Nov. 13, 1962 A. M. SPRINGER 3,064,088

ELECTROMAGNETIC TRANSDUCER

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FIG. 1

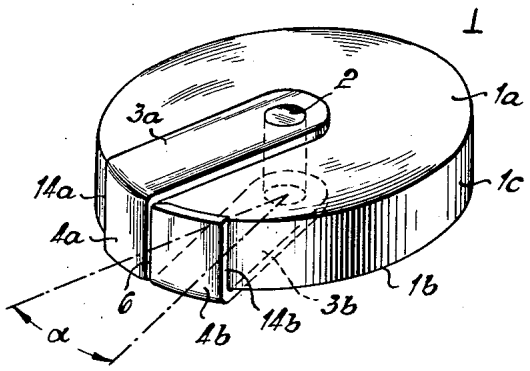


FIG. 2

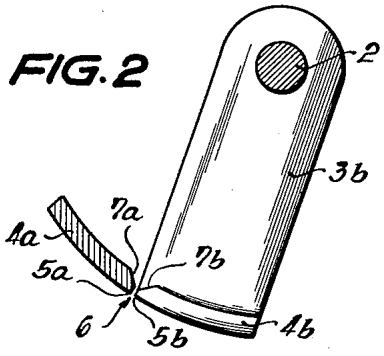
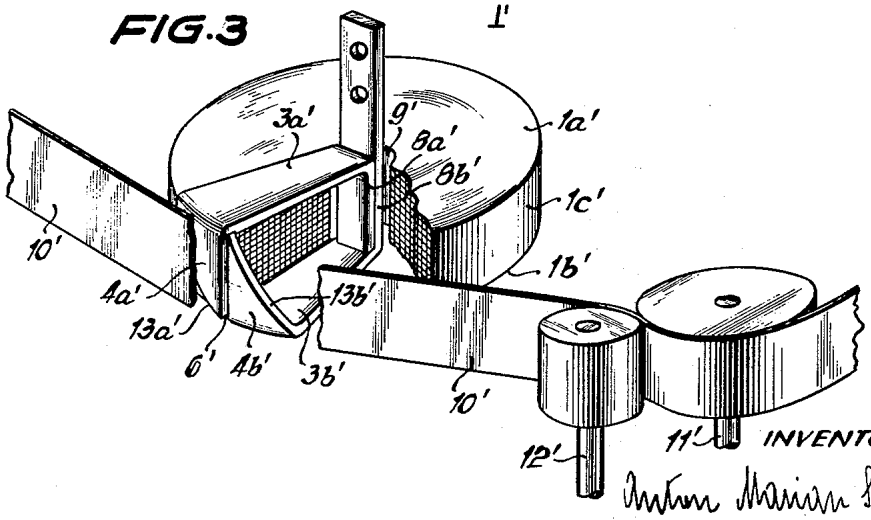


FIG. 3



INVENTOR

Anton Marian Springer

by Lewis Salzer Atty.

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FIG. 4

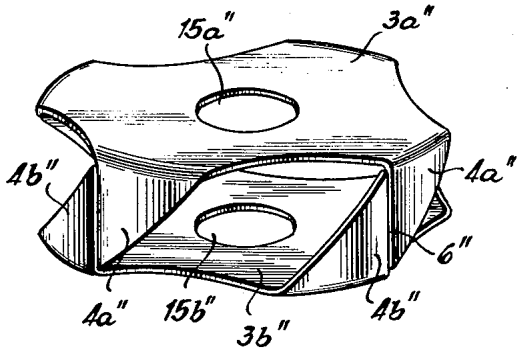
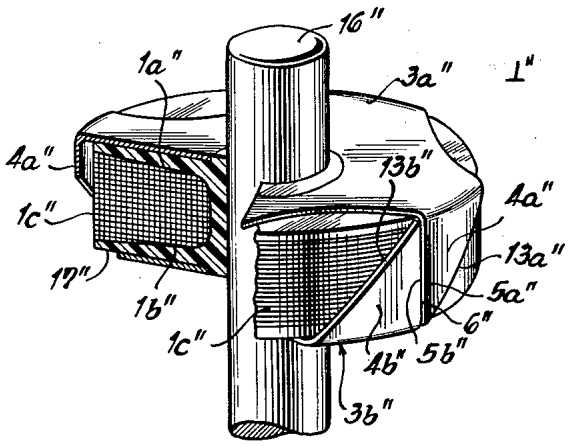


