Dec. 24, 1946. W. B. LATCHFORD ET AL 2,413,108

RECORDING AND REPRODUCING HEAD FOR MAGNETIC RECORDING

Filed March 14, 1945

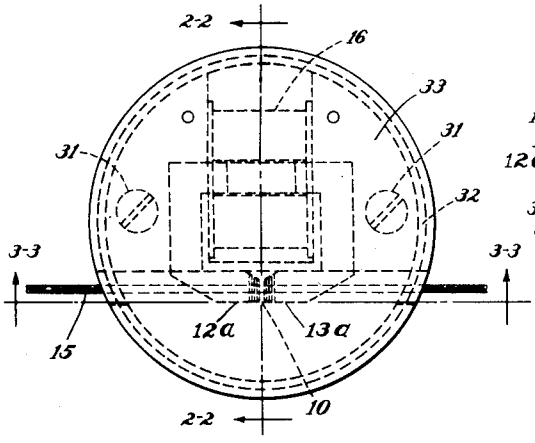


Fig. 1

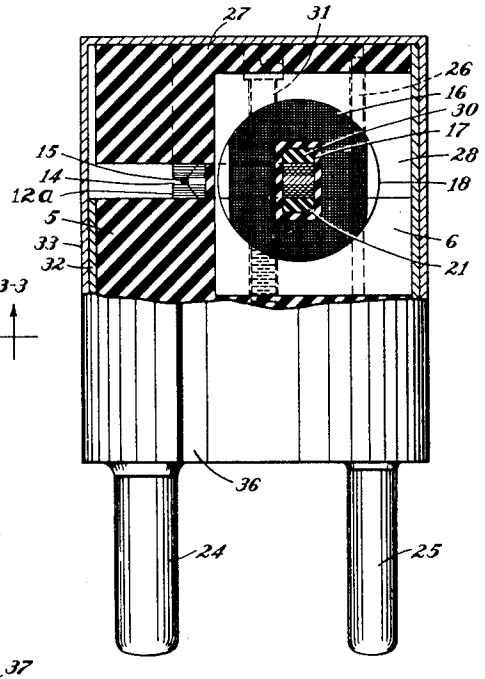


Fig. 2

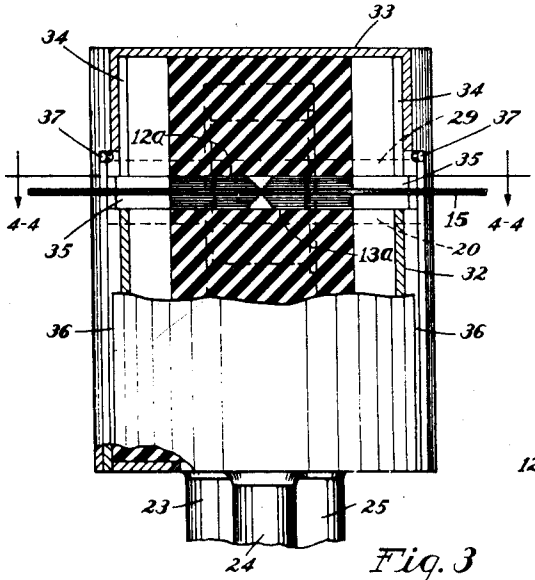


Fig. 3

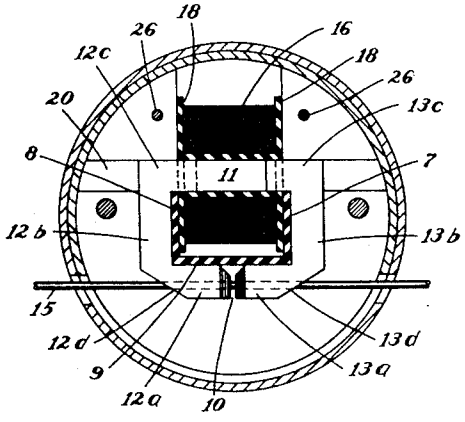


Fig. 4

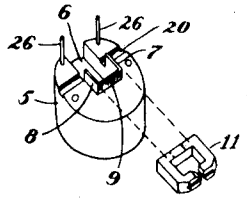


Fig. 5

INVENTOR.
WILLIAM B. LATCHFORD
LYNN C. HOLMES

BY D. Clyde Jones
ATTORNEY

Patented Dec. 24, 1946 2,413,108

UNITED STATES PATENT OFFICE

2,413,108

RECORDING AND REPRODUCING HEAD FOR MAGNETIC RECORDING

William B. Latchford, Rochester, and Lynn C. Holmes, Fairport, N. Y., assignors to Stromberg-Carlson Company, Rochester, N. Y., a corporation of New York

