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ELECTROMAGNETIC TRANSDUCER HEAD
AND ENERGIZING CIRCUIT THEREFORRobert A. von Behren, Valparaiso, Ind., assignor
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This invention relates to an electromagnetic transducer head and energizing circuit, and more particularly, to a bridge-type head and its associated energizing circuit.

In one method of magnetic recording, a lengthy magnetizable medium is drawn across an electromagnetic transducer head assembly at substantially uniform linear velocity. The head assembly includes a magnetic core having a non-magnetic gap over which the medium passes and is provided with suitable current-conducting exciting elements to produce a magnetic field across the gap.

During the recording operation, current is caused to flow in the exciting elements in accordance with the time variations of an intelligence to produce a time-varying magnetic field in the core in accordance with the value thereof. The lengthy magnetizable medium is subjected to the influence of this field as it is drawn therethrough, and magnetization is imparted to incremental lengths of the medium in accordance with the time variations of the intelligence, thus causing variations in the magnetization of the medium along its length in accordance with the time variations of the intelligence.

During reproduction, the lengthy magnetizable medium is drawn across the same or similar head assembly to set up a flux in the core portion thereof in accordance with the magnetization of the medium along successive incremental lengths thereof as it passes across the gap of the magnetic core member. The resultant time-varying flux induces voltage in the coil with which the flux is linked in accordance with the time rate of change thereof. This voltage may be amplified and suitably reproduced by a loud speaker or similar device to reproduce the intelligence recorded.

This magnetic recording and reproducing inherently involved the conversion of an intelligence into a time-varying magnetic field during the recording operation, and the conversion of a time-varying magnetic flux to an intelligence in the reproducing operation. Great improvements have been made in the magnetic recording field during recent years, and to some extent, this has been brought about by the use of a superimposed high frequency current on the audio current during the recording process. When the amplitude of this high frequency current is within a predetermined range so as to produce a field which bears a predetermined relationship with respect to the coercive force of the magnetic medium upon which the signal is to be recorded, greatly

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improved results are obtained. Many problems, however, arise when efforts are made to mix this high frequency of supersonic bias with the audio signal.

It has been suggested in the past that the audio and bias signals be mixed in an amplifier-mixer stage, and the composite signal applied to a single winding on the recording head. Most recording heads, however, have a large inductive reactance at the bias frequency, and therefore require a high bias voltage to develop the necessary signal. For that reason, the stage driving the recording head must be capable of delivering a bias voltage many times that of the maximum audio signal needed. A separate winding on the head has also been used for supplying the high frequency bias.

One of the novel features and objects of the present invention is to provide a novel electromagnetic transducer head having a novel core structure and a novel arrangement of audio and high frequency windings thereon.

A further object of the present invention is to provide a novel bridge-type recording head.

A further object of the present invention is to provide a novel electromagnetic transducer head and energization circuit therefor in which the oscillator may be left connected in the circuit of the head during playback operation.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization, manner of construction, and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Figure 1 is a diagrammatic illustration of an electromagnetic transducer head embodying the novel teachings and principles of the present invention, together with its associated electrical circuit, and in which Figure 2 is a schematic representation of the core of the head of Figure 1.

In the embodiment of the invention illustrated in the drawing, the electromagnetic transducer head 10 includes a core member 11 which is generally in the shape of a "figure 8." This core 11 includes a central cross leg 12, a pair of upstanding legs 13 and 14, having a pair of converging pole tips 15 and 16, respectively, and a pair of downwardly extending legs 17 and 18 which also have a pair of converging pole portions 19 and 20, respectively. It will be observed that the lower portion of the core structure 11 is symme-

trical with the upper portion. For convenience of designation, this core structure might be said to be arranged in bridge form with four outer legs 13, 14, 17 and 18 and a fifth center leg 12, as shown schematically in Figure 2. The gaps are thus in two opposite corners of the "bridge."

A relatively high impedance voice coil 21 is wound on the central leg 12 and is connected through conductors 22 and 23 to an audio amplifier 24. When the electromagnetic transducer head 10 is acting as a recording head, fluctuating electric energy is supplied from the audio amplifier 24 through the conductors 22 and 23 to the voice coil 21. When the electromagnetic transducer head 10 is acting as a playback head, flux threading the voice coil 21 induces a voltage therein which is transmitted through the conductors 22 and 23 to the audio amplifier 24. It will, of course, be understood that the connection of the voice coil 21 to the audio amplifier 24 forms no part of the present invention. It should, however, be understood that when the head 10 is acting as a recording head, the output of the amplifier is connected to the voice coil 21, but when the head 10 is acting as a playback head, the voice coil 21 is connected to the input of the audio amplifier 24.

The high frequency component for use during the recording operation is supplied through four coils 25, 26, 27 and 28 which are wound, respectively, on legs 13, 14, 17 and 18. These four coils 25, 26, 27 and 28 are connected in series to an oscillator 29 which is arranged to supply a high frequency bias current for the recording operation.

