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MAGNETIC TRANSDUCER HEAD HAVING ELECTRICALLY CONDUCTIVE CORE SUPPORTING MEANS SURROUNDED BY A MAGNETIC HOUSING

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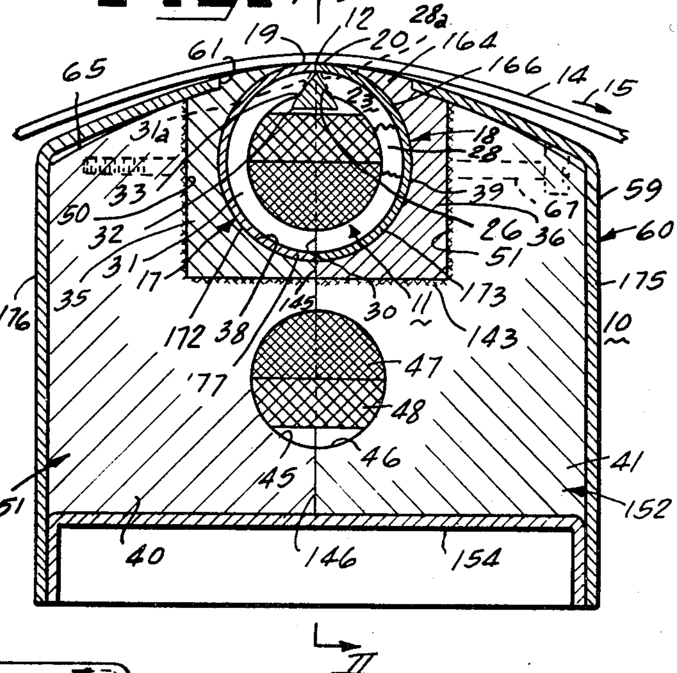

