United States Patent

[11] 3,591,729

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Continuation-in-part of application Ser. No. 835,017, Aug. 20, 1959, now Patent No. 3,382,325, dated May 7, 1968, and a continuation-in-part of 126,121, July 24, 1961, now Patent No. 3,334,192, dated Aug. 1, 1967.

[54] **MAGNETIC TRANSDUCER HEAD WITH AUXILIARY MEANS FOR DIVERTING RESIDUAL FLUX**
35 Claims, 29 Drawing Figs.

[52] U.S. Cl. .... **179/100.2** C, 340/174.1 F, 346/74 MC
[51] Int. Cl. **G11b 5/10,** G11b 5/12
[50] Field of Search .... 179/100.2 C; 340/174.1 F; 346/74 MC

[56] **References Cited**

UNITED STATES PATENTS

2,895,015	7/1959	Zenel et al.	179/100.2
2,230,913	2/1941	Schuller	179/100.2
2,431,541	11/1947	Camras	179/100.2
2,538,405	1/1951	Zenner	179/100.2
2,615,097	10/1952	Camras	179/100.2
2,911,481	11/1959	Augustin	179/100.2
3,360,614	12/1967	Comerci et al.	179/100.2

FOREIGN PATENTS

881,343	1/1943	France	179/100.2
930,545	7/1963	Great Britain	179/100.2

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Assistant Examiner—J. Russell Goudeau
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ABSTRACT: A magnetic head is shown having auxiliary core material in a substantially unstressed condition with very low direct current coercivity and located within the working magnetic core for diverting magnetic flux due to residual magnetization of the main core of the head away from the record medium path. Crossfield magnetic heads, offset pole magnetic heads, and composite core magnetic heads with windings for different frequency ranges are also disclosed.

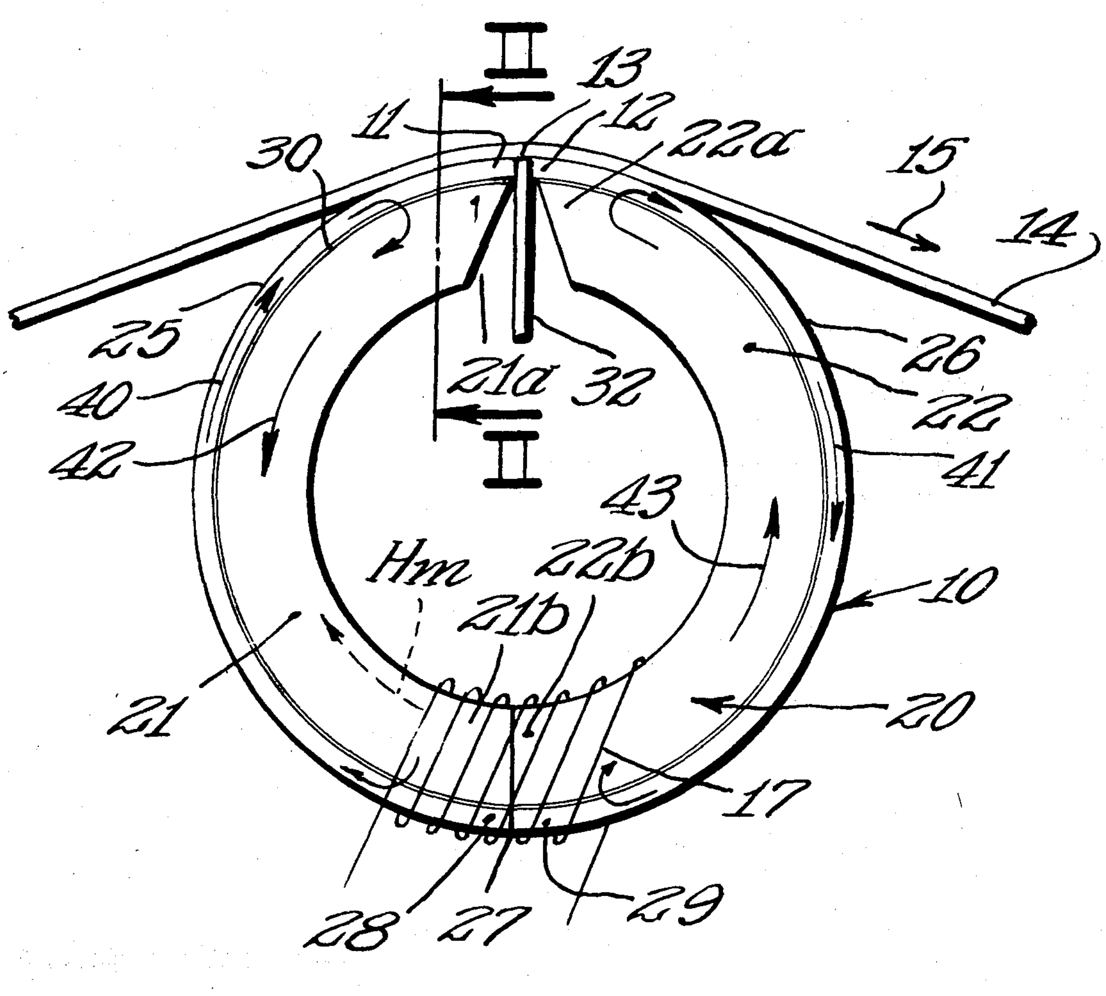

Fig.1

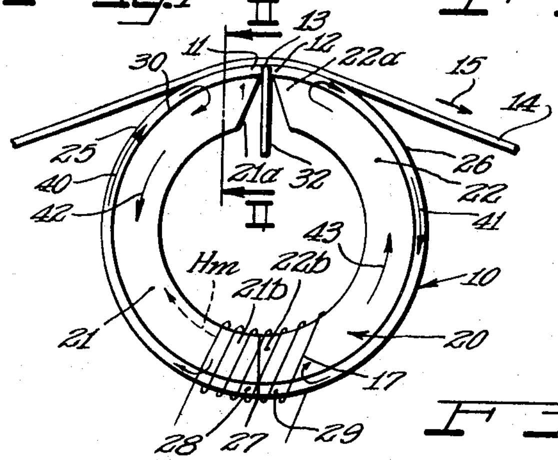

Fig.2B

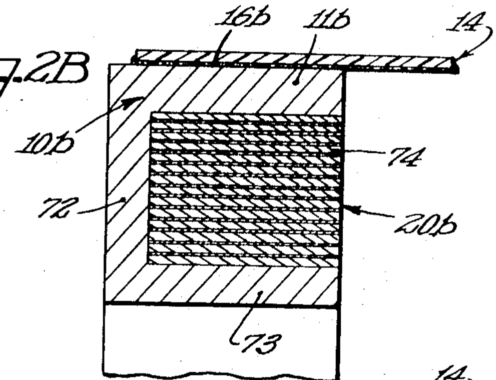

Fig.2C

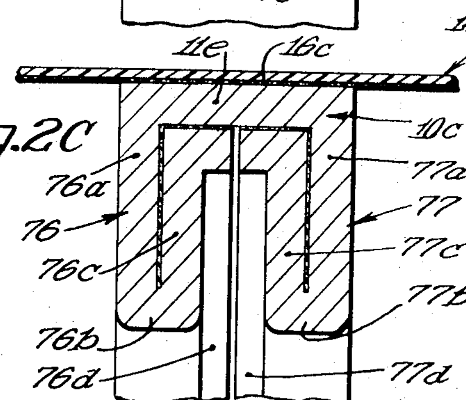

Fig.2

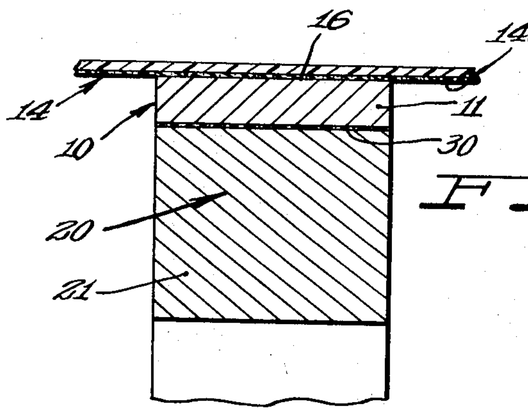

Fig.2D

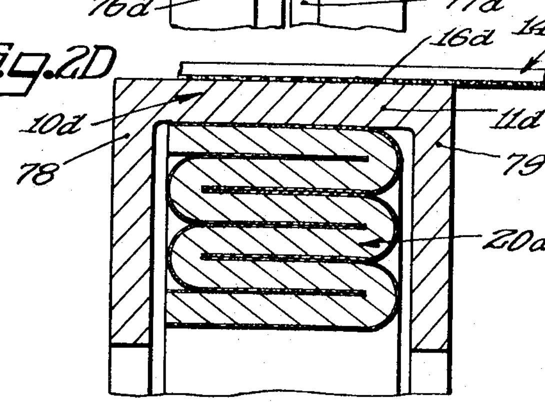

Fig.2A

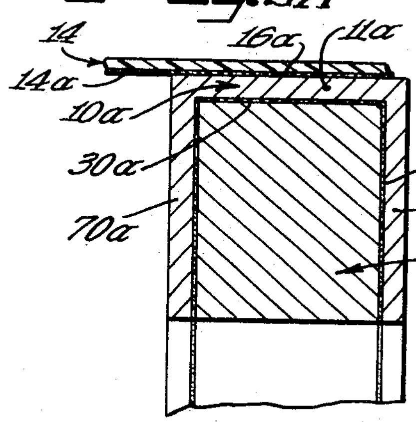

Fig.2E

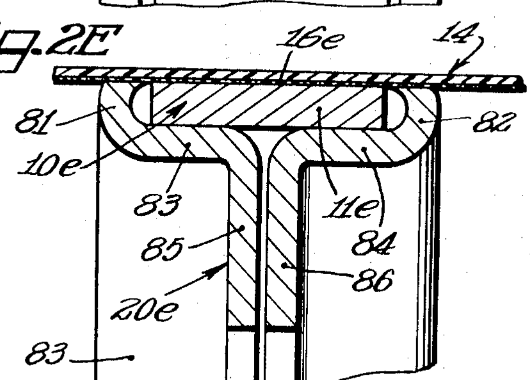

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Fig.2F

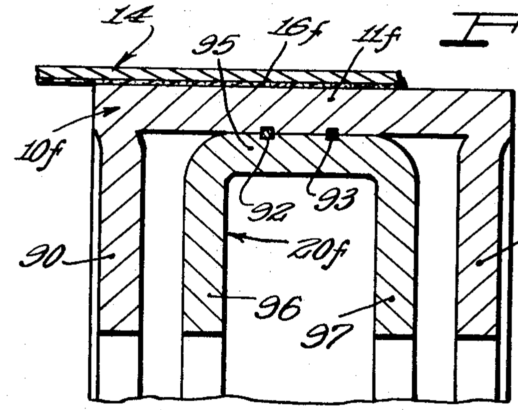
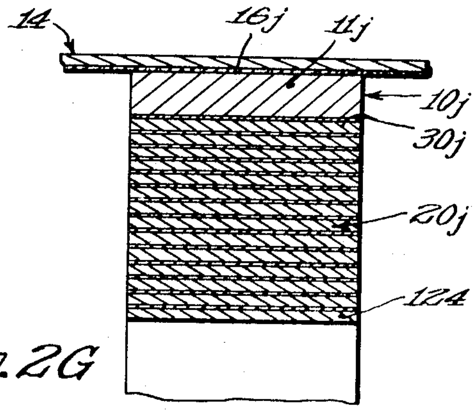