FIG. 5



INVENTOR:

Anton Marian Springer

by Irwin Salpeter

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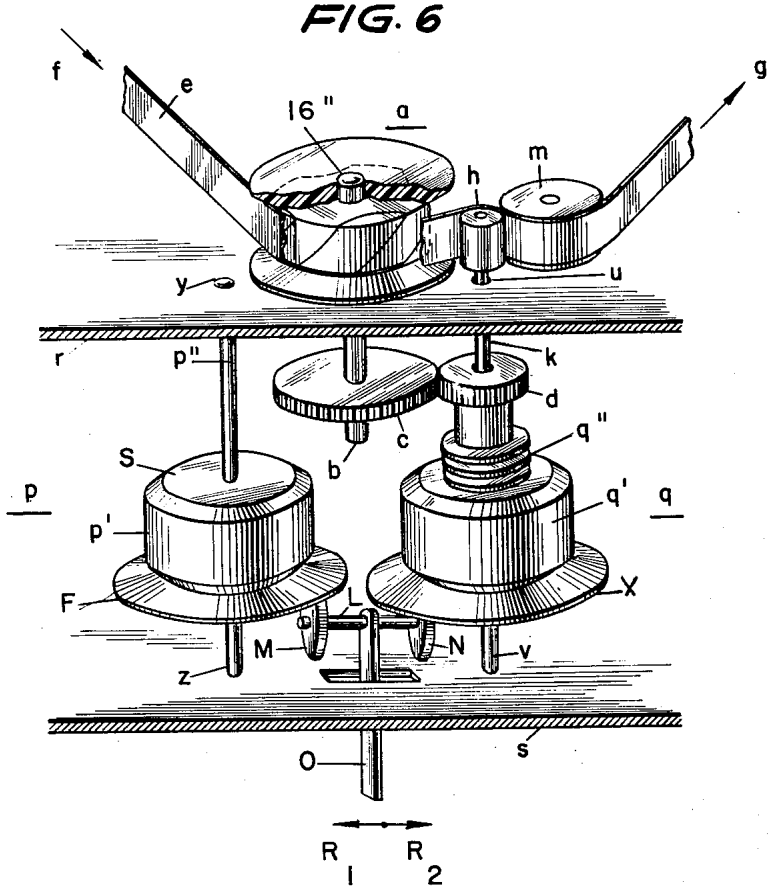
FIG. 6



INVENTOR:
Anton Marian Springer
by Irwin Salpeter Atty

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ELECTROMAGNETIC TRANSDUCER

Anton Marian Springer, Homburg vor der Hohe, Germany, assignor to Telefonbau und Normalzeit G.m.b.H., Frankfurt am Main, Germany

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6 Claims. (Cl. 179—100.2)

This invention relates to electromagnetic transducers to be used as recording heads, and as playback heads, in combination with magnetic recording tape.

Such transducers convert audio currents into a corresponding magnetic tape record when used as recording heads, and such transducers re-convert magnetic tape records of audible sounds into audio currents, when used as playback heads.

This application is a continuation-in-part of my copending patent application Ser. No. 618,766 filed October 29, 1956 for Rotatable Electromagnetic Transducer System, now U.S. Patent 3,022,383 issued February 20, 1962.

It is a general object of this invention to provide improved electromagnetic transducers to be used as recording heads and as playback heads.

Another object of this invention is to provide simplified electromagnetic transducers the constituent parts of which lend themselves to be readily assembled and which transducers do not tend to distort the sounds in the process of their original conversion into magnetic records, and their subsequent re-conversion from such records to sounds.

Another object of the invention is to provide electromagnetic transducers whose damping is substantially constant over a wide frequency range.

Another object of the invention is to provide electromagnetic transducers whose damping is substantially constant within the range of 50 and 16,000 cycles/sec., and varies but a few decibels.

Another object of the invention is to provide electromagnetic transducers whose leakage flux is controlled in such a way as to minimize disturbances.

Still another object of the invention is to provide electromagnetic transducers having pole pieces shaped in such a way as to minimize echo-like disturbances resulting from leakage flux.