It is a function of the oscillator 29 to generate a high frequency voltage for simultaneous application to the windings 25 to 28, inclusive, when a signal to be recorded is fed from the amplifier 24 to the signal coil 21 on the head 10. This oscillator 29 may be arranged to operate, for example, at a frequency of approximately 18 kilocycles, the frequency being determined principally by the natural resonant frequency of the inductor 30 and the capacitor 31. It will be observed that the oscillator 29 is a conventional Hartley circuit wherein positive feedback is obtained by connecting a tap on the inductor 30 to the cathode 33 of the electron discharge device 32 and the opposite ends of the inductor 30 to the control electrode 34 and the anode 35 of the electron discharge device 32, respectively.

Spaced path voltage for the electron discharge device 32 is derived from a supply line 36 which connects to a suitable source of uni-directional electric energy indicated at B+. A resistor 37 and a switch 38 are connected in this plate bias circuit. An output winding 39 is inductively coupled to the inductor 30, and this output winding 39 of the oscillator 29 is directly connected at all times to the windings 25, 26, 27 and 28 of the head 10.

The confronting poles 15 and 16 of the legs 13 and 14 on the head 10 define a small non-magnetic gap across which the magnetic record member 40 passes at substantially constant velocity. While this gap between the pole portions 15 and 16 may vary to a considerable degree depending upon the wave length of the average signal to be recorded and reproduced, it has been found in practice that this gap should preferably be between .0005 inch and .002 inch.

Referring now to the arrangement of the various coils on the head of the electromagnetic transducer head 10, it will be observed that if

the coils 25, 26, 27 and 28 are identical in number of turns and are wound as shown, magnetic flux from these four coils is in an additive sense around a path which includes legs 13, 17, 18 and 14. The flux produced by coils 25 and 26 also tends to flow in one direction across central leg 12, but it will be observed that the flux produced by coils 27 and 28 tends to flow across central leg 12 in the opposite direction. Since the magnetomotive forces which tend to set up these fluxes across the central leg 12 are equal and opposite, no flux is established across the central leg 12 as a result of the combined action of the high frequency bias coils 25, 26, 27 and 28.

There are two parallel flux paths for the flux set up by coil 21, one path being through the upper half of the core structure 11 and the other path being through the lower half of the core structure 11.

Since the voltages induced in coils 25 and 26 are equal and opposite to those induced in coils 27 and 28, no net voltage will appear across the bias windings 25, 26, 27 and 28. For that reason, it will be apparent that the flux in the loop which includes legs 13 and 14 due to the windings 25, 26, 27 and 28 will not be effected by the external impedance connected to the voice winding 21. Furthermore, the flux in this same loop due to the voice winding 21 will not be effected by the external impedance connected to the windings 25, 26, 27 and 28. It will thus be apparent that the voice coil winding and the bias windings are in effect completely isolated from each other. Flux linking the loop which includes legs 13, 14 and 12 alone will generate an E. M. F. in coils 25 and 26. Due to the fact that these coils are connected in series with coils 27 and 28, the same current will flow in all four coils. The M. M. F. due to this current has a demagnetizing effect on the flux in the loop including legs 13, 14 and 12, but reinforces the flux in the loop which includes legs 17, 18 and 12 to restore the original flux through the voice coil 21.

It will thus be understood that changes in the impedance of the coils 25, 26, 27 and 28 will have no effect on the magnetic coupling between the loop which includes legs 13, 14 and 12 and coil 21. The same relationship exists between the lower magnetic loop and the coil 21.

When the electromagnetic transducer head 10 is used as a recording head, the bias oscillator 29 is arranged to supply high frequency bias current to the windings 25, 26, 27 and 28 and the signal to be recorded is supplied from the amplifier 24 to the voice coil 21. Since there is no interaction between these circuits, each may be adjusted to optimum match without effecting the other. The coil 21 is highly inductive and may be used as a frequency-sensitive element in the audio circuit for purposes of pre-emphasis. During recording, it has been found advantageous to connect a peaking condenser 41 by closure of a switch 42 in parallel with the coil 21 to gain simultaneous pre-emphasis of the high frequencies and a sharp cut-off of frequencies higher than those desired to be recorded.

When the electromagnetic transducer head 10 is being used as a playback head, the coil 21 is connected to the input of the audio amplifier 24. Since the reluctance of the leg 12 is very low compared to that of the loop which includes legs 17 and 18, loss of signal due to the magnetic shunting action of this latter loop is negligible.

One of the important features of the present invention which is made possible by a head of

the type described above lies in the fact that the bias source may be left connected to the coils 25, 26, 27 and 28 (provided that the source is no longer active) since the flux linkages are not effected by this additional load. Thus, with this arrangement, it is simply necessary to disconnect the plate voltage supply from the oscillator stage when switching from the recording function to the reproducing function. The resultant gradual decay of bias oscillation will effectively demagnetize the head, thus yielding a substantially lower noise level in the reproduced signal. This feature thus provides a very substantial improved result and enables results to be obtained with a single head for both recording and reproduction which were hitherto possible, if at all, only with two separate heads.

