ring-shaped ferrite core elements threaded with conductive wires. The cores are arranged in columns and rows, and the wires are selectively disposed through the annular apertures of a designated series of cores for forming an electrically interconnected array of cores. For example, all the cores of a single matrix may be electrically coupled together by a single conductor threaded through each core, such single conductor being called a reading or sense wire and providing a readout signaling means. Conventionally, the cores of a single memory plane are each provided with four separate windings threaded through the annular aperture of the core, the windings being generally referred to as the sense, inhibit, and X and Y drive lines.

The stringing or threading of the wires through each of the cores is one of the major fabrication problems in matrix assembly. The problem arises as a result of the location of the cores relative to one another and the size of the cores. The cores are closely spaced in angular relationship to minimize the length of the aforementioned conductive lines and are physically very small to reduce the size of the memory planes. Because of the extremely small inside diameter of the core, for example, .018 inch, the copper wires used as windings are necessarily of small diameter usually falling within the range of thirty-six to forty-two gauge. It will be appreciated that the wiring of an aligned series of cores angularly arranged and spaced closely together with a wire having a diameter approximately that of a human hair is an extremely difficult and tedious task. A copper wire of such small diameter lacks rigidity and consequently it is exceedingly difficult to thread it through a series of aligned cores. To facilitate stringing of the cores, the end of each wire is provided with a needle-like device, much in the manner that a piece of thread is provided with a sewing needle to facilitate the stitching of material. For example, the end of the wire could be attached to a hypodermic needle, or the wire end could be inserted into a piece of rigid tubing and secured by crimping or soldering. The needle is inserted into the core aperture and drawn through the appropriate series of cores. After the needles are drawn through the desired series of cores, they are removed from the wires which are then secured to designated terminal areas. During the process of threading the wires through the cores, the problem of acquiring and maintaining sufficient clearance for the needle itself is acute. Clearance for the needle is reduced each time a wire is strung through the cores. As the effective inside diameter of a core is decreased, the possibility of core

and wire damage increases. Since ferrite cores tend to be strain sensitive the increased pressure caused by the insertion of the needle may result in an undesirable change in magnetic characteristics. Also, even a slight abrasion of the wire insulation is capable of causing an electrical failure. It is, therefore, advantageous and desirable to have wire needles having diameter variance on the order of a few ten thousandths of an inch, a feature not found in most wire-type needles.

Another disadvantage inherent in the aforementioned methods for preparing the wire ends to facilitate the stringing or threading of cores is the necessity of tediously affixing a rigid device (needles or tubing) individually on the end of each wire resulting in high production costs.

The method of the present invention obviates these problems. In the preferred method of practicing this invention the conductors are treated by electrodepositing a thin layer of nickel upon a selected portion thereof, the selected portion functioning as a needle on the end on the wire to facilitate threading the wire through the core apertures. The electrodeposition of a small amount of nickel upon the copper wire results in only a slight increase in the diameter of the wire but is effective to substantially increase the rigidity of the plated end-portion of the wire. To permit mechanical threading of the wire through the core apertures, the plated portion of the wire acts as a needle in the threading operation. This method of preparing the wire permits the fabrication of needle-acting portions with varying diameters, the smaller diametered needles being used after the effective core diameter has decreased as a result of the previous threading of wires through the core apertures.

It is, therefore, an object of this invention to provide a method for forming the end of the wire into a rigid needle-like portion, such method allowing economical and simple control of the needle diameter.

It is also an object of this invention to treat core memory wires for obviating the attachment of needle-like devices to individual wires for reducing the cost of memory plane assembly.

These and other more detailed and specific objects will be disclosed in the course of the following specifications, reference being had to the accompanying drawing, in which:

FIG. 1 is a front elevational view of the plating rack having a core-memory wire disposed thereon for treatment in accordance with this invention;

FIG. 2 is a fragmentary side elevational view of the apparatus of FIG. 1;

FIG. 3 is a flow chart illustrating a preferred process for fabricating needle-like portions on wires;

FIG. 4 is a fragmentary cross-sectional view on an enlarged scale taken along the line and in the direction of the arrows 4—4 of FIG. 1, this view showing the condition of the wire subsequent to the treatment thereof; and,

FIG. 5 is a top plan view of a magnetic core matrix illustrating one manner in which conductors may be threaded through the cores using a product of this invention.