A further object of this invention is to provide improved rotatable electromagnetic transducers which lend themselves to varying playback time without changing the pitch of the sounds involved.

The foregoing and other general and special objects of the invention and advantages thereof will become more apparent from the ensuing particular description thereof as illustrated in the accompanying drawings wherein:

FIG. 1 is an isometric view of a fixed transducer embodying the invention;

FIG. 2 is a section of the structure of FIG. 1 taken at right angles to the longitudinal axis thereof;

FIG. 3 is an isometric view of a modified form of the transducer of FIG. 1, some of the parts thereof being shown as being broken away, FIG. 3 also showing magnetic recording tape intended to be jointly used with the transducer and capstan means for moving the tape past the transducer;

FIG. 4 is an isometric view of some of the parts forming the magnetic path of a rotatable transducer embodying the invention;

FIG. 5 is an isometric view of a complete rotatable multipolar transducer embodying the invention with some of the constituent parts thereof shown as being broken away, said transducer comprising the magnetic path structure of FIG. 4; and

FIG. 6 is an isometric view of an application of the transducer of FIG. 5 in a playback machine adapted to control the speed of playback without changing the pitch of the sounds involved.

Referring now to the drawings and more particularly to FIGS. 1 and 2 thereof, numeral 1 has been applied to indicate a magnet coil or winding which is substantially cylindrical and has an upper end plane 1*a* and a lower end plane 1*b* and a lateral cylindrical surface 1*c*. The center region of coil 1 defines a passage accommodating a magnetic core 2 forming a path of low magnetic reluctance between the end planes 1*a*, 1*b*, of coil 1. Each of a pair of plates or laminae 3*a*, 3*b* of magnetic material having a high degree of permeability is arranged in one of end planes 1*a*, 1*b*, and plates or laminae 3*a*, 3*b* are thus magnetically connected by a path 2 of low magnetic reluctance. Plates 3*a*, 3*b* are angularly displaced, or arranged out of registry, and the angle enclosed by plates 3*a*, 3*b* has been indicated by the reference character α. Plates 3*a*, 3*b* have a pair of integral extensions 4*a*, 4*b* bent about 90 degrees out of the general planes of plates or laminae 3*a*, 3*b* and arranged substantially in the plane defined by the lateral cylindrical surface of coil 1. Extensions 4*a*, 4*b* are likewise laterally displaced or arranged out of registry. They form a pair of pole pieces having a pair of juxtaposed narrowly spaced edges 5*a*, 5*b* extending parallel to the axis of core 2 and at right angles to planes 1*a*, 1*b*. Edges 5*a*, 5*b* define a pole gap 6 adapted to be cooperatively engaged by a magnetic tape (not shown) movable relative thereto. Edges 5*a*, 5*b* are situated in radial planes of coil 1 and core 2.

The depth of the pole gap 6 upon which the efficiency of the magnetic recording head, or playback head, depends is determined by the thickness of the material or sheet metal of which parts 3*a*, 4*a* and 3*b*, 4*b* are made. The mechanical strength of dimensional stability of each pole piece 4*a*, 4*b* depends largely upon its width in a direction peripherally of coil 1. Thus gap depth may be chosen with little consideration to mechanical strength or dimensional stability requirements. The structure of FIG. 1 makes it also possible to chamfer the pole-gap-defining edges 5*a*, 5*b* of pole pieces 4*a*, 4*b* as indicated at 7*a*, 7*b*. Such chamfering, or bevelling, at the radially inner surface of pole pieces 4*a*, 4*b* makes it possible to reduce the depth of the magnetic poles formed by pole pieces 4*a*, 4*b* to a fraction of the thickness of the sheet stock of which parts 3*a*, 4*a*, and 3*b*, 4*b* are made.

It will also be apparent that the head shown in FIGS. 1 and 2 can readily be assembled from pre-fabricated parts, and in particular that coil 1 can also be pre-fabricated part rather than one which must be wound during the process of assembly. The entire unit shown in FIG. 1 may be encapsulated in a casting of synthetic resin. The high degree of dimensional stability of pole pieces 4*a*, 4*b* precludes occurrence of changes in the width of gap 6 during the process of synthetic resin encapsulation.