Application March 14, 1945, Serial No. 582,642

11 Claims. (Cl. 179—100.2)

1

This invention relates to a unit or head for use in recording and reproducing magnetic records.

The present invention has for its purpose a recording and reproducing unit which possesses a high degree of accuracy in the manufacture of its parts, to provide most efficient operation and yet the construction of the unit is such that it can be manufactured at greatly reduced cost. It is a further purpose of this invention to provide a recording and reproducing unit which is of conveniently small size and therefore can be readily shielded without sacrificing any of the efficiency of the unit.

The various features and advantages of the invention will best be understood from the detailed description and claims when taken with the drawing in which:

Fig. 1 is a top view of the unit of the present invention indicating the position of the wire record therein during recording or reproducing;

Fig. 2 is a side elevation of the unit with a portion thereof broken away substantially on the line 2—2 of Fig. 1;

Fig. 3 is likewise a side elevation of the unit with a portion thereof broken away substantially on the line 3—3 of Fig. 1;

Fig. 4 is a transverse section of the unit taken substantially on the line 4—4 of Fig. 3; and

Fig. 5 is an exploded perspective view of the base portion of the unit and an assembled core, without its coil, to be used therewith.

In a phonograph of the type employing a magnetic record there is provided a recording and reproducing unit or so-called head. Such a unit comprises a core of ferromagnetic material having a gap therein across which there is developed a magnetomotive force by a coil encircling a portion of the core and energized by alternating current. For best results, the unit should have certain electrical and magnetic characteristics which will be hereinafter set forth.

First the field intensity in the gap should be directly proportional to the current in the recording coil.

coil mmf. = iron mmf. + gap mmf.

(1) gap mmf. = coil mmf. − iron mmf.

(2) $H_g = \frac{\text{gap mmf.}}{L_g}$

where

mmf. stands for magnetomotive force.

H_g means the field intensity of the gap in the core.

L_g stands for the length of the gap.

The term iron means the ferromagnetic material of which the core laminations are made.

Referring to Equation 1, it is clear that for the gap mmf. to bear a linear relation to the total mmf., the iron mmf. must also bear a linear relation to the total. This means that the reluctance of the iron must remain constant over the working range. Even if this is not true, the gap mmf. will be nearly directly proportional to the coil mmf. provided the reluctance of the iron forms a small portion of the total reluctance of the circuit.

2

Two means are used for accomplishing the above result. In the first place, the material for the laminations is chosen so its permeability is reasonably constant over the working range used. In the second place, the area and length of the iron part are chosen so that the reluctance of the iron forms only a small percentage of the total reluctance.

It should be mentioned that it is possible to put the recording coil either around the upper leg of the circuit as shown in Fig. 4 or around the gap and the lower leg of the circuit. In either case, the mmf. relations are the same except for the leakage flux. Practically, the first position is much to be preferred, because the recording medium can simply be placed in the slot without having to thread it through the coil as is necessary when the coil is placed around the gap.

Second, the recording efficiency should be high. The signal current in the recording coil should produce as high a field intensity in the gap as is consistent with the linearity requirement under the first mentioned characteristic.

High recording efficiency depends on the ability of a given mmf. in a recording head to produce a high magnetic field intensity in the gap. For a given mmf. across an air gap, the field intensity is nearly inversely proportional to the length of the path. Therefore, a short gap length should give a high field intensity. There is a practical limit to the increase in intensity which can be obtained by decreasing the length of the gap because the effective gap length of a gap with pole pieces in actual contact is approximately 0.0005 of an inch.

