United States Patent

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Dayton, Ohio
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[54] **METHOD OF MAKING MAGNETIC HEAD DEVICE**
5 Claims, 22 Drawing Figs.

[52] **U.S. Cl.** ..... **29/603,** 179/100.2 C
[51] **Int. Cl.** **H01f 7/06**
[50] **Field of Search** ..... 29/603; 179/100.2 C; 346/74 MC; 340/174.1 F

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ABSTRACT: A method of constructing a magnetic head device comprised of a high-permeability hairpin core with a coil winding closely coupled to a leg of the core, which includes the steps of shaping a single integral strip of a very high-permeability magnetic alloy into the general form of a hairpin, annealing the hairpin core to optimize its magnetic properties, inserting a prewound coil on a leg of the hairpin and then securing together the end portions of the hairpin legs to form a gap interface.

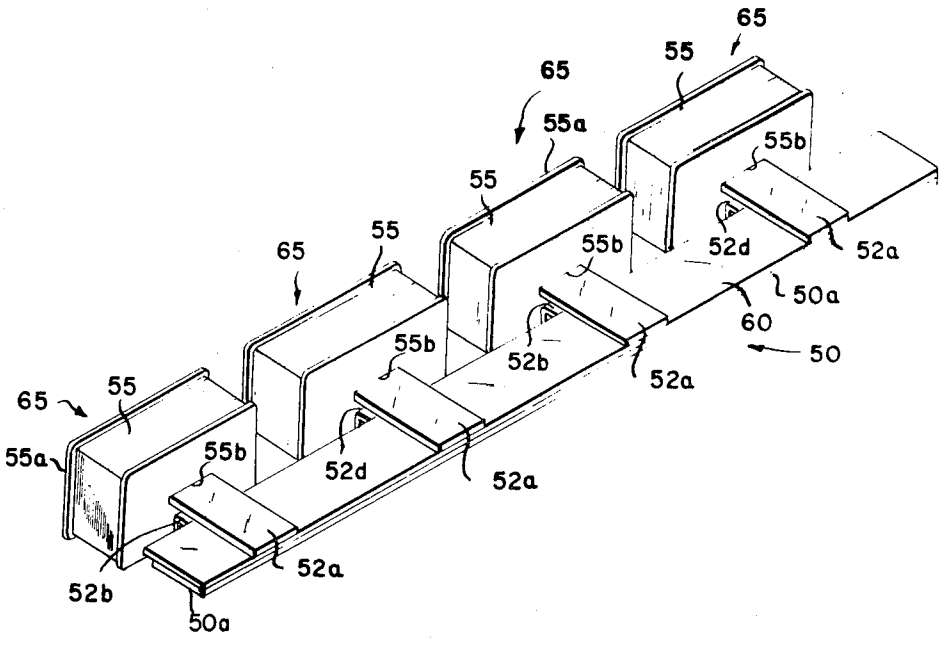


FIG. 1

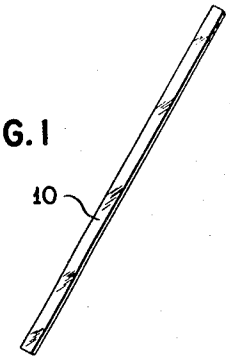


FIG. 2

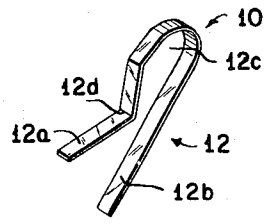
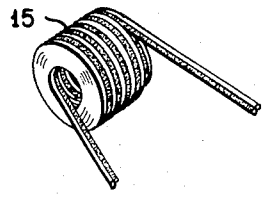