Referring now to FIG. 3 magnet coil 1 has end planes 1*a'*, 1*b'* and a lateral cylindrical surface 1*c'*. The structure comprises further two stampings 3*a'*, 4*a'*, 8*a'* and 3*b'*, 4*b'* and 8*b'* of a magnetic material having a high degree of magnetic permeability which are bent substantially into the shape of a U. The pole-piece-forming shanks 4*a'*, 4*b'* arranged substantially in the outer cylindrical surface of coil 1 are curved to substantially conform with the shape of that surface. The core-forming shanks 8*a'*, 8*b'* are inserted into the central passage 9' defined by coil 1. Shank 8*b'* extends beyond end surface 1*a'* and is provided with a pair of holes for receiving a pair of fasteners such as, for instance, a pair of screws, intended to support the entire head structure. The web

portions 3a', 3b' are arranged in abutting relation with end planes 1a', 1b'. Gap 6' is adapted to be engaged by magnetic recording tape 10' wound around roller 11' and driven by capstan 12'. The pair of extensions 4a', 4b' decreases in width in a direction peripherally of the lateral surface 1c' of coil 1, resulting in that their outline is substantially triangular in shape. The edges 13a', 13b' of extensions 4a', 4b' are substantially helical and have a predetermined pitch. The reason for this important feature will now be explained.

It will be apparent that the structures of FIGS. 1 and 2, on the one hand, and of FIG. 3, on the other hand, differ inasmuch as in the former the edges 14a, 14b of pole pieces 4a, 4b remote from gap 6 are parallel to the longitudinal axes of coil 1 and core 2, and parallel edges 5a, 5b. Edges 14a, 14b define magnetic gaps whose action tends to be detrimental. If the device of FIGS. 1 and 2 is used for playback, the edges 14a, 14b tend to cause undesirable echo-like effects. These effects may be deemed insignificant yet, in some cases, particularly in rotatable multiple heads as shown in FIGS. 4–6, these effects tend to be serious and their elimination is highly desirable. In the structure of FIG. 3 the slanting peripherally outer edges 13a', 13b' of pole pieces 4a', 4b' cause a gradual rather than an abrupt change of the magnetic leakage flux which leaves, or enters, pole pieces 4a', 4b' through these edges, thus minimizing, or eliminating, the aforementioned echo-like distortions of sound records.

Referring now to FIGS. 4 and 5, the structure shown therein is an application of the concepts underlying FIG. 3 to electromagnetic rotatable multihead transducers. The structure of FIGS. 4 and 5 comprises end laminae or end plates 3a'', 3b'' of a magnetic material having a high degree of permeability adapted to engage the end planes 1a'', 1b'' of a magnet coil 1, or the end planes of a spool or coil support 17''. Plates 3a'', 3b'' are provided with central apertures 15a'', 15b'' for the passage of a hollow core 16'' made of a material having a high degree of permeability. As shown in FIG. 6 hollow core 16'' may receive a rotatable shaft around which all the rotatable parts of the transducer may rotate. Core 16'' establishes a path of low reluctance between plates 3a'' and 3b''. Each of plates or laminae 3a'' and 3b'' is provided with a plurality of projections 4a'' and 4b'', respectively bent about 90 degrees out of the general plane of the aforementioned plates or laminae. Projections 4a'' are angularly displaced in regard to projections 4b'' or, in other words, projections 4a'' and 4b'' are out of registry. Projections or extensions 4a'', 4b'' form a plurality of pairs of pole pieces of which each pair has a pair of narrowly spaced edges 5a'', 5b'' parallel to the longitudinal axis of coil 1'' defining a pole gap therebetween. The extensions 4a'', 4b'' conform to the shape of cylindrical surface 1c'' of coil or winding 1 and the width thereof decreases in a direction peripherally of surface 1c''. The right part of FIG. 5 indicates a thin shell of synthetic resin encapsulating the transducer structure. In the left part of FIG. 5 this thin shell and portions of coil 1'' and spool 17'' have been shown as being broken away, thus exposing to view the inside of the transducer.