Referring now to FIG. 1, a preferred embodiment of a plating rack or frame **10** employed in performing a method of the present invention is shown. Disposed thereon is a copper magnet wire **12** such as is commonly used in stringing core matrices. The wire is ordinarily of very small diameter, often falling in the range of thirty-six to forty-two gauge, and is generally insulated with a film

of a non-conductor, for example, a polyvinyl alcohol-formaldehyde resin such as FORMVAR or the like. As such the wire is quite flexible. The rack member **10** is preferably rectangularly shaped and consists of an electrically conductive material, for example, copper. In the instant embodiment, a commercially available copper rod of approximately one-half inch in diameter was selected to form the rack member **10**, such selection being based upon the electrical conductivity of copper and the ease with which it may be formed and machined. It should be understood, however, that no limitation to this size, shape or composition is intended. The rack **10** has on its opposed ends a plurality of notches and for clarity, only a few notches **14**, **15** and **16** are identified. Preferably the upper and lower notches are vertically aligned. The notches support portions of the wire **12** in a laterally spaced relationship and maintain them in a relatively fixed position during the electroplating operation. Although not necessary, it is desirable to have the notches laterally spaced from one another a substantially equal distance, such distance being of the order of one-eighth inch in the present embodiment. Orienting of the wire **12** in the aligned notches **14**, **15** and **16**, etc., causes the end portions **19** of the wire to be spaced appropriately for receiving approximately the same amount of current during the electroplating step, resulting in an equal build-up of electrodeposit on each wire. The plating rack **10** is also provided with two hooks or clamps **17**, one on either side of the plating frame. As is best shown in FIG. 2, the clamps consist of an angled metal strap **18**, preferably copper, and a thumb screw **20** extending through one leg of the strap. As is conventional in the electroplating art, the angled strap **18** is saddled on a cathode member (not shown) for making electrical contact therewith, the cathode member being in the form of a round copper rod as is commonly used in the art and maintained above the level of the electroplating solution. The thumb screw **20** is tightened upon the cathode member securing the rack **10** in place, and, in the instant case, maintaining it in an upright position. Additionally, the frictional engagement of the thumb screw **20** with the cathode member provides a low resistance electrical connection between the rack **10** and the cathode member.

As is indicated in the flow-chart of FIG. 3, the method disclosed herein commences with step 1 wherein the wire **12** is placed on the plating frame **10**. The racking step may be accomplished manually in the following manner. An end of the wire **12** is secured to an upper portion of the rack, for example by a piece of pressure sensitive adhesive tape or alternatively by twisting as is shown at **22**. Desirable lengths of wire are unwound from the spool (not shown) upon which it is usually disposed, the wire **12** then being wound about the rack **10** several times, a portion of each winding of the wire being located in notches to equidistantly space the windings. For example, a portion of the wire **12** secured as at **22** is disposed in a notch **14** in the lower portion of the rack. The wire **12** is then wound as illustrated about the upper portion of the rack and located in notch **15**, after which the wire is wound about the lower portion of the rack and located in notch **16**. The wire racking step proceeds in the manner indicated, each winding of the wire being located in an upper and lower notch, and is continued until the desired number of windings are disposed on the rack, the wire finally being secured by twisting as at **23**. In racking, the wire is wound tightly and preferably as a single continuous piece, but may be severed atfer each winding to form a plurality of separate windings, the severed ends then being secured to the rack individually. The width of the rack **10** determines the maximum number of windings disposed on the rack. A rack ten inches wide will accommodate approximately seventy-five windings. The length of the rack member **10** may be selected to effect the total wire length necessary for wiring a specific series of cores. For example, if the desired overall wire length were twenty-four inches, the rack would be constructed having a length of approximately twenty-four inches. Thus a rack member **10** having a width of ten inches and a length of twenty-four inches would provide approximately one hundred and fifty-five wires, each having an overall length of approximately twenty-four inches.

Next step 2 is performed. The end portions **19** of wire **12** and the rack **10** are immersed in a stripping solution for removing insulation from the wire end portions **19**. The desired length of the needle-like end portion determines the length of wire that shall be immersed in the solution. For example, if a six-inch needle is desired, this length of wire is immersed into the stripping solution. The stripping is usually accomplished by immersion into a concentrated sulfuric acid bath. To expedite such stripping, mechanical agitation of either the solution or the rack may be employed. After the wire insulation is removed, the wire makes physical contact with the rack member **10** establishing an electrical connection therebetween. The wire **12** is therefore electrically connected to the clamps **17** by way of rack **10**.