FIG. 3



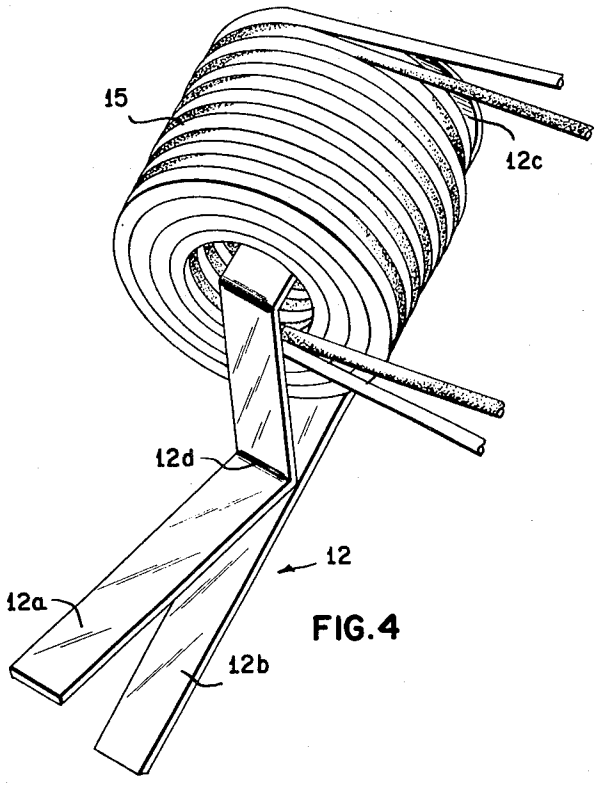


FIG. 4

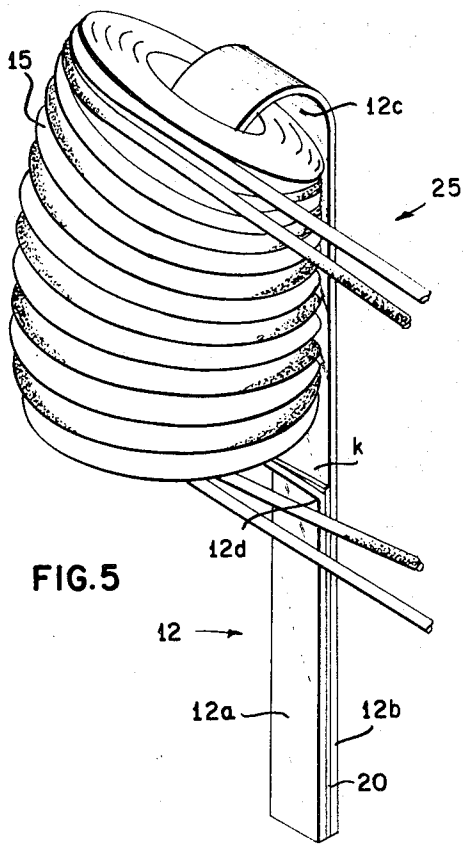


FIG. 5

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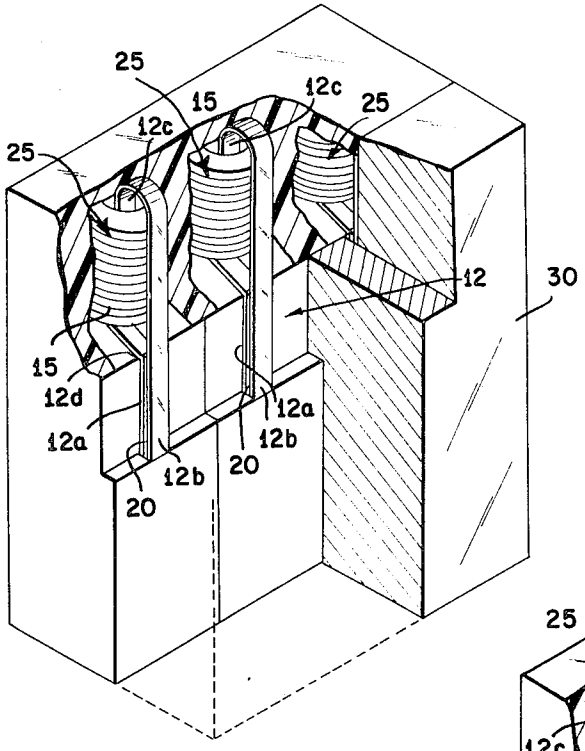


FIG.6

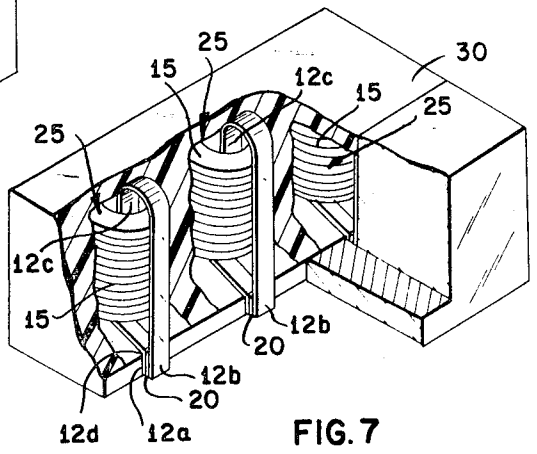
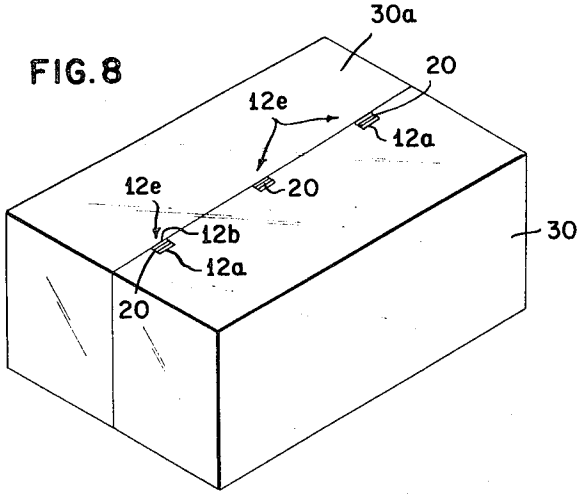