While the pole-piece-forming extensions 4a'', 4b'' are substantially triangular in the finished product, their configuration ought to be preferably initially rectangular or, in other words, similar to the shape illustrated in FIG. 1. During the process of manufacture the rectangular or square projections or extensions 4a'', 4b'' are cut down to their ultimate triangular shape as, for instance, by sawing. Such a mechanical change of annealed magnetic material causes changes in its molecular structure. As a result of being cut down to the triangular shape shown in FIGS. 4 and 5 a projection 4a'', 4b'' which was originally rectangular, or square, has a reduced permeability adjacent the slanting edges 13a'', 13b'' thereof. In other words, the permeability at the slanting edges 13a'', 13b'' is less than the permeability of the material at the pole-face-forming edges 5a'', 5b'' which are parallel to the axis of coil 1''.

Referring now to FIG. 6 of the drawing, reference character a has been applied to generally indicate the rotatable multiple magnetic recording and playback head shown in FIG. 5. Head a is driven by shaft b inserted into the hollow core member 16''. Gear c is fixedly mounted on shaft b and driven by gear d. Magnetic tape e is wound along a predetermined angle around the cylindrical surface of magnetic playback head a, and moves in the direction of arrows f and g from a supply reel (not shown) on the left to a take up reel (not shown) on the right of FIG. 6. The tape drive comprises capstan h fixedly mounted on driving shaft k parallel to driven shaft b, and the pressure roller m. The tape drive further includes a pair of synchronous motors generally indicated by reference letters p and q. The axes of rotation and the shafts of motors p and q are arranged parallel to each other, and parallel to the driving shaft b of magnetic playback head a. Motors p and q are arranged between a pair of parallel plates r and s forming part of a mounting frame structure or chassis. Synchronous motor q comprises the rotor q' mounted on, or coupled with, shaft k supported in bearings u and v provided in plates r and s, and stator q''. Friction plate X is arranged coaxially with respect to rotor q' and stator q'' and fixedly mounted on the former for joint rotation therewith. Synchronous motor p—which is an auxiliary motor—comprises the rotor p' mounted on shaft p'' supported in bearings y and z in frame plates r and s. Motor p further comprises the stator S fixedly mounted on the chassis, whereas stator q'' of motor q is rotatable about shaft k, and thus adapted to rotate relative to chassis plate r, s. Friction plate F is arranged coaxially with respect to rotor S and stator p', and fixedly mounted on the former for joint rotation therewith. Shaft L supporting friction rollers M, N is supported by a bearing rod O adapted to be shifted selectively either to the left, or to the right, as indicated by the arrows R_1 and R_2. Shaft L is arranged at right angles to shafts k and p'', and rollers M and N are in frictional engagement with friction plates F, X, and thus adapted to transmit the rotary motion of rotor p' of motor p to the rotor q' of motor q. Shifting of lever O to the left or right, as the case may be, permits a continuous change of the gear ratio of transmission F, M, L, N and X, and hence a continuous change of the angular velocity at which rotor q' is being driven by rotor p'. Gear d driving gear c on the shaft of playback head a is fixedly mounted on stator q'' for joint rotation therewith.

Since the relative angular velocity between the stator and the rotor of a synchronous motor is constant, and since playback head a is being driven by the stator q'' and capstan h is being driven by the rotor q' of synchronous motor q, the relative velocity between the surface of playback head a and the magnetic tape e will be constant. The absolute velocity of tape e depends upon the angular velocity of capstan c which, in turn, depends upon the angular velocity of rotor q'. The latter velocity depends, in turn, on the gear ratio of transmission F, M, L, N and X which can be changed continuously to achieve either decelerated, or an accelerated playback, as desired.

It will be understood that I have illustrated and described herein several preferred embodiments of my invention and that various alterations may be made in the details thereof without departing from the spirit and scope of my invention as defined in the appended claims.

I claim:

1. A multiple rotatable recording and playback head comprising a plurality of parts arranged within a cylindrical space defined by an upper end plane and a lower end plane parallel to said upper end plane and by a cylindrical lateral surface intersecting with said upper end plane along an upper circular edge and intersecting