Fig. 1

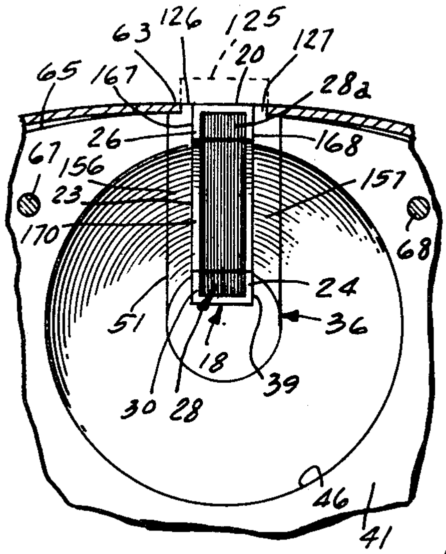

Fig. 2

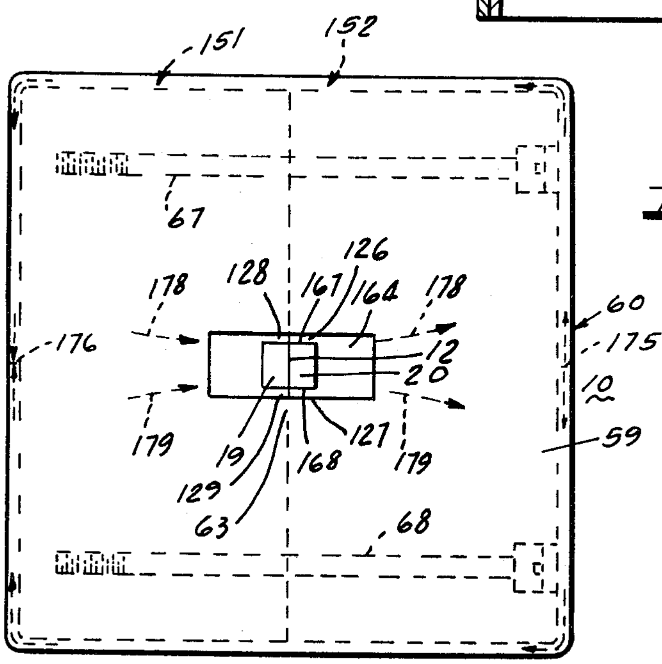

Fig. 3

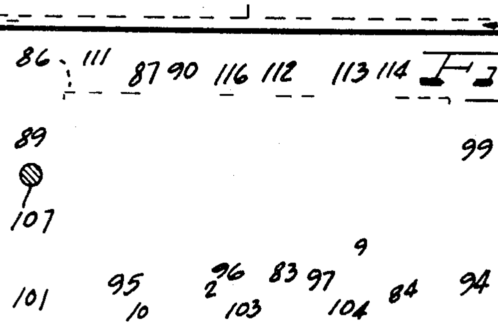

Fig. 4

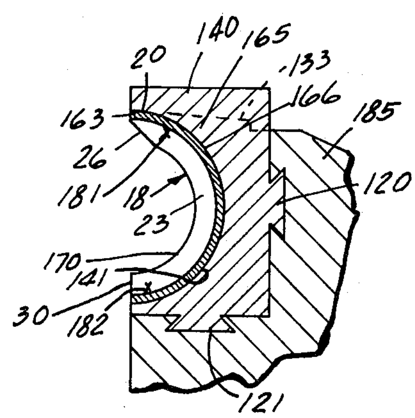

Fig. 5

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MAGNETIC TRANSDUCER HEAD HAVING ELECTRICALLY CONDUCTIVE CORE SUPPORTING MEANS SURROUNDED BY A MAGNETIC HOUSING

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ABSTRACT OF THE DISCLOSURE

In the illustrated embodiment, a high resolution transducer head is formed by assembling C-shaped core parts in conforming cavities of respective high conductivity insert blocks. The insert blocks are secured in notches in respective metal mounting blocks. The sub-assemblies are machined to form tape engaging surfaces, and a magnetic housing shell is inserted over the mated sub-assemblies with the core tape engaging surfaces exposed by means of a housing aperture. Also shown is a plural channel head assembly of similar construction. The heads have composite magnetic cores of a special construction providing reduced residual magnetization.

BACKGROUND OF THE INVENTION

An important problem in the video recording art relates to the need for higher resolution transducer heads which enable lower scanning speeds at a reasonable cost. Such transducer heads are particularly desired for fixed (non-rotating) head video recording and playback systems where low cost is a basic objective.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an improved transducer head for video recording and playback systems, and an improved method for making such a head.

Another object of the invention is to provide a relatively inexpensive transducer head having a stable gap dimension of 50 microinches or less.

A further object of the invention is to provide a transducer head in accordance with one or more of the foregoing objects also having a particularly low susceptibility to residual magnetization.

A still further object of the invention is to provide a magnetic transducer head providing a stable high resolution gap dimension in spite of temperature changes.

Another and further object of the invention is to provide a relatively inexpensive readily manufactured magnetic head assembly for magnetic transducer systems.

Still further objects of the invention relate to methods for producing head assemblies having the characteristics previously expressed and which methods are particularly simple and inexpensive and lend themselves to efficient quantity production.

Other objects, features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a somewhat diagrammatic longitudinal sectional view illustrating a head assembly in accordance with the concepts of the present invention;

FIG. 2 is a partial transverse sectional view taken along the line II—II of FIG. 1;

FIG. 3 is a somewhat diagrammatic top plan view of the head assembly of FIG. 1;

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FIG. 4 is a partial transverse sectional view somewhat diagrammatic in nature and similar to FIG. 2 but illustrating a multichannel head assembly; and

FIG. 5 is a partial longitudinal sectional view similar to that of FIG. 1 but illustrating a modification thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 there is illustrated a magnetic head assembly **10** comprising a magnetic core **11** having a coupling gap **12** for coupling to a magnetic tape record medium **14** moving along a record medium path, for example in the direction of the arrow **15**. The magnetic core **11** comprises a pair of generally semi-circular core members **17** and **18**. The core members **17** and **18** have polar surfaces **19** and **20** adjacent coupling gap **12** which are in sliding contact with the magnetizable surface of the magnetic record medium **14**. As illustrated in FIG. 2, the core member **18** has inturned side flanges **23** and **24** integral therewith. Each of the side flanges is beveled near the coupling gap **12** as indicated at **26** in FIG. 1.