FIG.7

FIG.8



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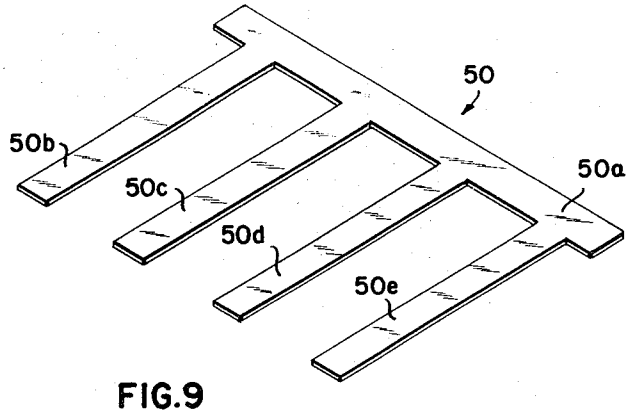


FIG.9

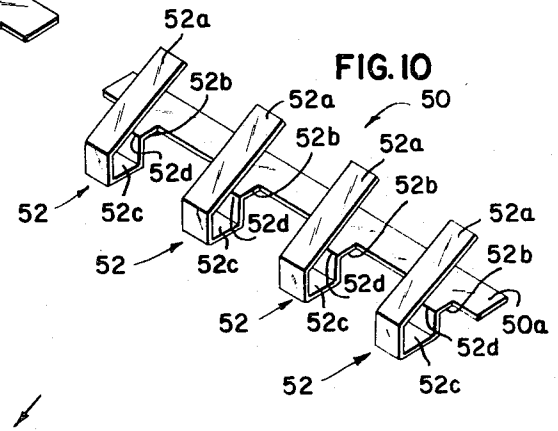


FIG.10

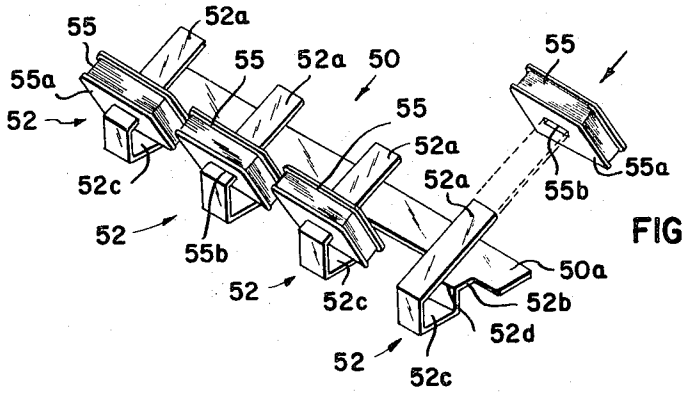
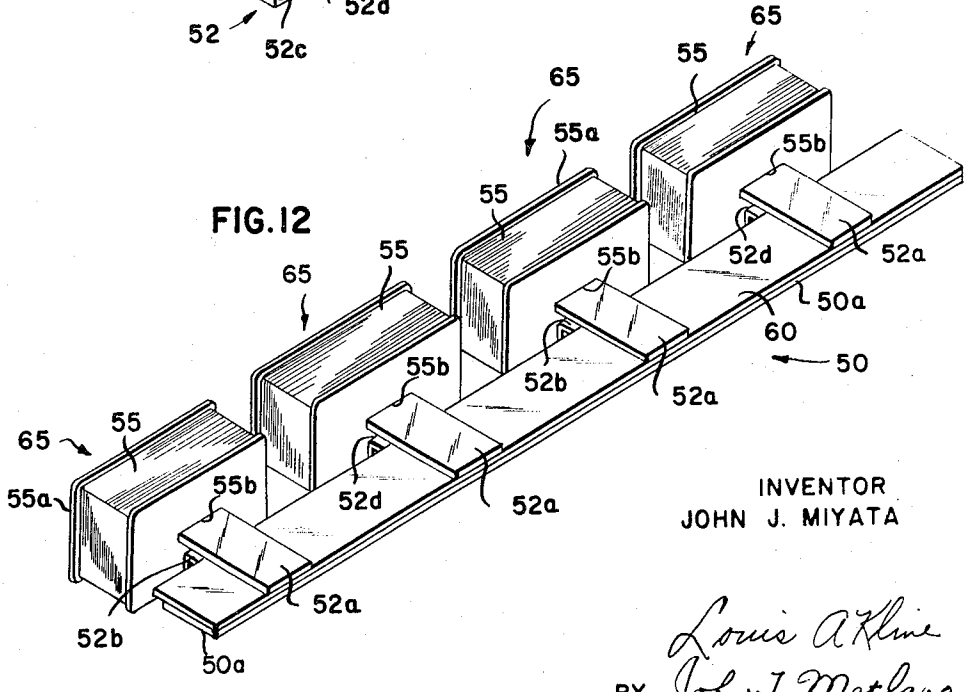