From the above description, it will be apparent that the novel electromagnetic transducer head herein described and its associated electrical circuit provides many distinct and novel improvements and advantages. Since the head will work into and out of high impedance audio sources, no audio transformers are necessary in conjunction with the recording head. Because of the isolation between the high frequency bias circuit and the signal circuit, a higher impedance winding may be used without destroying the head efficiency, thus reducing the head input requirements and/or delivering higher voltage to the audio amplifier during reproduction. It will also be observed that high frequency pre-emphasis can be obtained with a minimum expense by resorting to a peaking condenser across the head during recording. It will be further observed that since the bias oscillator need not be disconnected from the bias winding during reproduction, switching transients are eliminated, and in addition, an inexpensive means for demagnetizing the recording head is also provided. It will also be observed that while in normal use only one recording surface is available for recording or reproduction, nevertheless the symmetrical arrangement of the head with the non-magnetic gap at the bottom as well as at the top in effect provides two recording surfaces which are available for either simultaneous recording or simultaneous reproducing. It will also be observed that the head may be turned end-for-end when one surface is worn out and only a single recording gap is being used at a time.

From the above description, it will further be observed that the coils may be arranged for circuits requiring a low impedance winding on the center leg and a high impedance winding on the outside legs without having each adversely affect the operation of the other. Also, both sets of windings may be of a low impedance type, or both sets may be of a high impedance type. It will be apparent to those skilled in the art that instead of mixing an audio signal and a high frequency signal, two audio signals or pulses may be mixed.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto since many modifications may be made, and I, therefore, contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

I claim as my invention:

1. An electromagnetic transducer head comprising a figure "8" shape core with a non-magnetic gap at the top and a second non-magnetic gap at the bottom thereof, a signal winding on the central cross member of said core

and a distributed high frequency bias winding disposed around the remaining portion of said core.

2. An electromagnetic transducer head comprising a figure "8" shape core with a non-magnetic gap at the top and a second non-magnetic gap at the bottom thereof, a high impedance signal winding on the central cross member of said core and a low impedance distributed high frequency bias winding disposed around the remaining portion of said core.

3. An electromagnetic transducer head comprising a figure "8" shape core with a non-magnetic gap at the top thereof and a second non-magnetic gap at the bottom thereof, a signal winding on the central cross member of said core, and a distributed high frequency bias winding disposed around the remaining portion of said core, said distributed winding being wound on said core in such a manner as to produce a circular flux path around the outer portion of said core and across said gaps but to be canceled out across said central cross member.

4. An electromagnetic transducer head comprising a figure "8" shape core having a central cross leg, a pair of upwardly extending legs terminating in a pair of spaced confronting pole portions which form a non-magnetic gap therebetween and a pair of downwardly extending legs terminating in a pair of spaced confronting pole portions which form a non-magnetic gap therebetween, a signal winding wound on said central cross leg, and four high frequency bias windings wound on said four remaining legs, respectively.

5. An electromagnetic transducer head comprising a figure "8" shape core having a central cross leg, a pair of upwardly extending legs terminating in a pair of spaced confronting pole portions which form a non-magnetic gap therebetween and a pair of downwardly extending legs terminating in a pair of spaced confronting pole portions which form a non-magnetic gap therebetween, a signal winding wound on said central cross leg, and four high frequency bias windings wound on said four remaining legs, respectively, said high frequency bias windings having the same number of turns and being wound in a sense to produce a circular high frequency flux path around said upwardly and downwardly extending legs but with the flux produced across said central leg by said windings on said upper legs canceling out the flux produced in said central leg by the coils around said downwardly extending legs.

6. A balanced bridge electromagnetic transducer head having a core including four legs arranged in bridge form with non-magnetic gaps in two opposite corners thereof, a fifth leg connecting the other two corners thereof, a high frequency bias winding on each of said first four legs connected to produce flux in an additive relation around said bridge, the total flux produced by the windings on one side of said fifth leg being substantially equal to the total flux produced by the two windings on the other side of said fifth leg, and a signal winding on said fifth leg.

7. A balanced bridge electromagnetic transducer head having a core including four legs arranged in bridge form with non-magnetic gaps in two opposite corners, thereof, a fifth leg connecting the other two corners thereof, four high frequency bias windings each having the same number of turns substantially as the other on said four legs respectively, said windings being

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wound on their respective legs to produce flux in an additive relation around said bridge, and a signal winding on said fifth leg.

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REFERENCES CITED

The following references are of record in the file of this patent:

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UNITED STATES PATENTS

Number	Name	Date
2,351,003	Camras	June 13, 1944
2,351,004	Camras	June 13, 1944
2,351,009	Camras	June 13, 1944
2,351,011	Camras	June 13, 1944
2,456,767	Camras	Dec. 21, 1948