Between the sides **23** and **24** of the core member **18** are a series of generally semi-circular laminations **28** of identical configuration. The auxiliary core parts or laminations **28** are substantially or essentially unstressed and extend in parallel relationship with suitable insulation between the successive laminations and between the laminations and the core member **18**. The auxiliary core parts **28** have an exceptionally low coercive force and are in shunt with the main or working core member **18** which may have a higher coercive force. A suitable material is Supermalloy.

The laminations **28** may be essentially of the same configuration as the flange **23** partially shown in FIG. 1 except adjacent gap **12**. Thus near gap **12**, the laminations **28** may have bevel end faces as indicated at **28***a* terminating in spaced relation to and more distant from gap **12** than the bevel **26** of flange **23**. The end faces of liminations **28** at the ends thereof remote from gap **23** may be flush with the end face **30** of flange **23** (see FIG. 1). The core member **17** may be of identical configuration with the core member **18** and may have laminations **31** identical to the laminations **28**.

A mass of electrically highly conductive material such as copper may be disposed as indicated at **32** between and in conforming relation to the bevel faces such as **26** of the core member **18** and the corresponding bevel faces such as **33** of the core member **17**. The electrically conductive mass **32** may be suitably insulated from the end faces **28***a* and **31***a* of the laminations **28** and **31**.

The core members **17** and **18** are secured in confronting relationship by means of electrically conductive mounting means. In the illustrated embodiment, this mounting means comprises insert blocks **35** and **36** having cavities **38** and **39** therein conforming with and receiving the respective core members **17** and **18**. The insert blocks **35** and **36** are of material of high electrical conductivity such as copper or silver. The insert blocks **35** and **36** are in turn secured to main mounting blocks **40** and **41** which may be made of a lower conductivity material which is more readily machinable, or can be cast, or has other advantageous features. Other advantageous characteristics of the material of the main mounting blocks **40** and **41** might comprise one or more of the following: ease of manufacture, for example easier to form, to machine or to polish; especially desirable dimensional stability; and the like. While the insert blocks or core mounting bodies **35** and **36** are preferably of copper, other high conductivity materials may be used, as for example silver, beryllium copper and other nonmagnetic metals or alloys of comparable conductivity, which may have superior wearing properties.

As illustrated in FIGS. 1 and 2, the main mounting blocks **40** and **41** are provided with respective annular cavities **45** and **46** for receiving windings **47** and **48**. Each winding consists of a number of turns or coils encircling the lower part of the magnetic core **11**, the winding **48** being wound on top of the winding **47**.

The magnetic core receiving bodies **35** and **36** may be cast, welded, brazed, hard soldered or the like within the respective cavities **50** and **51** of the main mounting blocks **40** and **41**. Alternatively, the entire mounting means for the magnetic cores can be of copper or other comparable high conductivity material with cavities machined or pressed (coined) such as indicated at **38**, **39**, **45**, and **46**.

As indicated in FIGS. 1 and 2, a shell part **59** of a casing **60** of magnetic material may fit over the mounting means **35**, **36**, **40**, **41** in contacting relation thereto at the crest of the top face, and at the side faces of the mounting means. The casing **60** is provided with an elongated aperture **61** as best seen in FIG. 3 and through which the polar faces **19** and **20** are exposed for sliding contact with the magnetizable surface of the record medium **14**. The upper surface **63** of casing **60** may be in sliding contact with adjacent channels of the record medium **14** and may be substantially flush with the polar faces **19** and **20** where these polar faces engage an active channel of the record medium **14**. As seen in FIG. 2, the top surface **65** of the mounting means may be slightly crowned in the lateral direction and the casing **60** may have a generally corresponding crown so that the tape will be slightly concave as viewed in cross-section in FIG. 2.

The two half sections or sub-assemblies **35**, **40** and **36**, **41** of the mounting means together with the respective magnetic core sub-assemblies including core members **17** and **18** with their respective magnetic laminations **28** and **31** may be secured in mating relationship with a suitable gap spacer defining coupling gap **12** by any suitable means such as screws **67** and **68**, FIG. 3.