Fig.2J



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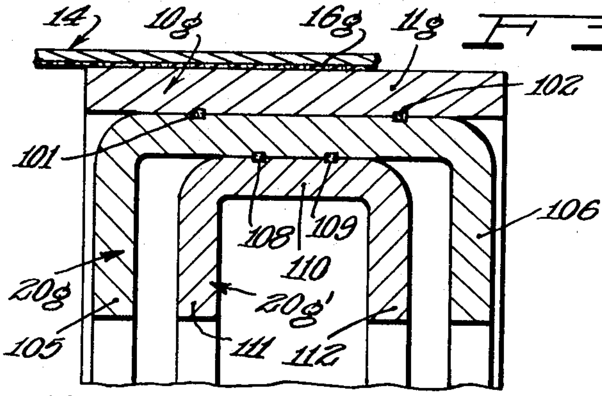
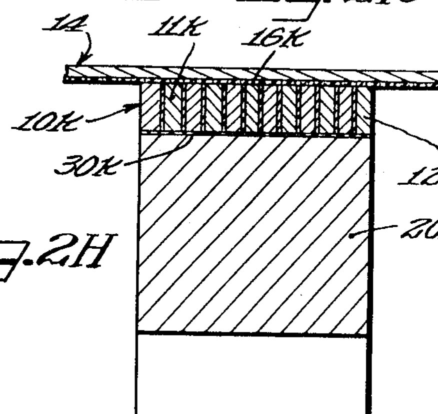


Fig.2K



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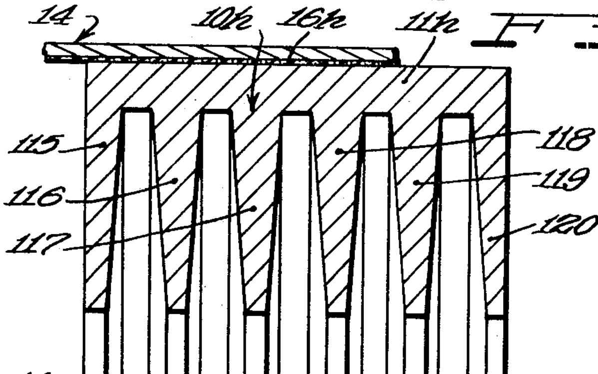

Fig.2I

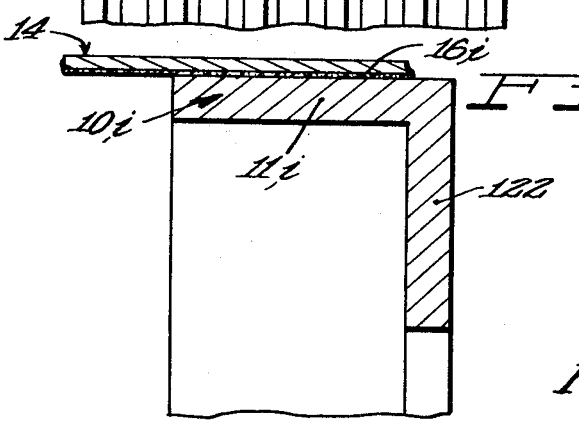

Fig.2L

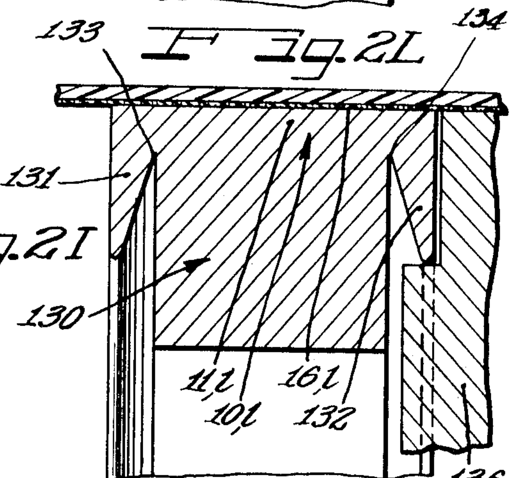

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Fig. 2M

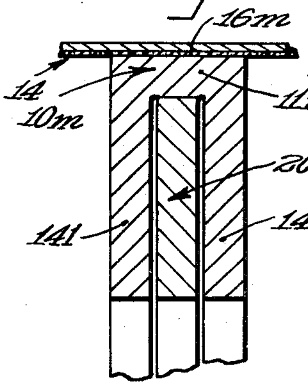
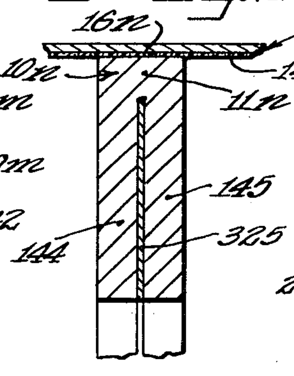


Fig. 2N



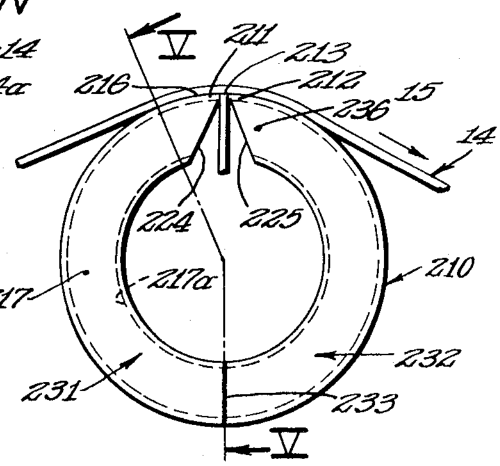


Fig. 4

Fig. 3

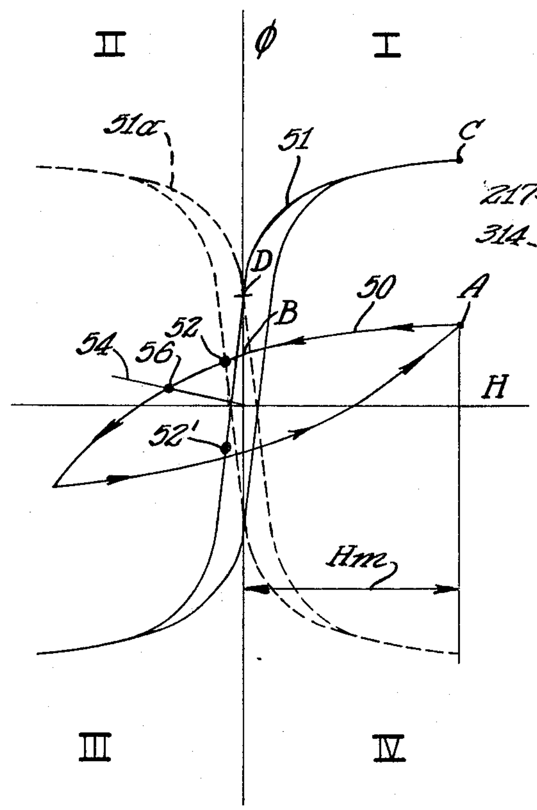
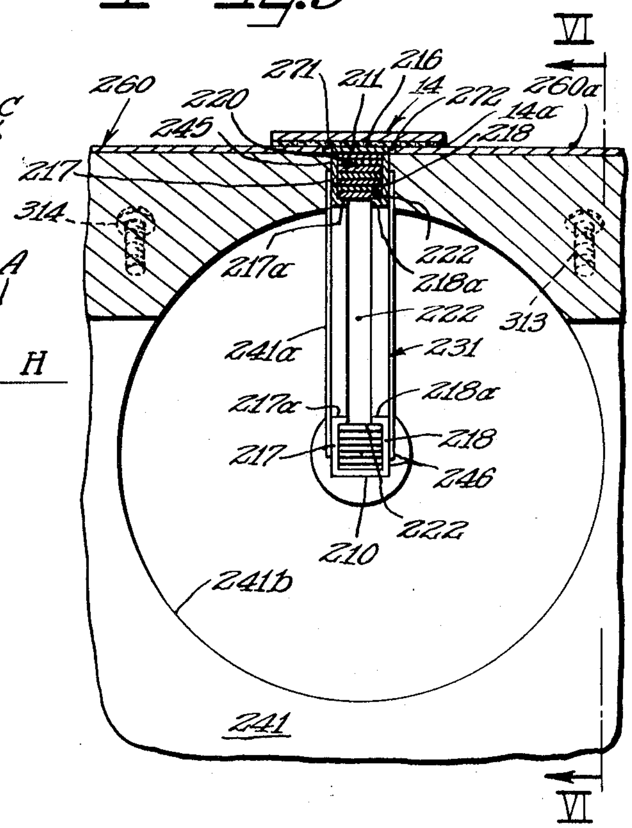


Fig. 5



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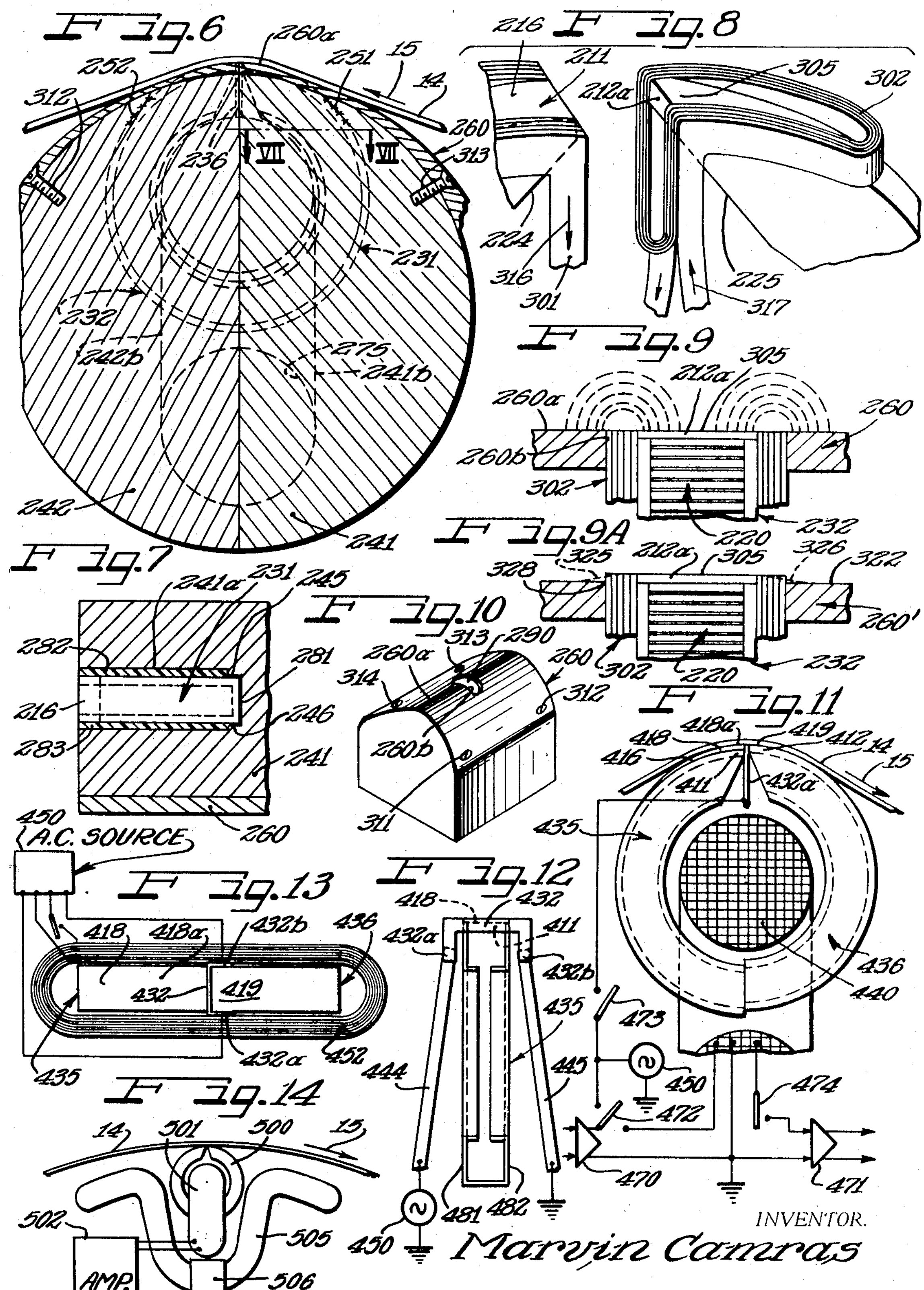

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MAGNETIC TRANSDUCER HEAD WITH AUXILIARY MEANS FOR DIVERTING RESIDUAL FLUX

CROSS-REFERENCES TO RELATED APPLICATIONS

The present application is a continuation in part of my copending applications Ser. No. 835,017 filed Aug. 20, 1959 (now U.S. Pat. No. 3,382,325 issued May 7, 1968); and Ser. No. 126,121 filed July 24, 1961 (now U.S. Pat. No. 3,334,192 issued Aug. 1, 1967); and the disclosures of each of these prior applications is hereby incorporated herein by reference.