Another means for using a given coil mmf. to best advantage in the recording gap is to design the iron part of the circuit so that very little drop in magnetic potential occurs in this part of the circuit. This can be accomplished by using a short flux path which has large sectional area and high permeability in the region of flux densities used.

A laminated structure for the magnetic circuit is desirable in order to reduce the eddy current losses and also to keep the effective reluctance low at the higher audio frequencies.

Third, the playback efficiency should be high. In order to have high playback efficiency, there must be close coupling between the recording medium and the magnetic circuit of the reproducing head. The ideal condition would be to have the recording medium pass through a channel in the reproducing head with zero clearance be-

tween the medium and the channel through which it passes. It is not practical to make such a head but this construction can be approached by use of a slot through which the record medium moves with minimum clearance. We have found that a slot with only 0.0002 inch total clearance is sufficient for a 0.004 inch diameter round wire. It has been discovered that the field strength in air in the vicinity of a round wire with a recorded signal on it falls off very rapidly as a function of the radial distance from the surface of the wire. This decay in field strength is much more rapid as the frequency is increased. At 10 kilocycles and a speed of five feet per second, the field strength at a distance of 0.001" from the surface is 25% of the value at the surface of a 0.004" diameter wire. This indicates the desirability of making the channel through which the medium passes just as small as possible. Another reason for making the channel small is the fact that the fringing effect (increase in effective gap length due to spreading of the magnetic flux) is increased as the slot opening forms a greater portion of the pole area.

Another factor which influences the playback efficiency is the coupling between the magnetic circuit where the wire or other record medium passes through the pole faces and the reproducing coil which may surround the wire or other record medium at that point or which may be located on the lower leg of the magnetic circuit. Here again, as in the case of recording, it is desirable for the iron part of the circuit to have as low reluctance as possible. In this case, however, the flux density in the head is very much lower than when recording. For playback, a magnetic material with high permeability at low densities is more efficient than a material which has its highest permeability in the region of the flux densities used in recording.

Fourth, the frequency response characteristic curve for a given reproducing head should be smooth. The high frequency response should not be seriously limited by the size or configuration of the magnetic circuit.

The signal output from a playback head can be considered to be the vector sum of two component E. M. F.'s. One of these components is due to the discontinuity in the magnetic circuit at the air gap. This is the component in which we are most interested. It can be shown that the root mean square value of this component increases steadily with frequency until the frequency at which the length of the air gap is equal to one half wave length of recorded flux density.

The second component of E. M. F. is due to the discontinuity at the edges of the magnetic circuit. This component also varies in magnitude as the frequency is changed. It can be shown to reach maximum effective values at regularly spaced frequency intervals. Successive maximum values are opposite in sign so that peaks and dips occur in the frequency response curve. One way in which this undesirable component of E. M. F. may be reduced is to provide a high reluctance path for the flux which is producing the E. M. F. This is accomplished by chamfering the edges of the magnetic circuit so as to make a less abrupt discontinuity. This has been found by experiment to yield a smoother frequency response curve.