FIG. 4 illustrates a magnetic head assembly **80** including head units **81–84** having respective coupling gaps for coupling to respective channels of a magnetic record medium **86**. Each of the head units may be formed of a pair of generally semi-circular head sub-assemblies such as indicated at **87** and each head sub-assembly may be formed of a plurality of magnetic core sub-assemblies such as indicated at **89** and **90**. The magnetic core sub-assemblies **89** and **90** may be identical to the magnetic core sub-assembly **18**, **28** shown in FIGS. 1 and 2. A longitudinal sectional view of each of the head units **81–84** would correspond essentially, for example, to the arrangement shown in FIG. 1, that is a ring type magnetic core with a coupling gap and with polar surfaces such as **19** and **20** across which the record medium **86** successively travels in sliding contact. The record medium would be in sliding contact with the polar surfaces of each of the magnetic core sub-assemblies such as **89** and **90**.

In the arrangement illustrated in FIG. 4, a single highly conductive insert block or magnetic core receiving body **94** is indicated having respective recesses **95–98** receiving the respective head sub-assemblies such as **87** of the head units **81–84**. Also as illustrated in FIG. 4 the insert block **94** is secured in a cavity **99** of a main mounting block **100**. The main mounting block **100** has successive cavities **101–104** for receiving individual winding assemblies which may be identical to the winding assemblies **47**, **48** shown in FIG. 1. Two channel assemblies are shown in each cavity to give a wider head than in FIG. 2. Such a construction with two or more channel pieces per cavity allows the low losses of thin core materials and large surface areas for skin effect flux carrying, and gives increased strength and support at the tape contacting portion of the cores.

The head assembly **80** would correspond to the head assembly **10** of FIG. 3 in having means such as indicated at **107** and **108** in FIG. 4 for securing the two halves of the head assembly together and then being provided with a casing **110** of magnetically soft material. The casing **110** is provided with apertures **111–114** corresponding to the aperture **61** of casing **60** for exposing the polar surfaces of the head units **81–84** for sliding contact with the record medium **86**. The upper surface **116** of casing **110** serves as a magnetic keeper surface contacting the channels of the magnetic record medium **86** which are located out of alignment with the head units **81–84**. For example, the head units **81–84** may have a spacing therebetween slightly exceeding the width of the magnetized tracks recorded by the head units so that the head assembly **80** may be shifted relative to the record medium by a distance approximately equal to the width of the head units to cause the head assembly to scan a second set of channels.

As in the previous embodiment, the entire mounting means may be formed of only two blocks of copper or other high conductivity material with cavities machined or pressed (coined) to receive the respective head units **81–84**. Alternatively, instead of a single pair of insert blocks such as insert block **94** shown in FIG. 4, separate insert blocks may be utilized for each head unit, the main mounting blocks such as mounting block **100** being provided with individual cavites for receiving the respective individual insert blocks.

By way of example, in each embodiment where a mounting means is utilized including a high conductivity insert block and a main mounting block of lower cost material or the like, the main mounting block may be formed of brass or bronze, for example. The main mounting blocks in each of the embodiments may be formed of die cast material, for example. The insert blocks may have ears such as indicated at **120** and **121** in FIG. 5. In FIG. 5, core subassemblies such as **18** are shown with the laminations **28** broken away completely to show the configuration of the side flanges such as **23**. In each embodiment the insert blocks may initially have a height dimension to project above the main mounting block such as **41**, FIG. 2 and be machined down to the configuration illustrated in FIG. 2. In FIG. 2 the initial configuration of the mounting means is indicated by the dot dash line **125**, material being removed as indicated by dash line **133** in FIG. 5 to leave side support portions such as indicated at **126** and **127** in FIG. 2 and at **126–129** in FIG. 3 at each side of each of the head subassemblies, the final finishing of the top surfaces of support portions **126–129** being done after final assembly with housing **60** in place.

The illustrated constructions are extremely stable, allowing coupling gaps such as indicated at **12** having a dimension in the direction of tape movement of 50 microinch (1 microinch equals one millionth of an inch) or below (down to 10 microinch or less) that are maintained through changes of temperature. The constructions minimize stress of magnetic core member such as **17**, **18** and particularly portions **28** and **31** are supported in a stress free condition.

One method of making the head assembly of FIGS. 1–3 may be outlined as follows:

(1) Respective blocks such as insert block **36**, FIG. 2, (before machining at **125**—see insert block **140**, FIG. 5) of silver or the like are formed with recesses such as indicated at **39** (machined or coined) so as to receive magnetic core subassemblies such as that indicated at **18**, **28** in FIGS. 1 and 2. Alternatively the insert blocks are solid, with the recesses formed in step 2.