The disclosure of my copending application Ser. No. 415,811 filed Mar. 12, 1954, and now abandoned, has been continued in Ser. No. 835,017, so that the broadest aspects of the present disclosure are supported by the embodiments of Ser. No. 415,811.

This invention relates to magnetic transducer heads and particularly to such heads having integral means for reducing the residual magnetization thereof.

Residual magnetization in tape recorder heads may be intense enough to erase a valuable record while it is being played back. In less extreme cases the residual magnetization of the playback head causes the recorded high frequencies on the record medium to deteriorate and results in a reproduced signal with increased noise level. Further, the sensitivity of the playback head to the recorded signal is reduced when the playback head has a substantial level of residual magnetization. Comparable adverse effects result during recording with a magnetized head. The adverse effects of residual magnetization are especially serious in microgap heads (a head having a gap length of 50 microinches or less) and in video recording.

Heads become magnetized by transient currents during switching of the circuits coupled with the heads; by the magnetic fields of nearby motors, loudspeakers, chokes or transformers; by peaks in the recording signal itself; by charging current in transistor input circuits; and even by strongly magnetized tapes or the earth's magnetic field.

Heads can be demagnetized manually with an external field or by means of a decaying current through their windings, but this is troublesome and unreliable. Automatic demagnetization such as described in my copending application Ser. No. 456,192 filed May 17, 1965 (now U.S. Pat. No. 3,449,528 issued June 10, 1969) is desirable but cannot guard against magnetization that occurs between demagnetizing intervals; also some extra parts are required which increase the cost of the recorder.

Various head constructions are described herein which are immune to residual magnetization in normal usage, giving benefits of lower noise, better sensitivity and improved high frequency response. One embodiment of the improved head constructions provides a shunt path for residual magnetism, the return path being made of a very low coercive force material such as Supermalloy in an essentially stress free condition.

Composite head configurations are illustrated which allow the use of mechanically harder materials of higher saturation density for the portion of the core that contacts the tape, which material otherwise would give unreasonably high residual magnetization. The alternative monolithic constructions are economical and give excellent response at very high frequencies.

It is therefore an important object of the present invention to provide a magnetic transducer head which is relatively immune to residual magnetization in normal usage.

It is a further object of the present invention to provide a transducer head construction which allows the use of mechanically harder materials and/or relatively high saturation density for the portion of the magnetic core that contacts the tape.

Another object of the invention is to provide an extremely economical head construction providing excellent response at very high frequencies.

A further object is to provide a head construction having a relatively large ratio of cross sectional perimeter to cross sectional area so as to minimize losses due to high frequency skin effect, thus providing a head for operation at video frequencies (1 megacycle per second or higher).

A still further object is to provide a magnetic head of relatively low inductance per winding turn squared.

Still another object of the invention is to provide a magnetic head wherein the inductance per winding turn squared decreases at high frequencies in the upper region of its operative bandwidth.

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

FIG. **1** is a somewhat diagrammatic elevational view of a core configuration in accordance with the present invention;

FIG. **2** is a partial cross-sectional view taken substantially along the line II–II of FIG. **1**;

FIGS. **2A** through **2N** are partial cross-sectional views of ring type core constructions similar to that shown in FIG. **1** with the section line for the respective views located as indicated at II–II of FIG. **1**;

FIG. **3** is a diagram showing the magnetization curve for the main core material of the head and the magnetization curve for the auxiliary or additional material of the head which is useful in explaining the concepts of the present invention;

FIG. **4** is an elevational view showing a further core construction in accordance with the present invention;

FIG. **5** is a somewhat diagrammatic partial vertical sectional view showing a section of the core of FIG. **4** taken along the line V–V and further illustrating other parts of the head assembly incorporating said core;

FIG. **6** is a somewhat diagrammatic partial vertical sectional view taken along the line VI–VI of FIG. **5**;

FIG. **7** is a partial horizontal sectional view taken along the line VII–VII in FIG. **6**;

FIG. **8** is a partial somewhat diagrammatic perspective view showing a further head configuration in accordance with the present invention;

FIG. **9** is a somewhat diagrammatic transverse sectional view and illustrating a keeper housing in association with the head configuration of FIG. **8**;

FIG. **9A** is a view similar to FIG. **9** but illustrating a different keeper housing configuration in association with the head configuration of FIG. **8**;

FIG. **10** is a diagrammatic perspective view of the overall head assembly whose interior construction is represented in FIGS. **8** and **9**;

FIG. **11** is a somewhat diagrammatic elevational view of a further head configuration in accordance with the present invention and showing the signal winding broken away and in section;

FIG. **12** is a diagrammatic side elevational view indicating further details of the head configuration of FIG. **11**;

FIG. **13** is a somewhat diagrammatic partial top plan view of the head configuration of FIGS. **11** and **12**; and

FIG. **14** is a diagrammatic elevational view illustrating a further head configuration in accordance with the present invention.

It has been found that the coercive force and residual magnetization of cores after fabrication in a head are considerably higher than expected from the published values for the material itself. Investigation has shown that this is caused by stresses in the material which cannot be completely avoided in a fabricated head, since the gaps must be polished and a contact surface provided which is abraded by the tape. Also the core must be held firmly enough so that its various parts including the gap remain unchanged during its life.

FIG. **1** illustrates a core construction in accordance with the present invention including a main or working core **10** having a pair of magnetic poles **11** and **12** defining a gap **13**. The core has a record medium path thereacross and a record medium is indicated at **14** travelling in the direction of arrow **15** successively across the poles **11** and **12** with the active magnetizable layer of the record medium **14** in sliding contact with surfaces such as **16** of the poles **11** and **12** adjacent the gap **13**. A signal winding is indicated at **17** which receives a signal current during a recording operation and which is threaded by a magnetic signal flux produced by the record medium during a playback operation. The working core **10** is of such a cross section as to provide adequate flux carrying capacity for the maximum signal recorded on the tape **14**, and the flux carrying capacity of the working core **10** is generally sufficient of itself to produce a maximum recorded signal on the tape when the signal winding **17** is energized. Accordingly, the term "working core" as utilized herein refers to that range of core configurations and cross sections which has heretofore been selected in constructing magnetic recording and/or playback heads from the standpoint of providing adequate signal flux carrying capacity and from the standpoint of other prior art criteria. It is a concept of the present invention to add further material to such a working core for the purpose of substantially reducing residual magnetization at the gap preferably by at least 50 percent which additional material would not be dictated by any of the criteria known to the prior art. The added material may also increase the flux carrying capability especially at high frequencies or may be used to reduce the head inductance and thus increase the self-resonant frequency. Such additional or auxiliary material is indicated at **20** in FIGS. **1** and **2**. In illustrated embodiment, the additional material **20** is provided by two generally C shaped parts **21** and **22** which are contiguous to the poles **11** and **12**, respectively, substantially up to the region of the **13**. The part **21** provides a substantially continuous low reluctance magnetic path in shunt with pole piece **11**, and the part **22** acts similarly with pole piece **12**. In the illustrated embodiment, the main core **10** is comprised of main core parts **25** and **26** of generally C shape having the poles **11** and **12** integral therewith defining the coupling gap **13** and having a back gap **27** between ends **28** and **29** of the core parts **25** and **26**. The reluctance of the path from **28** to **11** in core part **25** and from **21*a*** to **21*b*** in core part **21** and back to **28** is not substantially greater than the reluctance of the path from **28** to **11** to **12** to **29** to **28** including core parts **25** and **26** and gaps **13** and **27**. Preferably the reluctance of the local magnetic paths such as **28–11–21*a*–*21 b–28*** and **29–12–22*a*–*22b–29*** including the auxiliary material is less than the reluctance of the magnetic path **28–11–1 2–29–28** which includes the gaps **13** and **27** and the main core **10**.

The coercive force of the main core **10** is preferably as low as possible but may be considerably higher than the coercive force of the auxiliary core **20** because of mechanical considerations, stresses, use of a material for core **10** with superior saturation or wearing qualities and the like.

The main core **10** is necessarily subjected to stress since the gap surfaces of the poles must be polished and since the tape contacting surfaces such as indicated at **16** in FIG. **2** are abraded by the tape **14**. Also the main core **10** must be held firmly enough so that the main core parts and the gap defined thereby will remain unchanged during the life of the head.

The auxiliary core parts **21** and **22**, however, are substantially or essentially unstressed and extend in parallel with the stressed main core parts **25** and **26**. The auxiliary core parts **21** and **22** have an exceptionally low coercive force and are in shunt with the main or "working" core parts **25** and **26** which have a higher coercive force because of the considerations that have been indicated. The gap **13** has a dimension in the direction of tape movement equal to 0.00005 inch (50 microinch) or smaller, in the example shown. With such a small gap size there is difficulty even with very small cores. With unduly small cores the construction becomes expensive and the efficiency (Q) of the head becomes smaller.

It will be noted that as illustrated in FIG. **1**, preferably the signal winding **17** links the main core **10** and auxiliary core **20** in the same direction, so that the presence of the auxiliary core does not detract from the amplitude of signal flux

produced at the gap during recording and does not detract from the amplitude of signal flux threading the signal winding during playback and in fact enhances the efficiency of the core.

In one advantageous form of the invention the main core **10** is of a mechanically harder material and/or having a higher saturation density than could otherwise be used, since such material would given an unreasonably high residual magnetization in the absence of the auxiliary core **20**. The shunt return path provided by the auxiliary core **20** is preferably of a very low coercive force material such as "Supermalloy" is an essentially stress free condition. Supermalloy has a composition 5 molybdenum, 79 percent nickel and the remainder iron and impurities and has a coercive force (measured from saturation) in its final configuration as part of the head substantially of 0.002 oersteds, this being the value published in *Ferromagnetism* by Bozorth, copyright 1951, p. 871. The auxiliary core part **20** is preferably very carefully heat treated for lowest coercive force and is preferably mounted in unstressed but close fitting relation to the main core **10** as illustrated in FIGS. **1** and **2**. Where necessary sufficient clearance may be provided between the main and auxiliary cores to allow for expansion, and preferably the clearance space is filled with a nonhardening material as indicated at **30** in FIG. **2**, such as silicon grease or jelly, foamed plastic, etc. for holding the auxiliary core in place. The Supermalloy or other material of the auxiliary core **20** is preferably put in place during final assembly at the time that the signal coil **17** is assembled with the head. Alternatively it may be spot welded at **21*a*** and **22*a*** to the main core, and carefully annealed.

The gap **13** is preferably defined by an electrically conductive gap spacer such as indicated at **32** which spacer preferably extends through the space between ends **21*a*** and **21*b*** of the auxiliary parts **21** and **22** and terminates below such space as shown in FIG. **1**.

For general purposes the main core **10** may be of Permalloy having a composition of 4 percent molybdenum, 79 percent nickel and the remainder iron and impurities.

Where extra long life is desired, or where the head is subjected to abrasion or high tape-to-head pressures, the main core **10** may be made of a mechanically hard high permeability material as Sendust (having a composition of 5 percent aluminum, 10 percent silicon, and the remainder iron and impurities). Other mechanically hard materials for good wear resistance and sharply defined gap edges are Alfenol (an aluminum-iron alloy) and Duraperm which are available from the Hamilton Watch Co., Lancaster, Pa., U.S.A.; Silicon Steel, especially with higher silicon content such as 4 percent; and magnetic ferrites, especially single crystal and fine grain varieties which may has a glass bonded gap.

Where extra high recording fields must be generated at the gap so as to utilize tapes of exceptionally high coercivity or remanence or coating thickness, etc., without saturating the pole tips of the head (thus sacrificing resolution), the main core **10** may be made of Supermendur which has a saturation value of about 22,000 gauss (compared to about 8,700 gauss for Permalloy), or of other materials of the 50 percent cobalt, 50 percent iron type. Other high saturation materials are silicon steel (about 20,000 gauss), and 50 percent nickel-iron alloys (about 16,000 gauss). The latter is available as 4,750 alloy from Allegheny Ludlum U.S.A., Hiperik from Westinghouse U.S.A., etc.