with said lower end plane along a lower circular edge, said plurality of parts including a shaft coextensive with the axis of said space; a toroidal magnet coil arranged coaxially with respect to and jointly rotatable with said shaft; a magnetic core supported by and jointly rotatable with said shaft arranged inside said coil and forming a flux path between said upper end plane; a magnetizable top lamination arranged in said upper end plane and having edge portions receding from said upper circular edge to define a plurality of upper arms extending radially outwardly from said core and having a predetermined circular pitch; a magnetizable bottom lamination arranged in said lower end plane and having edge portions receding from said lower circular edge to define a plurality of lower arms extending radially outwardly from said core and having a predetermined circular pitch equal to said first mentioned circular pitch; each of said plurality of upper arms having an axial extension limited to regions thereof situated between said receding edge portions, said axial extension of each of said plurality of upper arms being bent about 90 degrees out of said upper end plane substantially into said cylindrical surface and each of said plurality of lower arms having an axial extension limited to the regions thereof situated between said receding edge portions, said axial extension of each of said plurality of lower arms being bent about 90 degrees out of said lower end plane substantially into said cylindrical surface; the axial extensions of said plurality of upper arms and the axial extensions of said plurality of lower arms having juxtaposed edges equal in length to the spacing between said upper end plane and said lower end plane forming a plurality of pole gaps extending parallel to the axis of said cylindrical space; and the portions of said axial extensions of said plurality of upper arms and the portions of said axial extensions of said plurality of lower arms remote from the regions said juxtaposed edges having a smaller permeability than the portions of said axial extensions of said plurality of upper arms and the portions of said axial extensions of said plurality of lower arms immediately adjacent the regions said juxtaposed edges.

2. A multiple rotatable recording and playback head comprising a plurality of parts arranged within a cylindrical space defined by an upper end plane and by a lower end plane parallel to said upper end plane and by a cylindrical lateral surface intersecting with said upper end plane along an upper circular edge and intersecting with said lower end plane along a lower circular edge, said plurality of parts including a shaft coextensive with the axis of said space; a toroidal magnet coil arranged coaxially with respect to said shaft and jointly rotatable with said shaft; a magnetic core supported by and jointly rotatable with said shaft arranged inside said coil; a magnetizable top lamination arranged in said upper end plane and having edge portions receding from said upper circular edge to define a plurality of upper arms extending radially outwardly from said core and having a predetermined circular pitch; a magnetizable bottom lamination arranged in said lower end plane and having edge portions receding from said lower circular edge to define a plurality of lower arms extending radially outwardly from said core and having a predetermined circular pitch equal to said first mentioned circular pitch; each of said plurality of upper arms having a substantially triangular axial extension limited to the regions thereof situated between said receding edge portions, said axial extension of each of said plurality of upper arms being bent about 90 degrees out of said upper end plane substantially into said cylindrical surface and each of said plurality of lower arms having a substantially triangular axial extension limited to the regions thereof situated between said receding edge portions, said axial extension of each of said plurality of lower arms being bent about 90 degrees out of said lower end plane substantially into said cylindrical surface; said axial extension of each of said plurality of upper arms having a first edge coextensive with a portion of said upper circular edge, a second edge parallel to the axis of said cylindrical space substantially equal in length to the spacing between said upper end plane and said lower end plane enclosing an angle of 90 degrees with said first edge, and a third edge substantially helical in shape enclosing acute angles with said first edge and with said second edge; and said axial extension of each of said plurality of lower arms having a first edge coextensive with a portion of said lower circular edge, a second edge parallel to the axis of said cylindrical space substantially equal in length to the spacing between said upper end plane and said lower end plane enclosing an angle of 90 degrees with said first edge, and a third edge substantially helical in shape enclosing acute angles with said first edge and with said second edge.