(2) The silver insert blocks **35** and **36** are soldered into the respective receiving recesses **50** and **51** of the main mounting blocks **40** and **41**, for example along the interface indicated by the successive cross lines at **143**, FIG. 1. The mating faces such as **145**, **146** of the resultant subassemblies **151** and **152** are semi-finished. The recesses **38** and **39** may then be formed or finished.

(3) The winding cavities such as indicated at **45** and **46** are formed as by machining or coining if these cavities are not already in the blank blocks.

(4) The filler portions **28**, **31** are coated with insulating material such as a magnesium oxide film, inserted between the side flanges of cores **17** and **18** and annealed for best magnetic properties. The core assemblies are then secured at the outer surfaces of cores **17** and **18** by epoxy adhesive to the walls of cavities **38** and **39**. The mating faces of cores **17** and **18**, especially at gap **12**, are finished to optical flatness.

(5) The winding assembly such as **47**, **48** is inserted between two mating subassemblies **151** and **152**, the gap spacer is inserted at **12**, and the subassemblies are secured together for example by screw means **67**, **68** of FIG. 3.

(6) The mated subassemblies **151** and **152** are then machined at the tape engaging polar surfaces as represented by the material removed between the dot dash line **125** and the solid lines in FIG. 2, and the magnetic casing shell **59** is secured over the other parts as represented in FIG. 1, a bottom magnetic closure being applied at **154** to complete casing **60**.

An alternative method of making the head would follow the preceding method steps except that the insert blocks such as **35** and **36** would be formed with both the magnetic core receiving recesses **38** and **39** and the winding cavities such as indicated at **156** and **157** in FIG. 2 prior to assembly of the insert blocks with the main mounting blocks **40** and **41**.

The two same alternative methods may be utilized essentially in the production of the head assembly **80** of FIG. 4. The screws such as **67**, **68** in FIGS. 1–3 and **107**, **108** in FIG. 4 are preferably located at a level generally half way between the level of the front polar edge faces defining the coupling gap **12** and the back edge faces such as **30**, as has been indicated in FIGS. 1 and 2 and in FIG. 4.

The following specific dimensions for the head of FIGS. 1–3 are given for the purpose of example only, and should not be construed as limiting the scope of the invention. The core parts **17** and **18** may be formed of .002 inch thick Supermalloy with an outside diameter of .110 inch and with a transverse or width dimension (at **20** in FIG. 2) of .020 inch. The filler laminations **28**, **31** may be made of .0005 inch thick Supermalloy. (Supermalloy comprises 5% molybdenum, 79% nickel, and the remainder iron and impurities.) The winding **47** may comprise 450 turns of No. 48 (American Wire Gauge) wire while the winding **48** may comprise 150 turns of No. 46 (American Wire Gauge) wire wound on top of the winding **47**.

During recording a video signal together with superimposed high frequency bias may be supplied to the winding **48** only, while the winding **47** may have a resistor (for example 1800 ohms) connected across its terminals, or the winding **48** may be short circuited for lowest impedance and highest resonance frequency. During playback, windings **47** and **48** may be connected so as to be in series opposing relation at frequencies below the resonance frequency of the winding **47**. With this connection of windings during playback, the electromotive forces induced in the windings **47** and **48** will be in aiding relation for frequency components of the recorded signal between the resonant frequency of winding **47** and the resonant frequency of the winding **48** so as to provide an appreciably greater output in this frequency range. It is also possible to connect the windings **47** and **48** in series aiding relation with respect to frequencies below the resonance frequency of the winding **47** so that at low frequencies the induced electromotive forces in the two windings will be in phase to provide low frequency boost.