It will be noted that many of the suggested materials are advantageous both for wear and magnetic saturation. All have a higher coercivity than unstressed Supermalloy or Permalloy.

Alfenol may comprise an iron-aluminum alloy with either 12 percent or 16 percent aluminum. Duraperm has properties generally comparable to that of Sendust. Supermendur may have a composition of 49 percent cobalt, 2 percent vanadium and the remainder iron and impurities. The 4,750 alloy may have a composition of 48 percent nickel and the remainder iron and minor constituents. Hipernik may have a composition of 50 percent nickel and the remainder iron and impurities.

By way of example, manufacturer's data gives a coercive force of 0.1 oersted for Alfenol with 12 percent aluminum, and a coercive force of 0.015 oersted for Alfenol with 16 percent aluminum. Supermendur is indicated to have a DC coercive force of 0.18 oersted when measured after an applied direct current field of 3 oersted. Vanadium Permendur having a composition of 1.8 percent vanadium, 49 percent cobalt and the remainder iron and impurities may also be used for the core **10** and is stated by Bozorth, supra, to have a maximum induction B_m of 24,000 gauss, and a coercive force from saturation (coercivity) of 2.0 oersteds.

Even where the main core is of Supermalloy, the Suermalloy cannot be in as good a magnetic condition, that is with as low a coercive force, as the auxiliary core **20** since after annealing, the top surface of the main core adjacent the gap **13** is abraded by the tape, the gap faces are mechanically polished, and the pole pieces must be firmly held in a head mount which introduces stresses from the clamping or cementing, or differential expansion.

Further, the main core **10** is preferably of an electrically lower loss material and such materials have a higher coercive force than Supermalloy.

With the head configuration shown in FIG. **1**, if the head has a residual magnetization during playback (or during recording), the direction of the residual magnetization in the main core **10** may be as represented by the arrows **40** and **41**. Since the main core has a higher coercive force, the magnetization of the main core will produce a residual flux in the auxiliary core having the direction indicated by the arrows **42** and **43**.

Referring to FIG. **3**, the magnetization curve for the main core **10** may be indicated at **50**, while the magnetization curve for the auxiliary material would have a shape as indicated at **51**. A curve **51*a*** is also shown in FIG. **3** which is obtained by plotting the values of Φ for curve **51**, but with negative values of H. With this arrangement, the intersection of the curves **50** and **51*a*** at point **52** in the second quadrant represents the magnetic condition of the head cores in the assembly in the absence of any applied external magnetization forces.

If the auxiliary core **20** were omitted, the residual magnetization of the main core would correspond to point **56** where the magnetization curve **50** intersects line **54**, the latter representing the Φ/H of the magnetic path **28–11–12–29–28**. Thus, in the absence of the auxiliary core, the main core would assume an operating condition as represented by the point **56** with the total residual flux being carried by the head gap (except for leakage); while with the auxiliary core present the main core assumes an operating condition as represented by the point **52** where the residual flux of the main core is carried by the auxiliary core, reducing the residual flux of the head gap to a negligible portion. This portion should be below the threshold where the tape is affected, preferably giving rise to gap fields below **200** oersteds.

By way of explanation of the curves **50** and **51** (FIG. **3**), during energization of the signal winding **17** with a current amplitude corresponding to a maximum field of H_m, the materials of cores **10** and **20** are cycled around the loops **50** and **51** as indicated. When the energizing field is removed, the condition of the main core material reverts from point A to point B, while the material of auxiliary core **20** follows the path from point C to point D. Points B and D are stable only for closed rings of each material being considered. The presence of the gap at **13** in the head circuit of the main core and the corresponding gap in the auxiliary core exerts a demagnetizing influence on the material of the main core which may be depicted by a shift of the condition of the main magnetic core from point B on curve **50** to a point on curve **50** in the second quadrant. Similarly the influence of the magnetization of the main core on the material of the auxiliary core causes its magnetization to reverse and to shift from a condition as represented by point D to a condition as represented by a point on its curve in the third quadrant. Considering that the residual flux due to the main core is generally equal but opposite to the residual flux threading the auxiliary core; and that the effective magnetizing force in the two materials is equal, the magnetic condition of the main core is at point **52**, and of the auxiliary core is at point **52′**.

For graphical analysis it is convenient to reverse the Φ–H curve of the auxiliary material as indicated by **51*a*** in FIG. **3**; in which case the magnetic condition of the materials is at the intersection of curve **51*a*** with curve **50** at **52** in the second quadrant.

The curves of FIG. **3** are illustrative of one condition of operation. For example, under actual conditions the auxiliary material may have a steeper and narrower loop, the H may be reduced by local magnetic paths, etc.

The magnetic length of the auxiliary core is preferably shorter than that of the main core as by locating the auxiliary core on an inner radius and making it thick, this condition reducing the magnetizing force H below that of the example where equal lengths were assumed.

FIG. 2A illustrates a modified ring-type core configuration wherein the working core **10*a*** is provided with an auxiliary core **20*a*** corresponding to the auxiliary core **20** in FIG. **1**, but the working core **10*a*** is further provided with additional core material as indicated at **70*a*** and **71*a*** which material is integral with the working core material **10*a***. A working core configuration including parts comparable to those at **10*a***, **70*a*** and **71*a*** has been proposed in my copending application Ser. No. 126,121 filed July 24, 1961, and the disclosure of this copending application is incorporated herein by reference in its entirety. In the copending application, a working core was formed from a flat sheet by a die into a U-cross section and annealed after mechanical operations were completed. Such a core configuration was thus a substitute for a laminated core wherein the core parts are relatively expensive and difficult to assemble. The thickness of the sheet material used in the prior application depended on the head dimensions and on the allowable eddy current losses. For a quarter track head, 0.043 inch wide "Permalloy" stock 0.006 inch thick very satisfactory. Heads of this construction have been used with bias frequencies of 100 kilocycles per second and have given satisfactory response to signals of 50 kilocycles per second and higher. Thicker material is suitable for lower frequencies or larger heads. As indicated in the copending application, the width of the side flanges such as indicated at **70*a*** and **71*a*** in FIG. 2A may taper at the region of the gap so as to tend to concentrate flux in the path of the record medium. The configuration of the side flanges of the core parts adjacent the gap provides a very sensitive and convenient adjustment of the magnitude of the cross field component where a crossfield gap is also employed in the head configuration. The channel construction described in the copending application gives a self-supporting pole piece having increased cross section by virtue of the lateral flanges, and low eddy current loss. The gap defining portions may be the same as the sheet thickness requiring no machining. The core material is in a relatively unstressed condition compared to conventional heads which are built up of laminations which are glued and clamped after annealing thus setting up stresses due to bending and to differential expansion of the glue and the laminations.

While the drawings of the prior application specifically showed a channel or U-cross section, other cross sections will produce the advantages of larger flux carrying capacity wit h low eddy current loss. For example, the core parts may have an L-cross section. A generally spiral cross section may also be formed in an initially flat sheet by bending the sheet at right angles at successively increasing intervals. In this case the sheet would be flat between successive right angle bends. The adjacent parallel portions of the sheet are suitably insulated to avoid forming a closed loop electric circuit for eddy currents.

The core parts may also have a generally O-cross section with flat sides similar to one convolution of the spiral type cross section. The free edges of the magnetic sheet formed into an O-cross section would have a nonconductive gap therebetween to avoid a closed loop electric circuit for eddy currents having a length less than the total perimeter of the cross section.

An O-cross secton may also be formed by nesting the lateral flanges of a pair of oppositely directed strips of channel cross section. The adjacent overlapping lateral flanges of the respective strips would be insulated from each other to avoid forming a closed loop circuit for eddy currents about the perimeter of the overall O-cross section.

As a further example, a series of channel cross section strips of different size and all oriented in the same way may be nested one within the other to form a large C-cross section. A channel or C-cross section type core leg may have a solid cross section nonmagnetic filler nested therein to rigidify the leg. The filler may be nonconductive or insulated from the core leg to avoid formation of an electrically conductive loop path about the perimeter of the overall square or rectangular cross section defined by the leg and filler.

The spiral and O-cross sections just described are advantageous over conventional laminated core parts because of their ease of assembly and relatively unstressed magnetic condition as finally assembled. The spiral and O-cross section core parts are advantageous over solid cross section parts of comparable flux carrying capacity because of their reduced eddy current loss. The spiral and O-cross sections provide more flux carrying capacity than a simple channel cross section, but are somewhat more difficult to fabricate and assemble. The nonmagnetic filler provides increased rigidity over the simple channel cross section core part.

FIG. 2B illustrates a working core part **10***b* with additional core material as indicated at **72** and **73** integral with the working core material **10***b*. The core configuration further includes auxiliary core material **20***b* formed by a series of laminations such as indicated at **74** which are electrically insulated from each other and from the core parts **10***b*, **72** and **73**.

In FIG. 2C the working core material **10***c* is provided with additional material integral therewith as indicated at **76** and **77** which is integral with the working core material **10***c*. Each of the legs **76** and **77** has a downwardly extending portion **76***a* or **77***a*, a reverse bend portion **76***b* or **77***b* and an inturned free edge portion **76***c* or **77***c*. The portions **76***c* and **77***c* terminate in confronting free edges **76***d* and **77***d*.

In FIG. 2D the working core material **10***d* has auxiliary material as indicated at **78** and **79** integral therewith, and has further auxiliary material as indicated at **20***d* in the form of a folded sheet of low coercive force material having any of the characteristics referred to in connection with the material **20** of FIGS. **1** and **2**.

In FIG. 2E, the working core material **10***e* has essentially the same configuration as the working core material **10** and is not provided with integral additional material. Additional core material is provided as indicated at **20***e* in the form of a strip of magnetic material folded about the working core **10***e*. The portion of the material **20***e* which covers the outer surface of the working core **10***e* is ground away or omitted in the region of the gap so that the tape record medium **14** travels in sliding contact with the polar surface **16***e* of the pole **11***e* in the same way as illustrated in FIG. **1** for the pole **11**. The working core material **20***e* includes side portions **81** and **82** integral with the portion of the material **20***e* covering surface of the working core **10***e* (except adjacent the tape path), and the side portions **81** and **82** connect with inturned portions **83** and **84** and then with radially extending free edge portions **85** and **86**. In the embodiment of FIG. 2E, the auxiliary material **20***e* is shown as being ground away in the region of the poles of the working core **10***e*.

In FIG. 2F, the working core **10***f* is shown as being provided with integral auxiliary material at **90** and **91** and with further auxiliary material at **20***f* welded to the working core **10***f* as indicated at **92** and **93**. The auxiliary core material **20***f* includes a central portion **95** and free leg portions **96** and **97**.

In FIG. 2G, the working core part **10***g* has the same configuration as illustrated for the working core part **10** in FIGS. **1** and **2**, while auxiliary material **20***g* is welded thereto as indicated at **101** and **102**. The auxiliary material **20***g* includes a central portion **104** and turned leg portions **105** and **106**. Secured within the auxiliary material **20***g* is further auxiliary material **20***g'* welded to the central portion **104** as indicated at **108** and **109** and itself including central portion **110** and turned leg portions **111** and **112**.

In FIG. 2H, the working core part **10***h* has integral auxiliary material as indicated at **115—120**. The configuration of FIG. 2H may be extruded with the cross section illustrated and then formed into a ring shape as indicated in FIG. **1**, or the portions **115—120** may be formed by milling or coining. Further auxiliary material may be provided by forming a complementary core configuration to that shown in FIG. 2H with its extensions corresponding to **115—120** extending between and intermeshed with the extensions **115—120** of the working core.

In FIG. 2I, the working core material **10***i* is provided with an integral flange part **122** providing auxiliary material having the characteristics discussed in connection with FIGS. **1**, **2** and **2**A.

In FIG. 2J, the working core material **10***j* is again as illustrated for the working core material **10** in FIGS. **1** and **2**, and in this case is provided with auxiliary material **20***j* comprised of a series of laminations such as indicated at **124**. The laminations of FIGS. 2B and 2J may have confronting C configurations comparable to the configuration of the auxiliary core parts **21** and **22** of FIG. **1**.