The teachings set forth above are embodied in the recording and reproducing unit of the present invention. This unit comprises a generally cylindrical base 5 of homogenous plastic material. The top surface of this base is provided with a recess 6 which is at least partially surmounted by upwardly directed parallel parts 7 and 8, connected by the upwardly directed part 9 extending at right angles thereto as best seen in Fig. 5. The upwardly directed parts constitute a raised generally hollow barrier or projection of predetermined configuration (in this case of generally rectangular outline open on one side). In other words there are provided 3 members (integral in the illustrated embodiment of this invention) adjacent three sides of the recess 6 which extend upwardly from the top surface of the base 5. This barrier serves to locate accurately and positively the laminations as hereinafter explained and, of course, must be of a height at least equal to the height of stack of laminations. The outside dimensions of the barrier comprising these parts are held to close tolerances since they determine the accuracy of the air gap 10 in the core, generally designated 11. It is important that the length of this air gap should not vary by more than 0.0001 or 0.0002 of an inch. The core is preferably made of ferromagnetic material having high permeability at low flux densities. This core is built up of generally rectangular laminations, each lamination comprising two C-shaped pieces. One piece is made up of the parts 12*a*, 12*b* and 12*c* while the other piece is composed of the parts 13*a*, 13*b* and 13*c*. The parts 12*a* and 13*a* of each lamination may be identical, as shown, and also the parts 12*b* and 13*b*, but the part 12*c* is longer than the part 13*c*. Thus, by having a short part 13*c* on the right and a long part 12*c* on the left in the case of the top lamination of Fig. 4, while the next lower lamination has its short part 13*c* on the left and the long part 12*c* on the right, and with the remaining laminations of the series in similar alternate arrangement, the core can be stacked or built up against and around the barrier with joints in the several laminations in staggered relation. It will be noted that the width of the parts 12*a* (see Fig. 2) and 13*a* of the center lamination or laminations of the core is less than the corresponding widths of the laminations at each side thereof thus providing a slot 14 in the core through which a wire, a strip or other magnetic recording medium 15 can travel with minimum clearance across the gap 10 in the core. As shown especially in Fig. 3, the edges of the core at the air gap 10 are stepped to give a tapered effect to the poles defining each side of the gap. This result is obtained by progressively shortening the parts 12*a* and 13*a* of the laminations from the central core portion to the outside of the core. This tapering of the core at the air gap 10 can be done in such a manner that the highest field intensity is produced in the gap for a given magnetomotive force. The core may be cut away as indicated at 12*d* and 13*d* to effectively chamfer the edges of the magnetic circuit so that a less abrupt discontinuity and consequently a smoother frequency response curve results. While the gap 10 has been shown as located at the midpoint of the length of the slot 14, it may be located eccentrically thereof. In fact, under certain conditions this eccentric location may be desirable.

The core 11 is encircled by a coil 16 formed of fine insulated wire. This coil is wound on a cellulose acetate spool comprising a rectangular tube 17 and the flanges 18. These flanges of the spool snugly fit the inner surfaces of the parts 7 and

8 of the barrier while the lower part of the spool and its coil are contained in the recess 6 of the base. The top surface of the base 5 (Fig. 4) has a slot 20 formed therein, which lines up with the opening in the tubular part 18 of the spool. The slot holds a retaining strip 21 (Fig. 2) of stiff material which passes through the tubular part of the spool and engages the lowermost lamination of the core at the region where the laminations pass through the spool. The base is provided with the terminals 23, 24 and 25. Two of these terminals such as 23 and 24 are electrically connected to the respective ends of the coil 16 while the third terminal 25 can be used for an independent ground connection. The upper surface of the base (Fig. 4) is provided with upstanding guide pins 26 which are received in holes in the covering means or the cap 27, hereinafter described, to afford simple means for quick and accurate alinement of the base and cap.

The cap which is made of a cylindrical piece of homogenous plastic material preferably of the same diameter as the base, has a recess 28 therein registering with the recess 6 in the base to receive a part of the spool and its coil 16. The under surface of the cap is also provided with a slot 29 similar to the slot 20 in the base. The slot 29 also receives a retaining strip 30 which likewise passes through the tubular part 18 of the spool to further clamp the laminations together by engaging a part of the upper surface of the core. When the base and cap are alined together, they can be drawn toward each other by screws 31 to clamp the remaining parts of the laminations therebetween, thus insuring positive location of laminations with respect to the base 5 and preventing relative movement between the laminations which would introduce noise.

The base and cap form a cylindrical unit or cartridge which provides complete protection for the laminations of the core 11 and for the coil 16. Ferromagnetic cylindrical shields 32 and 33 snugly enclose the cap and base, the outer shield 33 telescoping over the shield 32. It should be noted that slightly less than one-half of the upper part of the inner shield 32 above the top surface of the base, is cut away as indicated at 34, 34. Notches 35 in the remaining upper part of shield 32, are alined with the slot 14 in the core for the passage of the recording medium therethrough. The outer shield is provided with a pair of diametrically opposed slits 36, the upper ends of which are alined with the notches 34 in the inner shield and with the slot 14 in the core to permit passage therethrough of the recording medium, when this shield is in its normal position. An alining pin 37 projecting from the shield 32, engages either one of the slits 36 in the outer shield to guide this shield to its normal position. Since the outer shield 33 must be removed to insert a different record in the unit, the present construction of shields provides a novel and convenient arrangement for changing records. Since the openings 35 in the shields are relatively small, the parts within these shields are effectively shielded.