FIG.11

FIG.12



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FIG. 13

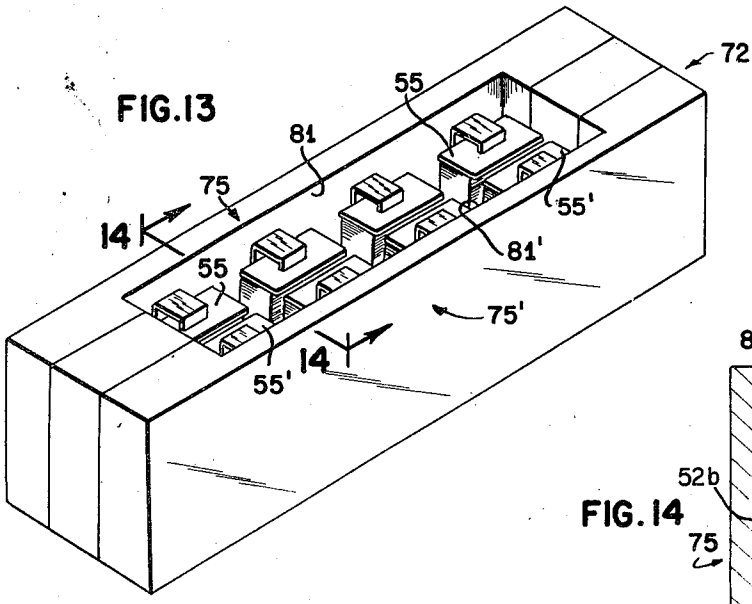


FIG. 14

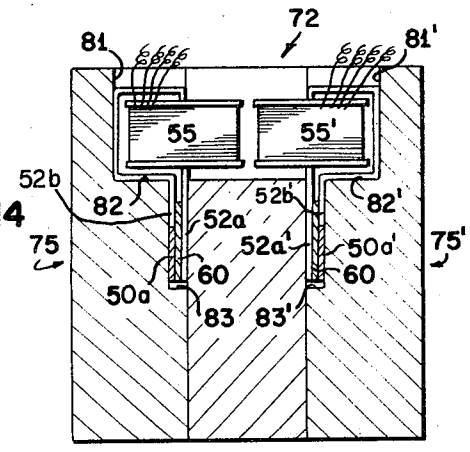
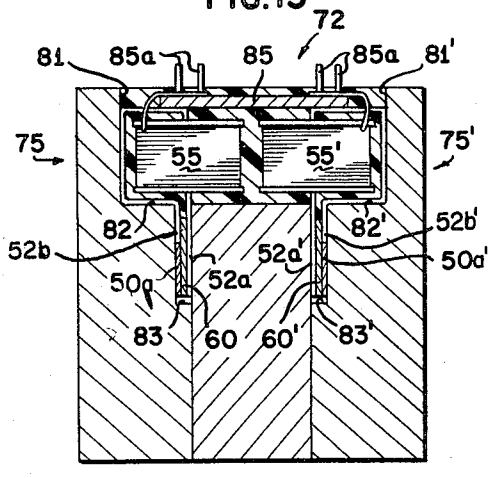