In FIG. 2K, the working core part **10***k* is comprised of a series of laminations such as indicated at **126**, each lamination having a C configuration generally conforming to the configuration of the working parts **25**, **26** of FIGS. **1** and **2**. The auxiliary core material **20***k* may be essentially identical in configuration to the auxiliary core material **20** of FIGS. **1** and **2**.

In FIG. 2L, the working core material **101** has additional material **130** integral therewith forming a configuration comparable to that which would be formed if the core parts **21** and **25** and the core parts **22** and **26** in FIG. **1** were respectively integral. The working core material **101** has integral extension parts **131** and **132** joined with the auxiliary material **130** by reduced portions **133** and **134** and the lateral extensions serve to provide for mounting of the core configuration to housing parts such as indicated at **136**. The thinned connecting parts **133** and **134** enable the auxiliary material to absorb stresses.

In FIG. 2M, the working core material **10***m* is provided with integral extensions **141** and **142** and with additional material as indicated at **20***m* which may be in the form of two ring-shaped parts having configurations such as indicated for parts **21** and **22** in FIG. **1**.

In FIG. 2N, the working core material **10***n* is provided with integral extensions as indicated at **144** and **145**, the configuration of the extensions conforming with the configuration of core parts **21** and **22** in FIG. **1**, that is tapering in the region of the gap in the working core **10***n* so that the working core **10***n* provides pole tips such as indicated at **11***n* having a cross section essentially as indicated at **11** in FIG. **2** in the region immediately adjacent the gap in the working core **10***n*.

It will be apparent to those skilled in the art that the working core material in each of the embodiments which has been designated by the reference numeral **10** followed by a letter preferably has the same configuration as provided by the working core parts **25**, **26** in FIG. **1**. Further, the auxiliary core material integral with the working core part and the auxiliary core material designated by the reference numeral **20** followed by a letter will generally have the configuration of the auxiliary core parts **21**, **22** in FIG. **1**. Thus, in each case the additional material integral with the working core part will taper adjacent the gap region so that the core configuration has a cross section such as indicated at **11** in FIG. **2** in the region immediately adjacent the gap at each side of the gap. The auxiliary material thus provides generally a ring configuration but with a gap region of greater reluctance than the coupling gap such as indicated at **13** in FIG. **1** which couples the core configuration with the magnetic record medium. The magnetic record medium contacts the poles of the working core configuration adjacent the gap in the same way as indicated in FIG. **1** in each of the other embodiments.

The auxiliary material integral with the working core material in each of the embodiments may be of any of the materials heretofore mentioned for the working core part **10** or **10***a*, and the auxiliary material separate from the working core parts may have any of the characteristics and be of any of the materials heretofore described with reference to the auxiliary core material **20** or **20***a*.

As further embodiments of the present invention, the integral material associated with the working core material may have any of the characteristics referred to in my copending application Ser. No. 126,121 filed July 24, 1961, and in this connection the auxiliary material may form part of the working core material for the purposes set forth in my copending application Ser. No. 126,121. Thus, within the broadest aspects of the present disclosure, the additional integral material may be actually required for adequate signal flux carrying capacity of the core configuration and may be dictated for adequate mechanical strength of the working core or to reduce eddy current losses and for the other purposes set forth in my copending application Ser. No. 126,121. On the other hand, within the scope of the present disclosure, the integral additional material may be present solely for the purpose of reducing residual magnetization of the core configuration, and may not be dictated by any prior art design considerations. This latter circumstance has been specifically indicated in each of the embodiments by designating a cross section generally corresponding to the cross section shown at **10** in FIG. **2** as the working core material, and by designating the further integral material such as indicated at **70***a* in FIG. 2A as additional material.

In each of the embodiments, a nonhardening material has been indicated by the reference numeral **30** followed by a letter to indicate a material corresponding to the material **30** described in connection with FIGS. **1** and **2**. Each of the embodiments is specifically disclosed with the nonhardening material present for the purposes described in connection with FIG. **2**, and is also specifically disclosed with such material omitted, but preferably with the auxiliary material electrically insulated from the working core material and from additional material integral with the working core material.

In each of the embodiments, the working core material and the parts integral therewith are preferably electrically insulated where their surfaces are in adjoining relation and are also electrically insulated from any additional core material such as designated by the reference numeral **20** followed by a letter. Adjacent surfaces of the additional core material designated by the reference numeral **20** followed by a letter are also preferably electrically insulated so as to minimize eddy current losses.

The reference numeral **16** followed by a letter designates a polar surface in sliding contact with the active undersurface of the tape **14** in the same way as described with reference to the surface **16** of pole **11** in FIGS. **1** and **2**.

In the various embodiments, the same reference numeral has been applied to a given part as shown in cross section and to the same part as shown in elevation so as to facilitate the reading of the drawings. Each of the FIGS. designated by the FIG. No. **2** followed by a capital letter should be considered as being a sectional view taken at a location comparable to that represented by the section line II—II in FIG. **1**.

The discussion given with respect to FIG. **3** represents the preferred operation for each of the embodiments of FIGS. **2A** through 2N.

Additional core configurations to some extent comparable to the illustrated embodiments are found in my copending application Ser. No. 835,017 filed Aug. 20, 1959, and each of these comparable embodiments is specifically incorporated herein by reference to illustrate certain very broad concepts included within the scope of the present disclosure.

FIGS. **4**—**6** illustrate an advantageous head configuration which has been built and tested and found to have a very low residual magnetization characteristic while providing low losses at highest frequencies.

In this embodiment, a working magnetic core **210** provides pole pieces **211** and **212** defining a gap **213** for coupling to the magnetic record medium **14** travelling in the direction of the arrow **15**. As seen in FIG. **5** the pole **211** may have a tape engaging surface **216** in sliding contact with the active undersurface of the magnetizable layer **14***a* of the tape **14** as in the previous embodiments. The working magnetic core material **210** is provided with integral extensions **217** and **218** somewhat similar to the extensions **70***a* and **71***a* of FIG. 2A, but with inturned free edges **217***a* and **218***a*. The working core is preferably further provided with separate auxiliary material **220** comparable to the auxiliary material **20***j* of FIG. **2J** previously described. Thus the auxiliary material is illustrated as comprising a series of electrically isolated laminations such as lamination **222**. Preferably each lamination is formed of a pair of C-shaped strips comparable in configuration to the core parts **21** and **22** of FIG. **1**, for example, the free edges of the strips defining a tapering configuration at the gap region as indicated at **224** and **225** in FIG. **4**. As in the preceding embodiments, the main core configuration may be formed of two separate C-shaped parts such as designated by the reference numeral **231** and **232** in FIG. **4** separated to define a back gap **233**. As in the previously described embodiments, the working core may comprise a rectangular cross section portion of the core parts **231** and **232** corresponding to the cross section of the pole tips **211** and **212** and corresponding to the cross section of the core parts **25** and **26** in FIG. **1**. Alternatively the main core parts **231** and **232** as a whole may represent the working core for any of the purposes described in my copending application Ser. No. 126,121 as has been discussed in connection with the preceding embodiments. An electrically conductive gap spacer defining gap **213** is indicated at **236** in FIG. **4**.

The core configuration of FIG. **4** may be mounted by means of a pair of mounting blocks **241** and **242**, FIG. **6** which may be of brass, bronze, or nonmagnetic stainless steel, or other nonmagnetic electrically conductive material. Each mounting block has a recess such as indicated at **241***a* for receiving one of the core halves such as the half including main core part **231**, FIG. **5**. These recesses have a configuration so as to engage the main core parts **231** and **232** along respective limited regions such as indicated at **245** and **246** in FIG. **5**. These semicircular regions may be suitably bonded to the core, for example by means of an epoxy resin having a location as diagrammatically indicated at **251** and **252** in FIG. **6** along the semicircular regions **245** and **246**.

A keeper housing such as indicated at **260** may enclose the mounting blocks **241** and **242** and may have a tape engaging surface such as indicated at **260***a* flush with the polar surfaces such as indicated at **216**, the keeper surface **260***a* conforming with the tape path which is indicated in FIG. **4**. The keeper **260** is provided with an elongated aperture through which the poles **211** and **212** project as indicated in FIG. **5**. The two mounting blocks **241** and **242** may be suitably electrically isolated at their interface, and the keeper housing will be suitably magnetically isolated from the poles **211** and **212**, as by being substantially spaced therefrom by nonmagnetic material at regions such as indicated at **271** and **272** in FIG. **5**.

The blocks **241** and **242** are provided with toroidal cavities **241***b* and **242***b* so as to accommodate a toroidal winding such as indicated at **275** in FIG. **6**. Instead of a single winding **275**, the core configuration may have two coils linking the respective main core parts **231** and **232**. In the illustrated embodiment, the keeper **260** as shown in FIG. **5** may be considered as having been ground away at the region of the poles **211** and **212** so as to show a thickness of for example 0.002 inch in FIG. **5** where its thickness elsewhere would be 0.015 inch. This configuration is shown to some extent in FIG. **6**.

Referring to FIG. **7** which is a partial horizontal sectional view taken generally along the line VII—VII of FIG. **6**, the epoxy resin material is designated by the reference numeral **281**. It will be observed that the core parts are secured to the mounting blocks principally at the working core portion **210**, so that the side legs 217 and 218 are predominantly stress free. As indicated at 282 and 283 in FIG. 7, the clearance spaces optionally may be filled with a yieldable material such as foamed plastic as indicated at 282 and 283. Alternatively, air spaces may be left as indicated in FIG. 5.

FIGS. 8, 9 and 10 illustrate certain important features applicable to all of the embodiments of the invention, but for convenience the features are shown applied to the embodiment of FIGS. 4—7, the same reference numerals being applied in FIGS. 8, 9 and 10 as in FIGS. 4—7.

In my copending application U.S. Ser. No. 528,934 entitled "Transducer System and Method" filed on Feb. 21, 1966, there is disclosed a transducer head configuration similar to that illustrated in FIGS. 8 through 10 of the present application except that in the prior disclosure a single muititurn crossfield conductor ribbon encircles both of the pole tips in the space between the pole tips and the edge of the keeper housing such as the edge indicated at 260*b* defining aperture 290 in FIG. 10 of the present application. The disclosure of said prior application is incorporated herein by reference in its entirety, and each of the applications referred to in said copending application is also incorporated herein by reference in its entirety, these applications disclosing overall systems for utilizing the features of the present invention.

In accordance with the embodiment of FIGS. 8—10, individual electrically conductive ribbons 301 and 302 are associated with the pole pieces 211 and 212, respectively, so that the conductive ribbons may be preassembled with the associated half of the transducer head, rather than being placed over the assembled halves of the transducer head as in the prior application. Specifically in the illustrated embodiment, the conductive ribbons 301 and 302 each make approximately three turns about the associated pole piece. It will be understood, however, that the conductive ribbons may make more turns about the poles, or less numbers of turns, or only a single turn may be employed. For example in FIG. 9, approximately four turns have been illustrated in association with the pole piece 212.

FIG. 9 illustrates by means of dash lines a portion of the magnetic field configuration produced by current flow in the conductor 302. The conductor 301 and 302 may receive high frequency bias current of constant amplitude having a frequency in the megacycle range. Heating of the head core by the conductors 301 and 302 (when energized with alternating current) increases the permeability of the gap region of the head and reduces its residual magnetization. It will be noted that the fields indicated in FIG. 9 provide a gradient in the transverse direction with respect to the width of the head core with the most intense crossfield component near the lateral edges of the poles 211 and 212. With such a cross field bias configuration, the parameters may be adjusted to give optimum short wavelength recording near the central portion of the record medium channel coupled to the head and to provide optimum long wavelength recording, for example at the lateral edges of the record medium channel where the bias field intensity is more intense. The record medium 14 when associated with the embodiment of FIGS. 8—10 thus provides a tape with a recorded track having a gradient in its response characteristic from edge to edge of the tape with the low frequencies recorded substantially in an optimum manner at the lateral margins of the channel of the record tape and with the high frequency components for example in the megacycle range recorded substantially in an optimum manner at the central portion of the recorded channel. Such a recorded tape has a gradient in its long wavelength response with respect to the transverse direction and has a gradient in its short wavelength response with respect to the transverse direction at right angles to the direction of tape movement.

In FIG. 9, the tape engaging surface 260*a* of the housing 260 is flush with the tape engaging surface 305 of pole 212 and flush with the tape engaging surface 216 of the pole 211.