While the method of assembling the unit is probably obvious, it may be helpful to indicate certain of steps involved. The coil 16 is first inserted in the recess 6 in the base and the ends of the coil are electrically connected to the terminals 23 and 24. Then, the laminations are stacked snugly against and around the parts 7, 8 and 9 of the barrier in the relation mentioned above. Since the sides of the barrier engage substantial areas of the inner edges of at least three sides of laminations, the laminations are very accurately and positively located. In the form of our invention shown herein, the barrier or surmounting means engages the entire inner edge of three sides of the core. Thereafter, the retaining strip 21 is inserted in the slot 20 of the base, and through the spool. Next the cap 27 is mounted on the base, being guided to its proper position by the pins 26 which enter holes in the cap. The retaining strip 30 may then be inserted through the slot 29 in the cap 27 and then through the tubular portion 17 of the spool. In this position strip 30 engages one surface of the core, the opposite surface of which is engaged by the strip 21. This arrangement of the strips 21 and 30 provides an effective means for clamping the laminations at one part of the core. Screws 31 are next inserted to draw the cap and base together to securely clamp the remaining portions of the laminations.

What we claim is:

1. In a sound recording and reproducing device, a base provided with a barrier of predetermined configuration, a core comprising a plurality of divided laminations stacked against and around said barrier in given relation thereto to provide a gap of predetermined dimension in said core, said barrier being shaped to engage substantial areas of the edge portions of said laminations whereby said laminations are positively located with respect to each other, a coil encircling said core and means for guiding a ferromagnetic recording medium along said core and across said gap.

2. In a sound recording and reproducing device, a base of plastic material provided with a barrier of predetermined configuration, a core comprising a plurality of divided laminations stacked against and around said barrier in predetermined relation thereto to provide a gap in said core, a coil encircling said core, means for guiding a ferromagnetic recording medium along said core and across said gap, a cap of plastic material substantially covering said coil and said core, and means for drawing said cap and base toward each other whereby the laminations of said core are clamped together.

3. In a sound recording and reproducing device, a base provided with a recess at least partially surmounted by a barrier of predetermined configuration, a core comprising a plurality of divided laminations stacked around said barrier in predetermined relation thereto to provide a gap in said core, a coil at least partially received in said recess and encircling said core, means for guiding a ferromagnetic recording medium along said core and across said gap, a cap attached to said base to clamp together a substantial portion of the laminations of said core, said cap and base constituting a protective unit for said core as well as said coil and having a passageway therein communicating with said means, said base also having a slot therein communicating with said recess, and a strip extending through said slot as well as between the coil and a portion of said core to clamp the laminations thereof together at said portion.

4. In a sound recording and reproducing device, a base provided with a slot and with a recess at least partially surmounted by a barrier of predetermined configuration, a core comprising a plurality of divided laminations stacked around

said barrier in predetermined relation thereto to provide a gap in said core, a coil at least partially received in said recess and encircling said core, means for guiding a ferromagnetic recording medium along said core and across said gap, a cap provided with a recess to receive substantially the remainder of said coil and also provided with a slot communicating with said recess, and strips extending through said slots as well as between the coil and the respective sides of a portion of said core to clamp the laminations thereof together at said portion, said cap being attached to said base to clamp together a substantial portion of the laminations together.

5. In a sound recording and reproducing device, a base provided with a generally rectangular recess, a rectangular barrier on said base surmounting said base adjacent at least three sides of said recess, a generally rectangular core made up of laminations stacked against and around said barrier and having an air gap therein, each lamination comprising two C-shaped pieces having two of their ends nearly in contact and their two other ends spaced to define a portion of said gap, and a coil partially received in said recess and encircling said core, an intermediate lamination at the side of the core which is provided with said gap, having a reduced width as compared with the width of adjacent laminations whereby there results a slot for guiding a ferromagnetic medium along said core and across said gap, at each side of the intermediate laminations the portions of the pieces of said laminations at their spaced ends being of different lengths to vary the contour of said gap.