FIG. 15



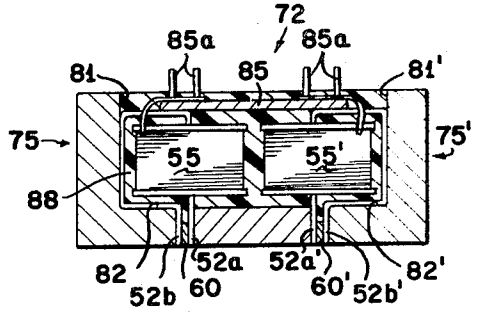


FIG. 16

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FIG.17

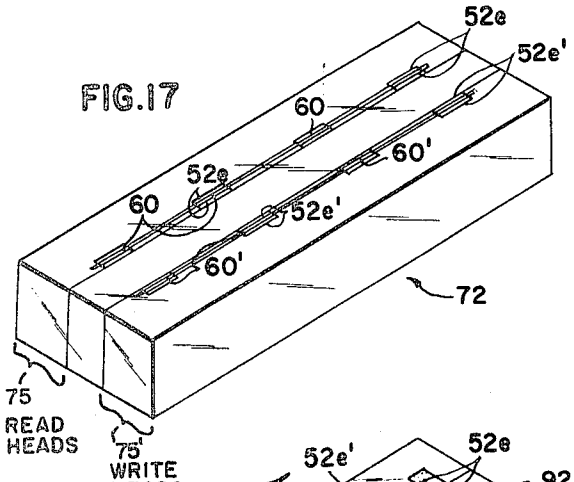


FIG.18

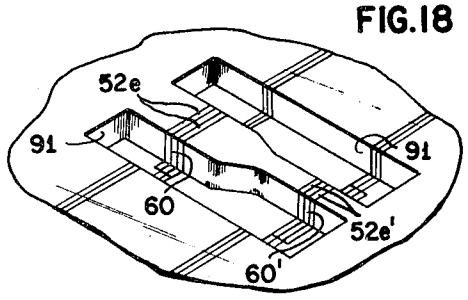


FIG.19

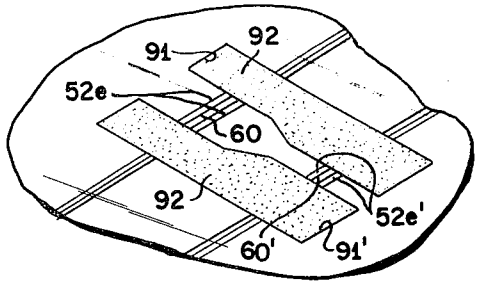
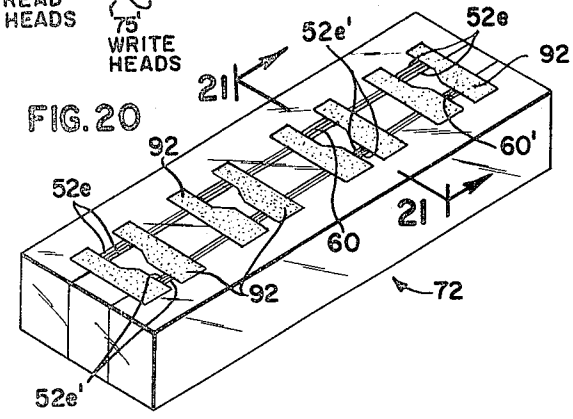


FIG.20



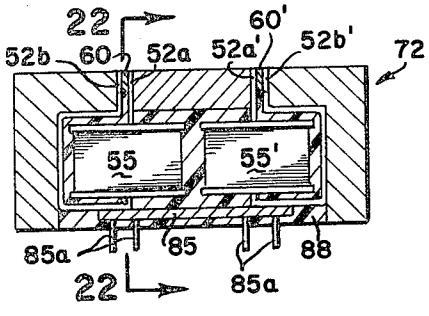


FIG.21

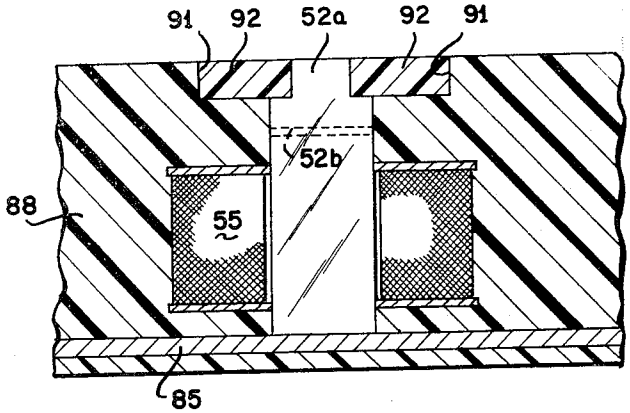


FIG.22

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METHOD OF MAKING MAGNETIC HEAD DEVICE

This is a division of copending U.S. application Ser. No. 564,912, filed July 13, 1966, now U.S. Pat. No. 3,504,134 granted Mar. 31, 1970.

This invention relates generally to magnetic transducer devices, and more particularly to novel magnetic transducer constructions and methods of making.

The magnetic transducer art has for many years been plagued by the extreme complexity and cost involved in making magnetic heads, and these difficulties continue to mount as the art progresses to higher and higher recording densities and smaller and smaller heads. It will be understood that the construction of such heads presents unusual problems because of the difficulties involved in making and assembling the small precisely dimensioned parts required, and particularly in providing the required windings therefor which are not only very small but use delicate conductors of very small diameter.

Accordingly, a broad object of the present invention is to provide improved magnetic head constructions and methods of making.

Another object of the invention is to provide improvements in the construction and method of making multiple head units containing individual read and write head portions.

A further object of this invention is to provide improvements in the construction and method of making miniature heads capable of high-density recording and reproducing.

Still another object of the invention is to provide improved means and methods for providing the windings of a magnetic head.