As indicated in FIG. 10, suitable fastening elements 311—314 are provided for securing the housing 260 to the head mounting blocks 241 and 242. For the sake of a definite example, screw-type fastening elements have been indicated in FIG. 6 at 312 and 313. The fastening elements 311—314 prevent head movement with respect to the keeper housing 260 in spite of temperature changes and the like.

With current flow in the ribbons 301 and 302 in the directions indicated by arrows 316 and 317, the ribbons 301 and 302 act jointly as a cross field in the same way as a single ribbon wrapped about both poles 211 and 212 together as in the aforementioned copending application Ser. No. 528,934 filed Feb. 21, 1966. With the current in ribbon 301 reversed from that shown by the arrow 316, the ribbons 301 and 302 (or one of the ribbons alone) acts as a signal coil or serves to produce a longitudinal component of bias frequency magnetic field, in place of supplying such bias frequency or signal current to the main winding 275, for example. The advantage of use of this configuration over a signal winding such as 275 lies in the fact that the conductors are close to the gap and give efficient coupling, especially at bias frequencies in the megacycle range.

The feature of FIG. 9A, taken in conjunction with FIGS. 8 and 10 are also applicable to any of the embodiments illustrated herein, but for convenience, the reference numerals and structure of FIG. 8 have been repeated in FIG. 9A. The housing 260′ is identical to that illustrated in FIG. 10 except that the external surface 322 of the housing is somewhat below the level of the tape engaging surfaces 305 of pole 212 and 216 of pole 211. The edges of the successive turns of the ribbon 302 and of the ribbon 301 are flush with the surfaces 216 and 305 and follow the configuration of the poles 211 and 212 for a substantial distance along the tape path at each side of the gap between the poles. The keeper 260′ which is also of a magnetically soft material may otherwise correspond identically to the housing 260 as illustrated in FIGS. 6 and 10, for example.

During polishing and in use of the heads such as illustrated in FIGS. 9 and 9A, the contour of the poles such as 212 at the tape engaging surface 305 and the upper edges of the ribbon conductors such as 302 become somewhat crowned as indicated by dash lines 325 and 326, and this crowning is desirable to insure good tape contact. This is also true of the other embodiments herein; that is the core configurations as viewed in transverse cross section should actually show a certain degree of crowning or protrusion of the tape engaging surfaces at the region of the gap 13 or 213.

The location of the machine screw fasteners 311—314 at the top surface of the keeper housing 260 maintain the head and keeper housing in accurate relation at the tape riding surfaces such as 260, 216 and 305 even with loose thread tolerances and allows differential expansion at the bottom between the head mounting blocks 241 and 242 and the housing 260. If the screws extend in a horizontal direction the thread tolerance could defeat the desired fixed accurate relationship between the tape engaging surfaces of the head and keeper housing.

In each of the embodiments the insulation between adjacent surfaces of the core part, that is the insulation between laminations such as indicated at 74 and between the laminations and the core parts such as 10*b*, 72 and 73 in FIG. 2B, for example, and between the core part 76*a* and 76*c* , for example, in FIG. 2C, and also the nonhardening material such as indicated at 30 in FIG. 2, for example, should be very thin to give the lowest possible magnetic reluctance between the auxiliary and working core parts. A suitable insulation is magnesium oxide formed by decomposition of a magnesium methylate coating. The magnetic reluctance is also reduced by increasing the area of contact between the auxiliary and working parts, the construction of FIG. 2A, for example, giving about three times the confronting area at the regions indicated at 30*a* as compared to the area between the confronting surfaces at the region 30 in FIG. 2. Spot welding at one point, for example of part 25 to part 21 at the region 11, 21*a* in FIG. 1, also decreases reluctance while allowing freedom of movement to prevent stresses. This limited region spot welding of adjacent core parts preferably at a single location, is specifically disclosed with respect to each of the embodiments herein. The adjacent spot welded core parts may be in substantial contact over their entire confronting surfaces or may have a very thin layer of insulation and/or non hardening material therebetween.

Referring to the embodiment of FIGS. **4** and **5**, by way of preferred example, the working core configuration **210** may have a width dimension of 18 mils (1 mil equals 0.001 inch), and depth dimension of 2 mils (corresponding to the thickness of the sheet material forming the working core an auxiliary parts **217** and **218**). The auxiliary core parts **217** and **218** may have a width dimension of 24 mils and the same thickness dimension of 2 mils. As illustrated, the working core **210** and the auxiliary parts **217** and **218** may be formed from a single sheet of Supermalloy, having an initial width of the order of 78 mils before it is formed into the channel cross section shown in FIG. 5. The inner flanges such as **217***a* and **218***a* may be of substantially semicircular configuration with a radius of curvature of 30 mils. The additional material **220** may be formed of laminations which are one-half mil thick Supermalloy and having a width dimension of the order of 14 mils, and formed into semicircular arcs with radii varying from approximately 32 mils to 52 mils.

As a first example, two coils 100 turns each may link the respective core sections **231** and **232** which coils are connected in series for playback, and in parallel for recording operation. Alternatively only one of the 100 turn coils may be used for recording. As a second example, two coils may be utilized on the core sections **231** and **232** respectively, one having 100 turns for use during recording and the other coil having 400 turns for use alone during playback. As a third example a single coil such as indicated at **275** may be utilized having 1000 turns which are all used for playback, the coil being tapped so that 50 turns, for example, may be utilized during recording.

As another example of dimensions, the working core **10***a*, FIG. 2A, may have a width dimension of 20 mils, a thickness of 2 mils, and the legs **70***a* and **71***a* may have a width dimension of 24 mils. As an alternative example for FIG. 2A, the core parts **10***a*, **70***a* and **71***a* may be formed from a sheet of Supermalloy having a thickness of 4 mils (0.004 inch), the auxiliary core material **20***a* also being formed of Supermalloy.

Referring to the embodiment of **2M**, the working core **10***m* may have a cross section 12 mils wide and 4 mils thick, while the legs **141** and **142** have a long cross-sectional dimension equal to about 22 mils.

In FIG. 2N, the working core **10***n* may have a width dimension of 8 mils and a thickness dimension of 4 mils with a very thin insulating layer therebetween as indicated at **325** for example of magnesium oxide as previously described. The legs **144** and **145** may have a long cross-sectional dimension of 20 mils, for example. It will be noted that embodiments such as indicated in FIGS. **2M** and **2N** give increased thickness for the tape engaging surfaces such as **16***m* and **16***n* while avoiding grooves in such surface of the type which are required for a laminated configuration as indicated at **16***k* in FIG. **2K**. Further, the configurations such as those of **2M** and **2N** require no cementing to hold them together after annealing, as is required with a laminated configuration such as indicated in FIG. **2K**.

It should be noted that in each case where auxiliary low coercive force material is to be utilized, it must have a special heat treatment as will be well understood by those skilled in the art, and this is especially true of Supermalloy.

As a further specific example, the auxiliary core parts **20***m* in FIG. **2M** are welded to the working core at a limited region preferably by means of a single spotweld for each part and preferably in the region of the poles such as **11***m* of the working core.

Preferably each of the heads is of very small diameter to reduce the ratio of iron lengths to gap lengths, the entire head preferably being one-sixteenth inch to one-eighth inch in diameter or less. A head one thirty-second inch in diameter has been constructed. The magnetic material forming the signal flux paths of the core including the auxiliary material may have a grain direction or magnetic orientation at right angles to the signal flux path for minimum residual magnetization in the direction of the signal flux path. The working magnetic core parts may, for example, be of a magnetically soft ferrite material, while the auxiliary material is of a magnetically soft metal.

FIGS. **11**, **12** and **13** illustrate a further embodiment particularly characterized in that pole **411** has its polar surface **416** spaced from the tape path by means of a nonmagnetic spacer **418** while the pole **412** has its polar surface **419** in sliding engagement with the magnetizable layer of the record tape **14** as in the previous embodiments. Electrically conductive gap spacer element **432** extends into the space between nonmagnetic material **418** and the pole **412** so as to provide at its upper edge a part of the tape engaging surface of the head in the same way as in the preceding embodiments. The nonmagnetic material **418** may have a tape engaging surface **418***a* which is crowned at the region of the gap, and the pole **412** may have its surface **419** similarly crowned, as was described in connection with the preceding embodiments.

The head configuration of FIGS. **11—13** may incorporate any of the features of the preceding embodiments, but by way of example core sections **435** and **436** may be identical to core sections **231** and **232** of FIG. **4** and may include the horizontal lamination filler as seen in FIG. **5**. An electrical signal winding is illustrated at **440** which may be of toroidal configuration and be associated with electrically conductive mounting blocks all as described in connection with FIGS. **5** and **6**, for example. The keeper housing for the embodiment may be as illustrated in FIG. **9** or **9A** and **10**. Where the keeper housing is arranged as illustrated in FIG. **9**, the keeper tape engaging surface **260***a* would be crowned and would conform in contour with the surfaces **418***a* and **419**.

FIG. **12** is a diagrammatic view illustrating the gap spacer **432** before the same is folded into the configuration illustrated in FIG. **13**. Connecting conductive ribbons are indicated at **444** and **445** which ribbons may lead to terminals at the bottom of the housing for the head assembly. The ribbons **444** and **445** lap end portions **432***a* and **432***b* of the gap spacer **432** and these end portions are shown as being folded against the core part **436** in FIG. **13**. For illustrative purposes a source of high frequency bias current is indicated at **450** which may supply constant amplitude bias current in the megacycle range to the gap conductor **432** for establishing a component of bias frequency magnetic field between the pole **411** and the pole **412**. Also for the purpose of diagrammatic illustration, a crossfield ribbon conductive winding **452** has been illustrated which is also shown as being energized at the bias frequency from source **450** so as to produce a cross field component of magnetic field between the keeper tape engaging surface such as diagrammatically indicated at **460***a* and the polar surfaces **416** and **419**. The keeper surfaces **460***a* may be flush with the upper edges of the winding **452** and with the tape engaging surfaces **418***a* and **419**, or the keeper surfaces **460***a* may be offset below the tape path and flush with the polar surface **416** in the manner indicated at **322** in FIG. **9A**. The winding **452** may be provided by means of individual winding sections as indicated at FIG. **8** with the current flow directions indicated at **316** and **317** so as to produce a bias frequency magnetic field in the crossfield or transverse direction. Of course, the bias frequency current supplied to gap conductor **432** and to winding **452** may be suitably adjusted as to relative amplitude and phase so as to produce the optimum resultant bias frequency field as explained in my pending applications such as Ser. No. 528,934 filed Feb. 21, 1966 referred to above.

FIG. **11** indicates suitable recording amplifier circuitry at **470** and playback amplifier circuitry at **471** and shows switch means **472**, **473** and **474** for connecting the circuitry to operate in various modes. For example with switch **472** in its upper position, recording current is superimposed on the bias frequency current and both are supplied to the gap conductor **432**. With the switch **472** in the lower position, recording current from the circuitry **470** may be supplied to 100 turns of winding **440**, for example. With switch **473** open and with switch **472** in an open or upper condition, the system may be conditioned for playback operation by closing switch **474** which may connect the entire winding **440** to the input of the playback circuit **471**.

All of the features herein described may be applied to the system of FIGS. **11—13**, and the features of FIGS. **11—13** may be applied to all of the other embodiments as will be apparent to those skilled in the art.

The material **418** may comprise a ceramic coating on the polar surface **416** and having a thickness from 0.0005 inch to 0.00005 inch. The gap spacer **432** may have a thickness from 0.0005 inch to 0.00005 inch. The core parts **435** and **436** may be formed with main core parts of 0.004 inch thick Supermalloy having an initial width of the order of 78 mils, but folded as indicated in FIG. **12** to provide a working core cross section of 18 mils by 4 mils thick and to provide auxiliary side legs such as indicated at **481** and **482** having a lengthwise cross-sectional dimension of the order of 20 mils with one-half mil Supermalloy laminations providing the auxiliary material **484**. Alternatively, the auxiliary material **484** may be of solid cross section Supermalloy. Where the amplifier circuitry **470** provides a video signal with frequency components up to the megacycle range, 100 turns may be utilized for the recording section of winding **440**. For playback of the video signal, the winding **440** may have 300 turns, or individual winding sections on the core parts **435** and **436** may each have **100** turns and be connected in series to the playback circuitry **471** for playback, while one of the windings may be connected to the output of circuitry **470** during recording. The winding **440** would have fewer turns for operation with frequency components above approximately 3 megacycles per second. In a preferred mode of operation, the switch **472** would be in the upper position so that the recording current including frequency components above approximately 3 megacycles per second or at least in the megacycle range would be supplied to the crossfield conductor **432**. The winding **440** would then be employed only for playback operation. Alternatively the gap spacer **432** could also be utilized during playback in conjunction with a step-up transformer.