It will be appreciated by those skilled in the art that the stripping of wire insulation is sometimes a complex and time consuming operation. To obviate the stripping step, it may in some cases be desirable to chemically deposit a metallic layer, for example copper, over the insulation and subsequently electroplate a stiffening metal on the electroless copper deposit.

After the insulation has been removed, or it has become evident that the insulation has become substantially non-coherent and non-adherent, step 3 is performed. The wire is immersed in a water bath and rinsed thoroughly in running water for approximately five to ten minutes. If small particles of insulation continue to adhere to the wire, they may be removed by a soft brush. After immersion in the water bath, step 3 is completed by immersing the wire in a dilute hydrochloric acid solution of about five percent by volume of hydrochloric acid for a period of from five to ten seconds.

Step 4 is performed after the hydrochloric acid dip. The rack member **10** and wire **12** are immersed in a nickel plating solution to a depth sufficient to permit the plating of nickel over the stripped end portion **19** of the wire **12**. Plating is accomplished in accord with conventional procedures. The nickel plating solution may be a Nickel-Lume nickel bath having the following composition:

Nickel sulfate—40 oz./gal.
Nickel chloride—8 oz./gal.
Boric acid—5½ oz./gal.
NL–1 addition agent—2.5 oz./gal.
NL–2 addition agent—.32 fl. oz./gal.
Antipit #5—.20 fl. oz./gal.

Cast carbon-nickel anodes are preferably employed with the above solution, although other types of nickel anodes may be employed. The nickel plating step is performed with the temperature of the solution being maintained at approximately 120° F. and with a current density of approximately 20 to 30 amperes per square foot. The plating step is continued until a predetermined thickness of nickel has been deposited on the wire end portion 19 from which the insulation has been removed. The diameter of the plated wire may be checked periodically by use of a micrometer or the like, or if desired, the rate at which the bath is plating may be determined and the wire left in the solution for a calculated period of time. To insure a smooth and uniform nickel coating it is desirable that during the plating operation either the plating solution be agitated, for example, by stirring, or the rack and wire be moved in the solution, for example, by cathode rod reciprocation.

As will be understood by those skilled in the art, the above described bath and its operating conditions may be varied somewhat to obtain satisfactory needle portions on the ends of wires.

The rigidity that may be effected by electroplating a portion of a fine copper wire is a function of the length of the plated portion of the wire and of the thickness and type of the electrodeposit. For rigidifying a six-inch length of a forty gauge wire, which has a diameter of approximately .0031 inch, to a degree sufficient to permit its efficient use as a needle in the stringing of apertured cores, it has been determined that an electrodeposit of hard nickel having a thickness on the order of .00050–.00070 of an inch must be electroplated on the wire. The plating of greater thicknesses of nickel, where it can be tolerated, is often accomplished to increase the rigidity of the needle-like portion. For example, the needle portion of the first wire to be inserted through the core apertures may, after plating, have a maximum outside diameter of .0055 inch. The needle portion of the second wire strung through the cores may have an outside diameter of .0050 inch and the diameter of the needle portions of the third and fourth wires may be .00450 inch. The ability to vary needle diameters a small amount allows compensation for the reduced effective core diameter which results when one or more wires have previously been strung through the core apertures. Although some degree of rigidity is sacrificed when the needle diameter is reduced, the needle remains sufficiently rigid to facilitate the stringing of the cores. If it were desired to compensate for such a loss in rigidity, the needle length may be decreased.

FIG. 4 illustrates the needle-like end **38** acquired by the wire **12** during the electroplating step. The nickel coating **24** having been deposited on that portion of the copper wire conductor **25** from which the insulation **27** has been removed, forms an integral portion of the wire. During the plating step, the plated metal coating **24** is caused to assume a taper as a result of the "thief" action" of the plating frame **10** with which the wire **12** is in contact. The rack **10** is effective to "steal" current from the wire, thus retarding the buildup of electrodeposited metal on the copper wire in the area of the rack. It will be appreciated that a needle-like portion having a reduced diameter at its tip facilitates the entry of the needle-like end into a core aperture. The needle does not have to be tapered for successful use, but the taper has been found to be advantageous for core stringing operations.