Briefly, in accordance with a typical embodiment of the present invention, the basic magnetic core is formed from a very high-permeability strip of magnetic alloy material which is bent into a shape generally resembling a "hairpin," and then annealed to optimize magnetic properties. The windings for the head are wound apart from the hairpin on an appropriate coil-winding machine so as to form a winding assembly containing all the required windings. This is a relatively simple matter, since there is no magnetic core present to hinder the winding operation. The legs of the hairpin are made sufficiently resilient to permit the winding assembly to be inserted on one leg thereof and the legs spot-welded together with a gap material therebetween without deleteriously affecting the magnetic properties of the resulting hairpin head. One or more of such hairpin heads are then suitably disposed in a housing for machining of the legs and the pole tips to the desired final dimensions.

The specific nature of the invention as well as other advantages, object and uses thereof will become evident from the following description and the accompanying drawings in which:

FIGS. **1–8** are views illustrating steps in the fabrication of a multiple-hairpin magnetic head unit in accordance with the invention, the completed head being shown in FIGS. **7** and **8**; and

FIGS. **9–22** are views illustrating steps in the fabrication of a read-write multiple-hairpin magnetic head unit in accordance with the invention, the completed head being shown in FIGS. **19–21**.

Like numerals refer to like elements throughout the figures of the drawings.

Referring to FIGS. **1–8**, illustrated therein are steps in the fabrication of a multiple magnetic head unit containing a plurality of aligned hairpin magnetic heads in accordance with the invention.

FIG. **1** shows the basic very high-permeability strip **10** used in making a hairpin magnetic head. This strip **10** may typically be 0.0013 inch and preferably less than 0.002 inch thick, 0.020 inch wide and 0.80 inch long and made of a very high-permeability alloy, such as high MU 80 obtainable from Carpenter Steel Company, Reading, Pennsylvania, or Molypermalloy obtainable from Allegheny Ludlum Steel Corporation, Pittsburgh Pennsylvania, or Hipernom, obtainable from Westinghouse Electric Corporation, Blairsville, Pennsylvania. Such material has a permeability of 30,000 and comprises approximately 78–81 percent nickel, 14–18 percent iron, 4–5 percent molybdenum, and small quantities of such elements as carbon, silicon, and manganese. As shown in FIG. **2**, this very high-permeability strip **10** of FIG. **1** is bent into a hairpin-shaped core **12** having legs **12***a* and **12***b* and an upper opening **12***c* formed by providing a sharp bend **12***d* in leg **12***a*. The resulting hairpin core **12** of FIG. **2** is then annealed to optimize its magnetic properties.

The head windings **15** for the hairpin core **12** in FIG. **2** are illustrated in FIG. **3**. These windings **15** are wound on a suitable coil-winding machine independently of the hairpin core **12** of FIG. **2**, and are then inserted on leg **12***a* thereof, as shown in FIG. **4**, the upper opening **12***c* of the hairpin core **12** being sufficiently large to accommodate the head windings **15**. The head windings **15** may typically comprise 60 bifilar turns of **46** gauge wire. The next step is to spotweld a strip of gap material **20** between the legs **12***a* and **12***b* to form the resultant hairpin head **25** shown in FIG. **5**, the gap strip being indicated by the numeral **20** in FIG. **5**, and may typically be a 0.020-inch-wide, 0.00025-inch-thick and 0.25-inch-long silver strip. The hairpin **12** is sufficiently resilient so that neither the insertion of the head windings **15** nor the spot welding to the final shape shown in FIG. **5** have a deleterious effect on the magnetic properties thereof.

One or more of the hairpin magnetic heads **25** shown in FIG. **5** are next encased in aligned fashion in a nonmagnetic supporting structure **30**, as typically illustrated in FIG. **6** for three hairpin heads. The supporting structure **30** with the hairpin heads **25** is then cut along the lower portion thereof, as illustrated in FIG. **7**, so as to reduce legs **12***a* and **12***b* (FIG. **5**) to the proper length desired for the gap interface, which should preferably be as small as possible for optimum efficiency, a length of 0.006 inch being typical, the length being preferably no greater than 0.01 inch nor less than 0.001 inch. The sharp bend **12***d* (FIG. **2**) in leg **12***a* or the hairpin core **12** permits accurate control of the gap interface and the angle *k* (FIG. **5**) should preferably be greater than 60° and most preferably close to 90°.

As illustrated in FIG. **8**, which is a view looking upward with respect to FIGS. **6** and **7**, the pole tips **12***e* are finished in a common surface with respect to a face **30***a* of the supporting structure **30**. Prior to such finishing an electrical spark discharge machine can be used to precisely shape the pole tips **12***e*. It will be understood that the face **30***a* of supporting structure **30** may be provided with any desired shape, as may be desirable, for example, where the head unit is to be used as a flying head with a disc where aerodynamic action is used to maintain the head at a precise distance from the disc surface. Looking comparatively between FIGS. **6** and **7**, it is seen that there is a portion of length where the two ends of the legs of the core strips face each other in a parallel fashion to form the magnetic poles. This confronting vertical length is called the "interface gap." Viewing the housing and the length of the interface gap in FIG. **6** and then seeing the result of the cutting operation in FIG. **7**, it will be observed that the housing and the "interface gap" has been cut so as to provide the minimum length (vertical) of interface gap. This may be of the order of six thousandths of an inch, that is, 0.006. Thus, the method of fabrication involved facilitates and permits the possibility that this particular type of very small interface gap can be simply and economically constructed.