FIG. **14** illustrates an embodiment wherein an especially small core configuration **500** may correspond to any of the core configurations herein disclosed and may have a toroidal winding as indicated at **501** for reproducing the higher frequency components of a recorded signal and supplying the same to an amplifier **502**. A low frequency core part is indicated at **505** having a winding **506** for reproducing low frequency components of the recorded signal and supplying them to the amplifier **502**. Still higher frequency components may be reproduced by a gap spacer of core **500** as in the embodiment of FIGS. **11—13**.

The turn-in gap energization as by gap spacer **432** is especially advantageous where the working core is of a relatively thick material, while a multiturn coil such as indicated at **440** is advantageous for playback. Multiturn coils can also be used for signal current during recording in any of the embodiments, with the high frequency bias for example in the megacycle range and above the highest frequency component to be recorded, supplied to the turn-in gap conductor such as **432**. Where the head core has considerable core loss at the highest frequencies, the head may be utilized with a playback amplifier such as indicated at **471** having an especially high rate of rise at high frequencies in its response characteristic as a function of frequency.

Head units in accordance with any of the embodiments hereof may be utilized in the color television recording and playback system of my copending application Ser. No. 528,934 filed Feb. 21, 1966 and of any of the applications referred to therein. The head unit dimensions may be such as to provide for four passes of a one-fourth inch tape (a total of 12 tracks, for example) giving an hour of color television recording or playback on a reel about 7 or 8 inches in diameter with extra thin tape.

Referring to FIG. **11**, it is important to have a very accurate straight sharp edge at the junction of a pole **419** with the gap spacer **432** that is maintained through the life of the head. Spacer **432** should preferably be of the highest possible electrical conductivity. Beryllium copper provides a hardness that will maintain a sharp junction and yet has high conductivity. The pole piece **419** may be of Sendust, Alfenol, and the like to hold the sharp edge; and it is also advantageous to make this pole piece of high saturation magnetic material as previously indicated.

The layer **418** may be of a glasslike material such as silicon monoxide which can be vapor deposited, quartz or porcelain enamel. The thickness of the separation layer **418** is of the same order as the thickness of the gap spacer **432**. As an example, such thickness may be from about 0.001 inch to about 0.00002 inch for heads operating in the megacycle range, or for wave lengths of 0.0002 inch or less.

Referring to the embodiment of FIG. **14**, the small head **500** records both short and long wavelengths efficiently using any of the arrangements herein described; but does not playback the long wavelengths efficiently. In addition to the increased playback efficiency when the core **505** is used with its low frequency winding **506**, the inefficient response of the small head **500** has the advantage of being innocuous to very short wavelength recordings on the tape. It has been found that sharp gap playback heads which are also efficient at long wavelengths have a tendency to concentrate the long wavelength magnetization picked up from the tape at the sharp gap and thus exert an erasing effect on the recorded short wavelengths. In the arrangement of FIG. **14** core **505** actually diverts this recorded long wave length flux from core **500** to avoid this erasing effect.

The material **418** may be a flame sprayed ceramic such as barium titanate, or stainless steel, or preferably chromium plate deposited on a pole surface **416** of Supermalloy or other material. To test the effectiveness of a head of the construction of FIGS. **4** and **5** a direct current was put through the windings, the current being approximately 100 times greater than the maximum recording current used with this head during normal operation. No adverse effect was noticed on playback of short waves of about 0.00005 inch wavelength immediately after this current was removed, and the noise level did not increase. No adverse effect was noticed when the same test was made during recording. When heads of ordinary construction were tested in this way, they erased the signal completely on previously recorded tapes and were inoperative or very noisy when used for recording.

The decrease in residual magnetization required for effective operation depending on the type of working core material, on its conditions of stress, on the sensitivity of the tape to such fields, on the criticality of the performance requirements with respect to noise and shortwave response, on the size and type of head gap, on the exposure to magnetizing conditions, etc. The preferred constructions described here allow the residual magnetization to be reduced to a value where it has no adverse effect on the tape under all operating conditions.

With respect to the embodiment of FIG. **2E**, it will be understood that an alternative arrangement is to utilize the material connecting regions **81** and **82** as the working core material and to utilize such working core material to define the poles for coupling to the record medium. In this event the material $\mathbf{10}_e$ would be the unstressed auxiliary material which would be out of contact with the record medium. In each of the embodiments, the auxiliary material is tapered in the region of the gap so that the pole faces have a cross section comparable to the cross section of the working core, although the poles may be ground down somewhat so that the pole end face such as seen at **212***a* in FIG. **9** and in FIG. **9A** may have a reduced thickness in comparison to the normal thickness of the working core. In each of the embodiments, the tape record medium may have a width substantially greater than the maximum width of the head so as to be supported by the keeper surface such as **260***a* at each side of the aperture such as indicated at **290** in FIG. **10**. Referring to FIG. **9**A, even after the head configuration is substantially crowned as indicated at **325** and **326**, the magnetizable surface of the record medium will still be spaced a substantial distance above the edges of the keeper housing such as indicated at **328** in FIG. **9**A. This means that the record medium will not be exposed to the relatively intense field immediately at the edges such as **328**, this field for example being a bias frequency field having a frequency in the megacycle range.

Referring to the offset pole feature of FIG. **11**, in wide band recording applications it is a common experience that when microsize gaps are used, serious disadvantages are encountered. During recording it is difficult or impossible to bias the tape adequately, and the head may saturate at recording levels well below the tape saturation level. During playback the head output voltage is low, and the signal to noise ratio is poor. If the recording density were greatly improved, the low output might be tolerated. However with very short gaps, the recording density turns out to be poorer than for larger gaps, at least with ordinary tapes. One is therefore forced to the conclusion that there is an optimum size of gap (engineering compromise), below which satisfactory operation may be unobtainable.

Where high frequency bias is used for recording, an inner boundary exists near the recording gap within which the bias field is so strong that ideally whatever recording takes place on one cycle is cancelled on the reverse cycle. Beyond this inner boundary, near the trailing pole there is a "critical zone" where the recording is made. That is to say, the recording in effect actually takes place near the trailing pole of the head as the tape passes thereover. This happens because the tape retains only the magnetization acquired in the critical zone. However, ideal conditions seldom exist; and especially with low bias and strong signals, or with biasless recording, certain wave lengths may be weakened or strengthened depending on gap and tape dimensions. For example, in the interval of time it takes for an increment of tape to transverse the recording gap region the flux can change such that some or all of the signal impressed on the tape prior to the critical zone is not cancelled, but is merely reduced or increased as it passes through the varying flux at the trailing pole in the critical zone.

On playback, nulls occur when the effective size of the head gap is an integral multiple of the recorded wavelengths, so that the signal is cancelled at high frequencies corresponding to short wavelengths. To overcome this problem fine gap heads of micron size must be used to prevent nulls within the operating frequency range, leading to the difficulties mentioned above.

The offset pole configuration of FIG. **11** overcomes the problems outlined above by providing a head construction which minimizes the deleterious effects of the leading pole of the magnetic head during recording and the null effect due to gap length during playback.

Each of the features described herein is specifically disclosed as being applied to each of the embodiments, and the description of each of the embodiments is specifically applied to each of the other embodiments to the extent not inconsistent with such other embodiments.

The head configurations disclosed herein may be utilized as erase heads as well as recording or playback heads.

The head units disclosed herein may be utilized in the embodiments of my prior applications Ser. No. 835,017 filed Aug. 20, 1959, Ser. No. 126,121 filed July 24, 1961, Ser. No. 344,075 filed Feb. 11, 1964, Ser. No. 389,021 filed Aug. 12, 1964, now U.S. Pat. No. 3,469,037 Ser. No. 401,832 filed Oct. 6, 1964, now U.S. Pat. No. 3,495,046, Ser. No. 407,402 filed Oct. **29**, **1964**,now U.S. Pat. No. 3,513,265, Ser. No. 439,340 filed Mar. 12, 1965, now U.S. Pat. No. 3,502,795, Ser. No. 456,192 filed May 17, 1965, now U.S. Pat. No. 3,449,528 Ser. No. 493,271 filed Oct. 5, 1965, now U.S. Pat. No. 3,531,600, and the aforementioned application filed Feb. 21, 1966, and each of the head units disclosed herein is specifically applied to each of the recording and playback systems illustrated in said copending applications and the resulting systems are each specifically incorporated herein by reference.

For present commercial magnetic record tapes having acicular oxide particles and a coercivity of about 250 oersteds, the threshold value of residual magnetic field just sufficient to have a substantial detrimental effect on such a record tape is about 200 oersteds. Thus the auxiliary means of the present invention whether integral with the working core, or separate from the working core, or provided by both integral and separate core parts, is preferably constructed and arranged to reduce the maximum residual field intersecting the record medium path to a value less than about 200 oersteds. Preferably the auxiliary means provides such a reduction under all operating conditions to which the head may reasonably be expected to be subjected.

Commercial data shows that values of DC coercivity for commercially available Supermalloy (as measured from direct current saturation) may have a range from 0.003 to 0.009 oersted, and that commercial values of DC coercivity for 4—79 Permalloy may range from 0.02 to 0.07 oersted (as measured from direct current saturation). In designing a commercial head in accordance with the present invention to provide a residual field in the tape path of less than 200 oersteds, it may be necessary to take into account possible variations in direct current coercivity of commercially available materials and other such factors. It is the value of direct current coercivity rather than coercivity as measured with an applied AC field of a specified frequency which best indicates the merits of a material for the purpose of this invention.

It may be noted that an analysis of the design of a head such as shown in FIG. **1** may be approached by plotting magnetic flux Φ as a function of magnetomotive force (mmf.) rather than as a function of magnetizing force H, as was done in FIG. **3**. The mmf. between points **28** and **11** in core parts **25** must always be essentially equal to the mmf. between points **21***b* and **21***a* in core part **21** where these adjacent points are separated by a minimum reluctance path as is desirable.

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.

The nonhardening layers such as **30***a* and the insulating layers which may be substituted therefor to provide electrical isolation, but with low reluctance between the working core parts and the auxiliary core parts such as **20***a*, may have a thickness of the order of 1 micron (one millionth of a meter).

The back gaps such as **27** may be of minimum reluctance, with faces of core parts **21** and **22**, and core parts **25** and **26** in abutting contacting engagement.

The maximum saturation density for Supermalloy may range from 6500 to 7800 gauss, and for 4—79 Permalloy may range from 6500 to 8000 gauss, in commercially available samples.

I claim as my invention:

1. A magnetic head comprising
   - a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and
   - auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium,
   - said auxiliary means being essentially disconnected from the material forming said magnetic core so as to accommodate relative thermal expansion therebetween.

2. A magnetic head comprising
   - a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and
   - auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium,

a relatively wide sheet of magnetic material having a first portion of the width thereof defining said magnetic core and having a second portion of the width thereof defining said auxiliary means,

said second portion of said sheet being joined with said first portion by means of a bend to offset said second portion from the level of the first portion.

3. A magnetic head comprising

a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and

auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium,

said magnetic core having a signal flux path therein and the material of said magnetic core being oriented generally at right angles to said signal flux path.

4. A magnetic head comprising

a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and

auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium,

a keeper housing containing said core and said auxiliary means and having a top surface adjacent the record medium path,

mounting means for holding the core, and

fastening means at the top surface of the housing securing the housing to the mounting means and exerting fastening force generally normal to the top surface of the housing

5. A magnetic head comprising

a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and

auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium,

said auxiliary means being a separate piece of material from said magnetic core and having a magnetic length substantially less than said magnetic core and a cross section substantially greater than that of said core.