The plating step is followed by the conventional water rinses, and the wires are allowed to air dry. After the plated units have been dried, the wires are removed from the rack. If the wire were racked as a continuous piece, it may be divided into the appropriate lengths by cutting or otherwise severing during the unracking step. A sharp object, such as a razor blade, may be used to sever the wire. This is readily accomplished by cutting each needle-like portion of the wire where it touches the rack member tangentially as at **26**.

As will be obvious to those skilled in the art, other stiffening metals such as chromium and rhodium may be electroplated on the wire **12** in sufficient thicknesses to stiffen the plated portion of the wire.

FIG. 5 illustrates the use of the plated portion of the wire as a needle for stringing a magnetic core matrix, the core matrix comprising a frame **30** and a plurality of toroidal magnetic cores **32** and **32'**, and being geometrically arranged in eight horizontal and eight vertical rows. The cores are axially aligned and placed upright in order to facilitate the threading of the cores with appropriate wire windings. As was mentioned hereinbefore, each core is conventionally strung with four wires. However, for clarity, the drawing shows the stringing of a portion of the cores with two wires **12** and **36** only.

In accord with the invention herein disclosed, needle-like end portions **38** and **40** have been prepared on the ends of wires **12** and **36** respectively. In stringing a predetermined series of cores, the plated or otherwise stiffened end portion **38** of the wire **12** is inserted through the aligned apertures of a designated series of cores. By drawing the needle-like end of the wire through the apertures, the wire conductor forms a winding which is appropriately disposed in electrical relationship to the cores. As is shown in FIG. 5, the wire **12** has already been woven through several cores, and the needle-like end **38** is positioned for insertion into the next series of cores in the manner indicated by the dotted line **39**. The stringing of the second wire **36** having the needle-like end **40** is accomplished in the same manner as the first, the wire **36** usually being disposed overlying the wire **12**. However, when stringing the second wire **36** it must be realized that the effective core aperture diameter, for example of cores **32'**, has been reduced by the presence of the previously strung wire **12**. In accord with one aspect of this invention, the reduced core aperture diameter is compensated for during the preparation of the needle-like ends on the wire. Thus the needle portion **40** of the wire **36** has a diameter slightly less than that of the needle portion **38** of wire **12**. It will be appreciated by those skilled in the art that the problem of weaving cores becomes more complex as the number of wires woven through each core aperture increases and, therefore, the ability to vary the diameter of the needle small amounts becomes increasingly important with each winding. Subsequent to the threading of the cores **32** and **32'** the wires **12** and **36** may be terminated by removal of the needle portions **38** and **40**, the ends of the wire then being secured to the frame in the manner well known in the art.

While the electroplating step offers the advantages of selectively plating a portion of the wire with a variety of metals, having easily controlled diameters, it will also be readily seen by those skilled in the art that other coating processes may be utilized to deposit a thin layer of metal upon a portion of a flexible copper wire. For example, a nickel layer may be chemically deposited upon the wire. Vapor deposition techniques may also be used to deposit nickel or the like on the wire; however, masking requirements and other features of this technique create problems which make this technique less desirable.

It is understood that suitable modifications may be made in the structure as disclosed provided such modifications come within the spirit and scope of the appended claims. Having now, therefore, fully illustrated and described our invention, what we claim to be new and desire to protect by Letters Patent is:

What is claimed is:

1. A method for forming a plurality of threading wires, each having a stiffened end portion, from a supply of an insulatively coated fine flexible wire whereby each individual threading wire length is adequate for threading a selected series of apertured articles and each said stiffened end portion facilitates the threading of said articles, which method comprises the steps of:

(A) winding on a frame a plurality of spaced turns of an insulatively coated fine flexible wire such that each turn of the wire disposes a portion thereof intended to be stiffened in a substantially straight line;

(B) securing the wire to the frame;

(C) removing the insulation from the portions of the wire turns intended to be stiffened;

(D) applying a coating of metal onto the insulation removed portions of the wire, the applied coating being integral with the wire and of sufficient thickness to cause the metal coated portions of the wire to substantially stiffen;

(E) cutting said turns at the said stiffened portions to remove the turns from the frame and thereby provide a plurality of individual threading wires each having a stiffened straight end portion.

2. A method as in claim **1** wherein said metal is applied by electroplating.

3. A method as in claim **2** wherein said metal is nickel.

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