Referring next to FIGS. **9–22**, illustrated therein are steps in a modified method of fabrication of a multiple magnetic head unit in accordance with the invention having adjacent read and write sections, each section containing a plurality of aligned hairpin magnetic heads. Although the method of FIGS. **1–8** are described in connection with the fabrication of only one head section, it will be understood that it too can be provided with both read and write sections. As will become evident, an important difference between the fabrication methods of FIGS. **1–8** and FIGS. **9–22** is that the latter forms each plurality of aligned hairpin magnetic heads of a section out of a single integral piece of material, whereby the required

precise alignment between each hairpin head of a section is automatically obtained, and the desired precise relationship between the two sections is readily achievable.

FIG. 9 shown the basic piece of very high-permeability alloy material 50 used in making four aligned hairpin heads, there being one such piece of material for the read hairpin heads and another for the write hairpin heads. Since the initial steps in the fabrication of the read and write hairpin heads are the same, the fabrication of only one set of aligned heads will be considered at this point in the description. It will be understood that the same very high-permeability alloy material may be employed as previously mentioned in connection with FIG. 1. As will be seen from FIG. 9, the basic piece of material 50 comprises a base 50*a* having four legs 50*b*, 50*c*, 50*d* and 50*e* extending therefrom, one for each hairpin magnetic head to be formed. Typically, the material 50 may be 0.0013 inch thick with each leg and the base being 0.04 inch wide, and the legs being 0.80 inch long and 0.20 inch apart measured from their centers.

Using a suitable forming fixture (not shown), the basic piece of high-permeability alloy material 50 illustrated in FIG. 9 is shaped to form four hairpin cores 52 extending from base 50*a*, as illustrated in FIG. 10, each hairpin core 52 having legs 52*a* and 52*b* and an opening 52*c* formed by providing a sharp bend 52*d* in leg 52*b*. It will be understood from a comparison of FIGS. 2 and 10 that elements 52, 52*a*, 52*b*, 52*c* and 52*d* generally correspond to elements 12, 12*a*, 12*b*, 12*c* and 12*d* in FIG. 2 and are provided for like purposes. One difference, however, is that, as illustrated in FIG. 11, the head windings 55 for each hairpin core 52 are slipped on the unbent leg 52*a* thereof, which is advantageous in that the bend 52*d* in the other leg 52*b* of each hairpin core 52 can be made sharper to provide greater control of the gap interface and less strain on the core 52 and windings 55 when the gap strip 60 (FIG. 12) is spot welded between legs 52*a* and 52*b* of the hairpin heads 52, as shown in FIG. 12. Each of the head windings 55 is wound separately and apart from the hairpin cores 52, and may have the same number of bifilar turns and wire gauge as the head windings 15 of FIG. 3. However, for the embodiment of FIGS. 9–20, each of the head windings 55 is preferably wound on a suitable form 55*a* having an aperture 55*b* chosen to provide a snug accurate fit when inserted on its respective leg 52*a*, and having a size which will appropriately fit within its respective opening 52*c* after spot welding, as shown in FIG. 10. The gap strip 60 may be of the same material as in the embodiment of FIGS. 1–8. The gap strip 60 is placed upon the common base so as to provide an accurately spaced gap when the other leg of the core is pressed against it and spotwelded thereto.

The resulting structure illustrated in FIG. 12 thus contains four integrally connected hairpin magnetic heads 65. The next step in the fabrication is to take two of these structures of FIG. 12, one for reading and one for writing, and to insert them into respective read and write sections 75 and 75′ of a nonmagnetic metal supporting housing 72, as illustrated in FIGS. 13 and 14, FIG. 14 being a cross-sectional view taken along the line 14—14 in FIG. 13. Unprimed numerals will hereinafter refer to elements in the read section, while primed numerals will refer to elements in the write section.

As will be seen from FIGS. 13 and 14, housing 72 is provided with a cavity 81 having a base 82 and slots 83 and 83′ (FIG. 14) accurately machined to receive the read and write hairpin head structures (each as illustrated in FIG. 12), with the spot-welded legs 52*a*, 52*b* and 52*a*′, 52*b*′ thereof fitting into respective slots 83 and 83′. A terminal board 85 having terminals 85*a* is next disposed over the hairpin heads, as illustrated in FIG. 15, and the ends of the head windings 55 and 55′ are soldered to respective ones thereof, after which the entire inner cavity 81 of the housing 72 is filled with potting compound 88 and suitably cured, whereby the read and write hairpin heads and terminal board 85 are secured in proper aligned position within cavity 81.