6. In a sound recording and reproducing device, a base provided with a generally rectangular recess, a rectangular barrier on said base adjacent at least three sides of said recess, a generally rectangular core made up of laminations stacked against and around said barrier and having an air gap therein, each lamination comprising two C-shaped pieces having two of their ends nearly in contact and their other two ends spaced to define a portion of said gap and a coil partially received in said recess and encircling said core, an intermediate lamination at the side of the core which is provided with said gap having a reduced width as compared with the width of adjacent lamination whereby there results a slot for guiding a ferromagnetic recording medium along said core and across said gap, at each side of the intermediate laminations the portions of the pieces of said laminations adjacent said gap being of progressively lesser lengths so that the core is shaped with pole pieces tapering toward said gap.

7. In a sound recording and reproducing device, a base provided with a flat surface having a recess at least partially surmounted by a raised barrier of a given height and configuration, said surface having a slot communicating with said recess, a core comprising a plurality of divided laminations stacked against and around said barrier to the top thereof in predetermined relation to said barrier to provide a gap in said core, a spool received in said recess and having a coil wound thereon, said spool with its coil encircling said core, means for guiding a ferromagnetic recording medium along said core and across said gap, and an insulating strip extending in said slot and through said spool to clamp together the laminations where they pass through the spool.

8. In a sound recording and reproducing device, a base provided with a flat surface having a recess at least partially surmounted by a barrier of given configuration, said surface having a slot communicating with said recess, a core comprising a plurality of divided laminations stacked against and around said barrier in predetermined relation thereto to provide a gap in said core, a spool having a tubular part of rectangular cross section with a coil wound thereon, said spool and coil encircling said core, means for guiding a ferromagnetic recording medium along said core and across said gap, and means including an insulating strip of rectangular cross section extending in said slot and through said tubular spool to clamp together the laminations where they pass through the spool.

9. In a sound recording and reproducing device, a base provided with a recess, a rectangular barrier on said base adjacent a substantial part of said recess, a generally rectangular core made up of laminations stacked against and around said barrier and having an air gap therein, each lamination comprising two C-shaped pieces having two of their ends nearly in contact and their other two ends spaced to define a portion of said gap, the portions of said pieces of several of said laminations at their spaced ends being of different lengths to vary the contour of said gap, a coil partially received in said recess and encircling said core and means for guiding a ferromagnetic medium along said core and across said gap.

10. In a sound recording and reproducing device, a cylindrical base provided with a flat end having a recess therein, a rectangular barrier on said base adjacent said recess, a generally rectangular core made up of laminations stacked around and against said barrier, said core having an air gap therein, each lamination comprising two C-shaped pieces, having two of their ends nearly in contact and their other two ends spaced to define a portion of said gap, the portions of said pieces at their spaced ends being of different lengths to vary the contour of said gap, a coil partially received in said recess and encircling said core, means for guiding a ferromagnetic recording medium along said core and across said gap, tubular means of electrical shielding material enclosing said base, and a tubular cover means of electrically shielding material in telescopic relation with said tubular means, said shielding means having openings therethrough whereby said recording medium can be guided along said core and across said gap.

11. In a sound recording and reproducing device, a base provided with a recess, a barrier on said base at each side of said recess, a core made up of laminations stacked against and around said barrier and having an air gap therein, each lamination comprising two C-shaped pieces having two of their ends nearly in contact to form a joint and their two other ends spaced to define a portion of said gap, the joints in adjacent laminations being arranged in staggered relation, a coil partially received in said recess and encircling said core, means for guiding a ferromagnetic medium along said core and across said gap, and means for clamping the flat surfaces of the laminations together at said joints.

WILLIAM B. LATCHFORD.
LYNN C. HOLMES.

Disclaimer

2,413,108.—*William B. Latchford,* Rochester, and *Lynn C. Holmes,* Fairport, N. Y. RECORDING AND REPRODUCING HEAD FOR MAGNETIC RECORDING. Patent dated Dec. 24, 1946. Disclaimer filed July 23, 1948, by the assignee, *Stromberg-Carlson Company.*

Hereby enters this disclaimer to claim 1 of said 'patent.

[*Official Gazette August 31, 1948.*]