Referring to FIG. 5, for example, it will be appreciated that the present invention contemplates a method of making a magnetic core subassembly for a magnetic head which comprises securing a magnetic core part such as indicated at **18** within a conforming recess such as indicated at **141** of a block **140** of electrically conductive material, removing material from the block of electrically conductive material, for example down to a line such as indicated at **133** in FIG. 5 to expose a polar surface **20** of the magnetic core part for sliding contact with a magnetic record medium, thereby to form a magnetic core subassembly, and finishing the subassembly as by polishing the gap defining edge face **163** to optical flatness so that the subassembly is adapated to form part of a magnetic head such as indicated in FIG. 1 or FIG. 4 while leaving a major portion of the magnetic core part which is to confront the record medium path covered by electrically conductive material of the block **140** (see the electrically conductive material indicated at **164** in FIG. 1 and at 165 in FIG. 5). It will be appreciated that not only the radially outer surfaces such as **166** of the magnetic core part **18** which directly confront the record medium path are covered, but the lateral exterior surfaces **167** and **168** (FIGS. 2 and 3) of the core part **18** adjoining the surface portions **20** and **166** have at least a major portion thereof covered and are shown substantially completely covered. As previously mentioned, the upper edge faces **126–129** of the blocks **35** and **36** may be slightly below the level of the polar surfaces **19** and **20** when the blocks are of copper so as to be out of contact with the magnetic record medium. If the blocks **35** and **36**, **94** and **140** are of aluminum, for example, the surfaces such as **126–129** may be flush with the polar surfaces **19** and **20**, so that the entire area of side surfaces **167** and **168** are covered. In any event, side surfaces **167** and **168** of the magnetic core part **18** are substantially fully covered by the electrically conductive material of the block in the illustrated head.

Referring to FIG. 5, the block **140** has a curved face (corresponding to face **156**, FIG. 2, of block **36**) flush with the surface **170** of core part **18**, and it is in this surface that the recess **141** is formed. The surface **170**, of course, defines part of the toroidal cavity such as the cavity indicated at **46** in FIG. 2.

It will also be observed that the electrically conductive material of the block covers the exterior surfaces such as **172** and **173**, FIG. 1, of the core parts **17** and **18** which confront the keeper housing shell **59** so as to tend to prevent leakage flux through this housing part from one side of the electric windings **47**, **48** to the other side of the electric windings **47**, **48**. Referring to FIG. 1, at the level of the center opening of windings **47** and **48**, portions of the housing part **59** such as indicated at **175** and **176** surround the base **177** of the magnetic core **11** so as to provide potential leakage flux paths from the portion of the core base **177** to the right of windings **47**, **48** and from portion **175** to portion **176** (about the perimeter of the case **59** as indicated by the dotted arrows **178** and **179** in FIG. 3) to return to the portion of base **177** to the left of the windings **47**, **48**.

It will be appreciated that the core parts **17** and **18** need not be of identical configuration so as to define a circular magnetic core, that one of the polar surfaces **19** and **20** may be offset and out of contact with the magnetizable surface of the tape record medium **14**, and that only one of the core parts **17** and **18** could be formed by the method of the present invention while still achieving substantial advantages over the prior art. Each of the embodiments of FIGS. 1 through 5 is disclosed both for the case where filler laminations such as **28** and **31** are present, and for the case where these filler laminations are omitted.

In each embodiment, the volume occupied by the electrically conductive material of windings such as **47**, **48** is substantially greater than the volume of the magnetic core such as **11**, preferably being two to five (or more) times the volume of the magnetic material of the core. This is particularly advantageous when the head is used to record frequency components in the megacycle range, or where short gaps or especially low residual magnetization or thermal noise levels are desired.

The triangular member **32** may be omitted and the winding **48** extended to substantially completely fill the space otherwise occupied by the member **32**.

The auxiliary laminations **28** and **31** are preferably very carefully heat treated for lowest coercive force. Commercial data shows that values of D.C. coercivity (as measured from direct current saturation) for commercially available Supermalloy may have a range from 0.003 to 0.009 oersted. The laminations **28** and **31** are preferably mounted in unstressed condition but with good magnetic contact at regions such as indicated at **181** and **182** in FIG. 5, adjacent the respective opposite ends of the cores **17** and **18**. Thus each lamination **28** preferably firmly contacts core **18** at regions **181** and **182**, and the ends of each of the laminations **31** preferably firm contact the core **17** at corresponding regions adjacent the respective opposite ends of core **17**, so that the laminations **28** and **31** serve to efficiently divert residual magnetic flux due to residual magnetization of the core parts **17** and **18** from the path of the record medium. The good magnetic contact of laminations **28** at **181** and **182**, for example, is desirable to provide a head exhibiting low residual magnetization and improved magnetic efficiency.