3. A multiple rotatable recording and playback head comprising a plurality of parts arranged within a cylindrical space defined by an upper end plane and a lower end plane parallel to said upper end plane and by a cylindrical lateral boundary surface intersecting with said upper end plane along an upper circular edge and intersecting with said lower end plane along a lower circular edge, said plurality of parts including a shaft coextensive with the axis of said space; a toroidal magnet coil arranged coaxially with respect to said shaft and jointly rotatable with said shaft; a magnetic core supported by and jointly rotatable with said shaft arranged inside said coil; a magnetizable top lamination arranged in said upper end plane and having edge portions receding from said upper circular edge to define a plurality of upper arms extending radially outwardly from said core means and having a predetermined circular pitch; a magnetizable bottom lamination arranged in said lower end plane and having edge portions receding from said lower circular edge to define a plurality of lower arms extending radially outwardly from said core and having a predetermined circular pitch equal to said first mentioned circular pitch; each of said plurality of upper arms having a substantially triangular axial extension limited to the regions thereof situated between said receding edge portions, said axial extension of each of said plurality of upper arms being bent about 90 degrees out of said upper end plane substantially into said cylindrical surface and each of said plurality of lower arms having a substantially triangular axial extension limited to the regions thereof situated between said receding edge portions, said axial extension of each of said plurality of lower arms being bent about 90 degrees out of said lower end plane substantially into said cylindrical surface; said triangular extension of each of said plurality of upper arms having a first edge coextensive with a portion of said upper circular edge, a second edge parallel to the axis of said cylindrical space equal in length to the spacing between said upper end plane and said lower end plane enclosing an angle of 90 degrees with said first edge, and a third edge substantially helical in shape enclosing acute angles with said first edge and with said second edge; said triangular extension of each of said plurality of lower arms having a first edge coextensive with a portion of said lower circular edge, a second edge parallel to the axis of said cylindrical space equal in length to the spacing between said upper end plane and said lower end plane enclosing an angle of 90 degrees with said first edge, and a third edge substantially helical in shape enclosing acute angles with said first edge and with said second edge, said triangular extension of each of said upper arms and said triangular extension of each of said lower arms having a higher permeability in the region of said second edge thereof than in the region of said third edge thereof.

4. A multiple rotatable recording and playback head for sound reproducing systems comprising a plurality of

parts arranged within a cylindrical space defined by an upper end plane, a lower end plane parallel to said upper end plane and a lateral cylindrical surface forming an upper circular edge at the locus of intersection thereof with said upper end plane and forming a lower circular edge at the locus of intersection thereof with said lower end plane, said plurality of parts including a shaft coextensive with the axis of said space; a toroidal magnet arranged substantially coaxially with respect to and supported by said shaft; a magnetic core inside said coil; a first lamination of a magnetizable material arranged in said upper end plane and having a peripheral edge comprising circular segments coextensive with portions of said upper circular edge, said peripheral edge further comprising portions alternating with said circular segments and recessed radially inwardly from said upper circular edge; a second lamination of a magnetizable material arranged in said lower end plane and having a peripheral edge comprising circular segments coextensive with portions of said lower circular edge, said peripheral edge of said second lamination further comprising portions alternating with said circular segments of said second lamination and recessed radially inwardly from said lower circular edge; said circular segments and said recessed portions of said peripheral edge of said first lamination being angularly displaced relative to said circular segments and said recessed portions of said peripheral edge of said second lamination; said first lamination having axial extensions limited to the region of said circular segments thereof and bent about 90 degrees out of said upper end plane substantially into said cylindrical surface; said second lamination having axial extensions limited to the regions of said circular segments thereof and bent about 90 degrees out of said lower end plane substantially into said cylindrical surface; said axial extensions of said first lamination and said axial extensions of said second lamination having edges parallel to said axis of said cylindrical space equal in length to the spacing between said upper end plane and said lower end plane establishing a pattern of pole gaps; the peripheral width of said extensions of said first lamination being narrowest immediately adjacent said lower end plane and increasing progressively toward said upper end plane; and the peripheral width of said extensions of said second lamination being narrowest immediately adjacent said upper end plane and increasing progressively toward said lower end plane.

5. A multiple rotatable recording and playback head as specified in claim 4 wherein said axial extensions of said first lamination are substantially in the shape of triangles each defining a right angle immediately adjacent said upper end plane, and wherein said axial extensions of said second lamination are substantially in the shape of rectangular triangles each defining a right angle immediately adjacent said lower end plane.

6. An electromagnetic transducer for converting audio currents into corresponding magnetic tape records, and for re-converting magnetic tape records of audible sounds into audio currents comprising, in combination: a magnet coil having a pair of end planes and a cylindrical lateral surface; a pair of magnetic laminae each superimposed upon one of said pair of end planes of said coil; said pair of laminae having radially outer ends angularly displaced in regard to the axis of said coil, each of said radially outer ends being bent about 90 degrees out of the general plane of one of said pair of laminae into a second cylindrical surface substantially coaxial to said cylindrical lateral surface of said coil, said radially outer ends having juxtaposed narrowly spaced edges parallel to the axis of said coil and forming a pair of pole surfaces of opposite polarity; and said pair of laminae having radially inner ends each bent about 90 degrees out of the general plane of one of said pair of laminae and occupying the center region of said coil.

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