The next step, the end product of which is illustrated in FIG. 16, is to cut the housing 72 along the lower portion thereof as viewed in FIG. 14, so as to reduce the "read" hairpin legs 52*a* and 52*b*, and to reduce the "write" hairpin legs 52*a*′ and 52*b*′ to the proper length desired for the gap interface. The amount of magnetic leg material removed is at least equal to the width of the common base of the strip 50*a* as shown in FIG. 9, and shown crosshatched in FIG. 14. The resulting multiple head unit containing both read and write head sections 75 and 75′ (four read and four write heads) is illustrated in FIG. 17 which is a view looking at the pole tips 52*e* and 52*e*′ which tips would couple to a magnetic recording medium.

The final steps in the method are to properly shape the read and write pole tips 52*e* and 52*e*′, and to machine the pole tips and the adjacent surfaces of the housing 72 to final dimensions. The pole tips 52*e* and 52*e*′ may advantageously be shaped using an electrical spark discharge machine which acts to remove conductive portions from a selected area. FIG. 18 is a fragmentary view illustrating the cutout portions 91 produced for a typical pair of aligned read and write hairpin heads using the electrical spark discharge machine. A read head width of 0.005 inch and a write head width of 0.0113 inch are typical, the write head width being made larger than the read head width to obtain wide-write, narrow-read recording and reproducing. As shown in the fragmentary view of FIG. 19, the cutout portions 91 produced by the electrical spark discharge machine are next filled with potting compound 92. The pole tips and adjacent surfaces of the housing are then machined to a common surface having the desired final dimensions, the resulting head being illustrated in FIGS. 20, 21 and 22. FIG. 21 is a cross-sectional view taken along the line 21—21 in FIG. 20, and FIG. 22 is a cross-sectional view taken along the line 22—22 in FIG. 21.

It is to be understood that the embodiments of the invention disclosed herein are only exemplary, and that many modifications and variations may be made therein without departing from the present invention. Accordingly, the present invention is to be considered as including all possible embodiments coming within the scope of the invention as defined in the appended claims.

What is claimed is:

1. A method of making a multiple magnetic head unit comprising the steps of: providing a single thin piece of a very high-permeability magnetic material having a common base portion with a plurality of spaced strips extending in a parallel fashion from said common base at right angles to form a plurality of spaced strips; shaping each strip in the general form of a hairpin having two legs with at least one of said legs being sharply bent near an end thereof; providing a coil inductively coupled to each hairpin; securing together the end portions of the legs of each hairpin with a nonmagnetic gap material which provides a precise gap space therebetween; and cutting the end portions of said legs to provide a gap interface of predetermined length for each hairpin, said cutting being done so as to sever all portions of the of the magnetic material of the common base which interconnect the plurality of spaced strips.

2. A method of making a multiple magnetic head unit comprising the steps of: providing a single thin integral piece of a very high-permeability magnetic sheet having a common base portion and a plurality of spaced strips extending therefrom, shaping each strip in the general form of a hairpin having two legs with one of said legs being sharply bent near an end thereof for forming a gap interface at the ends of said legs and further bent to form a coil-receiving opening between said legs, annealing each hairpin to optimize its magnetic properties, winding a coil for each hairpin apart therefrom and then inserting the coil on a leg of each hairpin, securing together the end portions of the legs of each hairpin with a very thin nonmagnetic gap therebetween to form a gap interface, enclosing the resulting hairpin heads in a nonmagnetic housing, and cutting the housing and legs to provide a predetermined length for each gap interface, said cutting being done so as to sever the entire common base portion of the magnetic sheet which interconnects the plurality of spaced strips.

3. A method of making a multiple magnetic head unit containing read and write sections comprising the steps of: providing first and second sheets of a very high-permeability magnetic material, each sheet having a common base portion from which extend in parallel a plurality of spaced strips, shaping each strip of each sheet in the general form of a hairpin having two legs forming poles with one of said legs being sharply bent near an end thereof for forming a gap interface at the ends of said legs and further bent to form a coil-receiving opening between said legs, annealing each hairpin to optimize its magnetic properties, winding a coil for each hairpin apart therefrom and then inserting the coil on a leg of each hairpin, securing together the end portions of the legs of each hairpin with a very thin nonmagnetic gap material therebetween to form a precisionally spaced gap interface, and securing the thus-formed first and second sheets in a housing in a precisely predetermined alignment relationship wherein each pole of the read section is aligned with a corresponding pole of the write section; and cutting a portion of each of said legs so as to sever the common base portion of each of said first and second sheets.

4. The invention in accordance with claim 3, including the step of finishing the ends of said legs into shaped tip areas in a common surface with said housing.

5. The invention in accordance with claim 4, including the step of shaping the ends of said legs into pole tips of desired dimensions using an electrical spark discharge machine.

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