The coercive force of the main core parts **17** and **18** is preferably as low as possible but may be considerably higher than laminations **28** and **31** even when the same material (such as Supermalloy) is used because stressed are produced in polishing the gap surfaces such as **163**, FIG. 5, and because the tape contacting surfaces **19** and **20** are abraded by tape **14** during use of the head. Also the main core parts **17** and **18** must be held firmly enough so that gap **12** will remain essentially unchanged during the life of the head.

Where the magnetizable surface of the tape **14** is to come into direct contact with copper, silver, or other relatively soft metal which has a tendency to adhere to the material of the pole pieces **19** and **20**, it is useful to charge the tape with graphite or a graphite substance such as molybdenum disulfide. For this puropse, the magnetizable surface of the tape may be run over a block of graphite material, or the graphitic substance may be incorporated as part of the tape coating formulation. The thickness of the graphic layer overlying the magnetizable surface of the tape record medium should approach molecular dimensions, and is preferably not over a few microniches thick.

In operating a head having a construction of the general type disclosed herein for recording, a bias current of the order of 7 milliamperes r.m.s. (root mean square value) at a bias frequency of 3 to 10 megacycles per second was supplied to winding **48**, superimposed on a signal current to winding **48** of about 0.7 milliamperes r.m.s. at video frequencies.

For the sake of a clearer indication, the location of the beveled end faces **28***a* and **31***a* of laminations **28** and **31** have been indicated by dash lines in FIG. 1. With normal drawing conventions, line **28***a* would not appear in FIG. 1 since laminations **28** have been broken away at this section. Line **31***a* would normally appear as a solid line in FIG. 1 but so showing line **31***a* might lead to confusion between lines **31***a* and **33** in FIG. 1. The reference numeral **185** in FIG. 5 designates a mounting block generally corresponding to block **41** of FIGS. 1 and 2.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A magnetic transducer head assembly comprising
a pair of confronting magnetic core parts defining a coupling gap therebetween,

a pair of insert blocks of electrically conductive material having confronting surfaces lying substantially in the plane of said coupling gap and having recesses in said confronting surfaces receiving the respective magnetic core parts, and
a pair of metal mounting blocks having mating surfaces lying substantially in the plane of said coupling gap and having notches in said mating surfaces receiving said insert blocks.

2. A magnetic transducer head assembly comprising a pair of confronting magnetic core parts defining a coupling gap therebetween for coupling to a magnetic record medium and together forming a magnetic core of ring confrontation with a base portion remote from the coupling gap,
a pair of blocks of electrically conductive material having mating surfaces lying substantially in the plane of the coupling gap, and
a housing of magnetic material having an interior configuration substantially corresponding to the external configuration of the blocks when disposed in confronting relation at their mating surfaces and closely receiving the pair of blocks therein,
said mating surfaces having cavities therein defining a toroidal winding space and having respective recesses adjoining said cavities in which the respective magnetic core parts are secured, the electrically conductive material of the blocks overlying substantially the entire external surface area of the core, and
said blocks having electrically conductive winding means substantially filling said toroidal winding space and encircling the base portion of the magnetic core, the volume occupied by the electrically conductive material of the winding means being at least two times the volume of the magnetic material of the core, said electric winding means being operable to transduce signal components in the megacycle range.

3. The transducer head of claim **2** with said winding means comprising a first winding having a relatively large number of turns wound on the base portion of the magnetic core and a second winding having a lesser number of turns and wound over the first winding radially outwardly of the first winding and in encircling relation to the first winding, said magnetic core having a central window forming part of the toroidal winding space, and the first and second windings together substantially filling said central window.

4. A magnetic transducer head assembly according to claim **2** with said housing having an aperture receiving a portion of the magnetic core including a coupling gap, said core providing polar surfaces for sliding contact with a magnetic record medium, and the blocks having upper faces surrounding said polar surfaces of the magnetic core but being slightly below the level of said polar surfaces so as to be out of contact with the magnetic record medium.

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