6. A magnetic head comprising a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the redium, said auxiliary means being in a substantially unstressed condition, said magnetic core having a signal flux path therein and having a cross-sectional configuration transverse to said signal flux path with an interior space, and said auxiliary means comprising auxiliary magnetic material disposed within said interior space of said magnetic core, the material of said magnetic core extending on three sides of the auxiliary magnetic material within said interior space.

7. A magnetic head comprising a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium, said auxiliary means being in a substantially unstressed condition, said auxiliary means in its entirety being spaced from the record medium path so as to be clear of contact with the magnetic record medium, said magnetic core having confronting poles with upper record contacting surfaces for sliding engagement with the record medium, the coupling means comprising a nonmagnetic gap between the poles, and the poles having under surfaces opposite the upper record contacting surfaces thereof, and said auxiliary means comprising auxiliary material extending along the under surfaces of the poles and having a substantially greater thickness dimension than the thickness dimension of the poles between the under surfaces and the upper record contacting surfaces thereof.

8. A magnetic head comprising a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium, said auxiliary means being in a substantially unstressed condition, said auxiliary means being formed in the same magnetic material and integral with said magnetic core and said magnetic core having adequate flux carrying capacity for efficient recording operation without said auxiliary means, and said auxiliary means having a cross section substantially greater than the cross section of said magnetic core and serving to reduce the field due to residual magnetization of said magnetic core which intersects the record medium path to a value substantially below the coercivity of the record medium.

9. A magnetic head comprising a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium, said auxiliary means being in a substantially unstressed condition, said auxiliary means reducing the residual flux which intersects the record medium path by at least 50 percent in comparison with the case where the auxiliary means is omitted, said magnetic core having confronting poles with upper record contacting surfaces for sliding engagement with the record medium, the coupling means comprising a nonmagnetic gap between the poles, and the poles having under surfaces opposite the upper record contacting surfaces thereof, and said auxiliary means comprising auxiliary material extending along the under surfaces of the poles and having a substantially greater thickness dimension than the thickness dimension of the poles between the under surfaces and the upper record contacting surfaces thereof, said auxiliary material being within a distance of not greater than about 0.001 inch of said magnetic core, but being entirely clear of the region between said poles.

10. A magnetic head for coupling to a track on a magnetic record medium and having a predetermined scanning width corresponding to the width of said track, said head comprising

a magnetic core having coupling means for coupling the magnetic core to said track as the record medium travels along a record medium path across said core,

a relatively wide sheet of magnetic material having a first portion of the width thereof forming said magnetic core and having a second portion of the width of said sheet substantially increasing the flux carrying capacity of the head without increasing the scanning width thereof, said first portion of the width of said sheet having a width dimension defining the scanning width of the head, and

auxiliary means comprising said second portion of said sheet and providing magnetic material having a coercivity substantially lower than the coercivity of the magnetic core for diverting residual flux due to residual magnetization of the magnetic core from the path of the record medium.

11. A magnetic head comprising a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and auxiliary means of magnetic material disposed adjacent said magnetic core and being in a relatively unstressed condition, said magnetic core comprising a core portion adjacent said coupling means and across which the record medium travels, and said auxiliary means comprising an integral lateral extension of said core portion and extending on the side of said core portion remote from the record medium path.

12. A magnetic head comprising a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and auxiliary means of magnetic material disposed adjacent said magnetic core and being in a relatively unstressed condition, said magnetic core having a generally channel cross section to define a pocket on the side of the core remote from the record medium

path, and said auxiliary means comprising separate pieces of magnetic material disposed inside said pocket.

13. A magnetic head for coupling to a magnetic record medium comprising a magnetic core having a plurality of individual core parts of sheet magnetic material defining a magnetic circuit having a region for coupling to a magnetic record medium, at least one of said core parts having a body portion with a width dimension between opposite side margins extending generally transversely to the path of magnetic flux through said one of said core parts and having an integral angularly related portion extending at a substantial angle from at least one side margin of said body portion for increasing the cross-sectional area of the portion of the magnetic circuit defined by said one of said core parts without a corresponding increase in the width dimension of the core part.

14. A magnetic head for coupling to a magnetic record medium comprising a magnetic core having a plurality of core parts of sheet magnetic material defining a magnetic circuit having a region for coupling to a magnetic record medium, said core parts having a channel section transverse to the flux path through said parts throughout a substantial portion of the length thereof.

15. A magnetic head for coupling to a magnetic record medium comprising a magnetic core having a plurality of core parts of sheet magnetic material defining a magnetic circuit having a region for coupling to a magnetic record medium, said core parts having a channel cross section transverse to the flux path through said parts throughout a substantial portion of the length thereof but having a rectangular cross section adjacent said region for coupling to the record medium to provide reduced cross section pole portions.

16. A magnetic head comprising a magnetic core having a signal flux path therein of loop configuration and having coupling means for coupling the signal flux path of the magnetic core to a magnetic record medium traveling along a record medium path, auxiliary means of magnetic material disposed adjacent said magnetic core and being in a relatively unstressed condition as finally assembled, said magnetic core having an elongated side face thereof which defines a boundary of the signal flux path in said magnetic core and said elongated side face extending over substantially the entire length of said signal flux path in said magnetic core, said auxiliary means comprising separate auxiliary magnetic material formed entirely separately from the magnetic core and said separate auxiliary magnetic material having an elongated surface thereof disposed in confronting relation to said elongated side face of said magnetic core material over substantially the entire length of said elongated side face, said auxiliary magnetic material having a substantial cross-sectional area in comparison to the cross-sectional area of said magnetic core so as to provide substantial additional flux carrying capacity parallel to said signal flux path, and an electric winding encircling in common the signal flux path of said magnetic core and said separate auxiliary magnetic material.

17. A magnetic head having a pair of poles, means providing a path for a magnetic record medium successively across said poles, one of said poles being disposed directly at the record medium path and the other of said poles being substantially offset from said record medium path and a nonmagnetic material interposed between the other of said poles and said record medium and having a thickness dimension of the order of 0.0005 inch.

18. The head of claim 17 with said nonmagnetic material being plated on said other of said poles.

19. A magnetic head having a pair of poles, means providing a path for a magnetic record medium successively across said poles, one of said poles being disposed directly at the record medium path and the other of said poles being substantially offset from said record medium path, and the other of the poles being offset from the record medium path by a distance in the range from about 0.001 inch to 0.00002 inch.

20. The head of claim 19 with said other pole having a spacer of chromium plated thereon to provide said offset, with said record medium being in sliding contact with said spacer as it travels along said record medium path.

21. A magnetic head comprising a magnetic core having a signal flux path therein of loop configuration and having coupling means for coupling the signal flux path of the magnetic core to a magnetic record medium traveling along a record medium path, auxiliary means of magnetic material disposed adjacent said magnetic core and being in a relatively unstressed condition as finally assembled, said magnetic core having an elongated side face thereof which defines a boundary of the signal flux path in said magnetic core and said elongated side face extending over substantially the entire length of said signal flux path in said magnetic core, said auxiliary means comprising auxiliary magnetic material having an elongated surface thereof disposed in confronting relation to said elongated side face of said magnetic core over substantially the entire length of said face, said auxiliary means in its entirety being spaced from the record medium path so as to be clear of contact with the magnetic record medium and having a cross-sectional area at least approximately equal to the cross-sectional area of said magnetic core to add substantially to the flux carrying capacity of the magnetic core without substantially increasing the scanning width of the magnetic head, and an electric winding encircling in common the signal flux path of said magnetic core and said auxiliary magnetic material.

22. A magnetic head according to claim 21 with the magnetic core being formed of magnetic material which is in an unstressed condition compared to laminations which are glued and clamped after anneal.

23. A magnetic head comprising a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and auxiliary means of magnetic material disposed adjacent said magnetic core and being in a relatively unstressed condition, said magnetic core having magnetic core material defining a loop magnetic flux path for coupling with the magnetic record medium at said coupling means, said magnetic core material providing at an outer side of the loop magnetic flux path an outer elongated side face which slidably engages with the magnetic record medium adjacent said coupling means, and providing at an inner side of the loop magnetic flux path opposite said outer side an inner elongated side face, said auxiliary means of magnetic material comprising auxiliary magnetic material of sheet configuration disposed substantially at right angles to said inner elongated side face of said magnetic core and extending along said inner elongated side face over substantially the entire length thereof, said auxiliary magnetic material having a cross section at least substantially equal to the cross section of said magnetic core material, said auxiliary means in its entirety being spaced from the record medium path so as to be clear of contact with the magnetic record medium, said auxiliary magnetic material serving to substantially add to the flux carrying capacity of the magnetic core without increasing the scanning width of the magnetic head, and an electric signal winding coupled in common to said signal flux path of said magnetic core material and said auxiliary magnetic material.

24. A magnetic head in accordance with claim 23 with said magnetic core material being in an unstressed condition compared to laminations which are glued and clamped after anneal.

25. A magnetic head comprising

a magnetic core having coupling means for coupling the core to a magnetic record medium traveling along a record medium path, and

auxiliary means disposed adjacent said magnetic core for diverting residual flux due to residual magnetization of the core from the path of the record medium,

mounting means secured to said magnetic core for fixedly positioning the same relative to said record medium path during a transducing operation, and

said mounting means being spaced from said auxiliary means by a nonrigid medium so as to avoid stressing of the material of said auxiliary means.

26. The head of claim 25 with
said auxiliary material being integral with said magnetic core, and the space between said auxiliary means and said mounting means being filled with a yieldable material.

27. The head of claim 25 with
said auxiliary means being separated from said magnetic core by a layer of nonrigid medium.

28. The head of claim 27 with
said auxiliary means being spot welded to said core at the part thereof near said coupling means.

29. The head of claim 27 with
said layer having a thickness dimension of not greater than about 0.001 inch over at least a substantial proportion of the area thereof.

30. A magnetic head comprising
a magnetic core having a coupling gap for coupling of the core with a magnetic record medium moving along a record medium path across the core, said magnetic core being formed of relatively wide sheet material,
said sheet material having confronting free end portions of reduced width at opposite sides of said coupling gap, said sheet material providing a loop magnetic flux path between said free end portions for magnetic flux interlinkage with the record medium at said coupling gap, said free end portions having a width dimension extending along the transverse boundaries of said coupling gap corresponding to the width of the channel of the record medium to which said magnetic core is coupled,
said sheet material providing a main magnetic core portion extending along said loop magnetic flux path and having a width equal to the width dimension of said free end portions,
said sheet material providing an auxiliary magnetic core portion for diverting residual flux due to residual magnetization of the core from the path of the record medium, and extending laterally from the main core portion to provide a total width of said sheet material transverse to said loop magnetic flux path except at said free end portions which total width is substantially greater than the width dimension of said free end portions at the transverse boundaries of said coupling gap,
said auxiliary magnetic core portion being spaced from the record medium path over its entire extent so as to be clear of contact with the record medium, and
auxiliary means comprising said auxiliary magnetic core portion for reducing the field intersecting the record medium path due to a maximum residual magnetization of the magnetic core to a value substantially below the coercivity of the record medium.

31. A magnetic transducer head according to claim 30 with
said auxiliary magnetic core portion of the width of said sheet material having a lateral dimension at least substantially equal to the width dimension of said main magnetic core portion so that the total width of said sheet material is at least substantially twice the width dimension of said main magnetic core portion.

32. A magnetic transducer head according to claim 30 with
said auxiliary magnetic core portion of the width of said sheet material providing a residual magnetic flux path for residual flux produced by residual magnetization of said main core portion bypassing said record medium and serving to reduce the residual flux intersecting the record medium path by at least about 50 percent compared with a head consisting of said main magnetic core portion only.

33. A magnetic transducer head according to claim 30 with said auxiliary magnetic core portion of said sheet material having a cross section substantially greater than that of said main magnetic core portion of said sheet material.

34. A magnetic transducer head according to claim 30 with
said auxiliary means being further provided by auxiliary magnetic material disposed adjacent to but insulated from said sheet material on the side thereof away from said record medium path.

35. A magnetic transducer head according to claim 34 with said auxiliary magnetic material having a coercivity as measured from direct current saturation not substantially greater than from 0.003 oersted to 0.009 oersted.