June 13, 1944. M. CAMRAS 2,351,007

MAGNETIC RECORDING HEAD

Filed Aug. 10, 1942 2 Sheets-Sheet 1

Fig. 1.

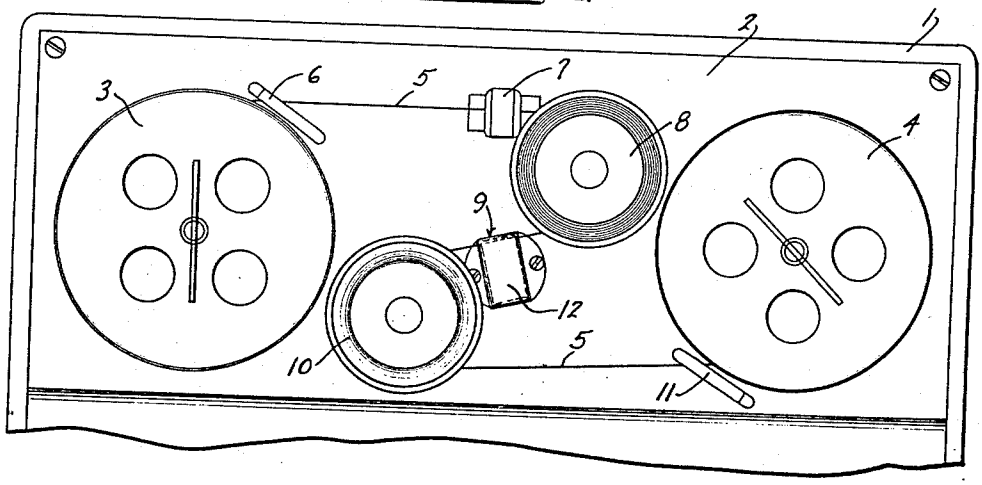


Fig. 2.

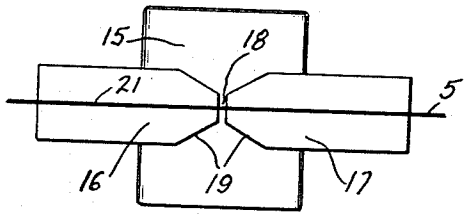


Fig. 5.

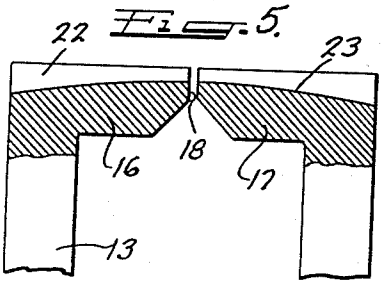


Fig. 3.

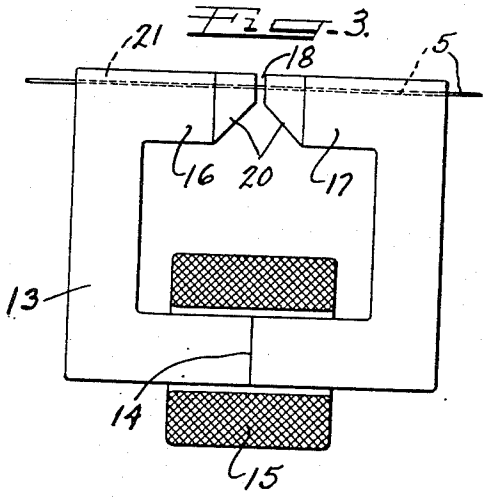
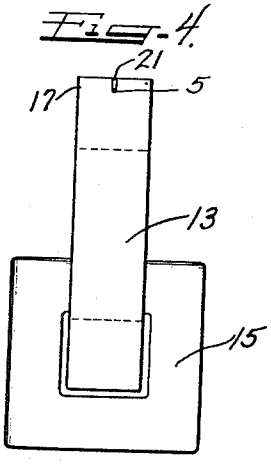


Fig. 4.



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by Charles W. Hills Attys.

June 13, 1944. M. CAMRAS 2,351,007

MAGNETIC RECORDING HEAD

Filed Aug. 10, 1942 2 Sheets-Sheet 2

Fig. 6.

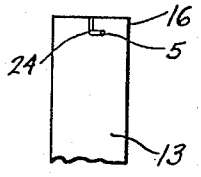


Fig. 7.

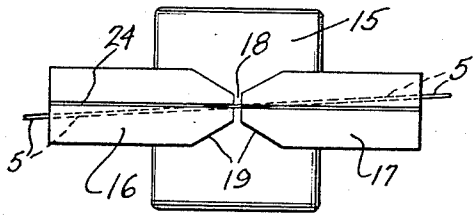


Fig. 8.

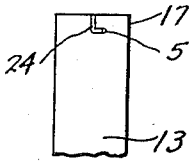


Fig. 9.

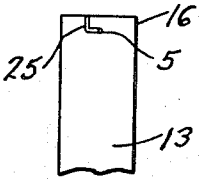


Fig. 10.

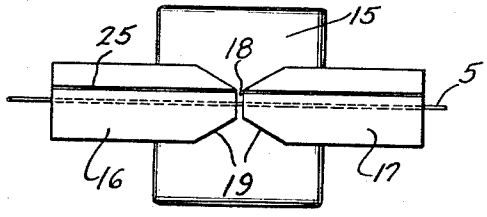


Fig. 11.

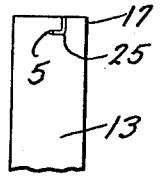


Fig. 12.

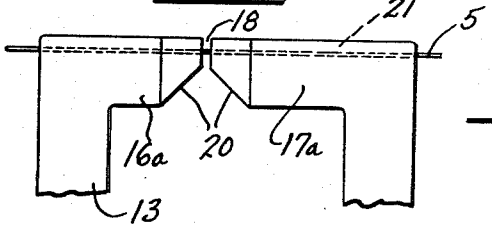


Fig. 14.

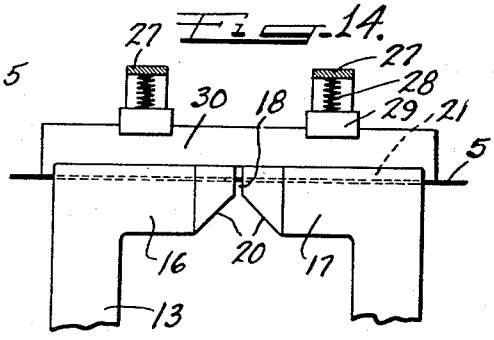


Fig. 13.

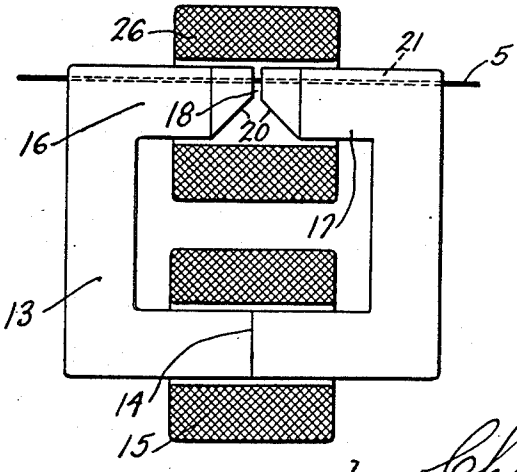
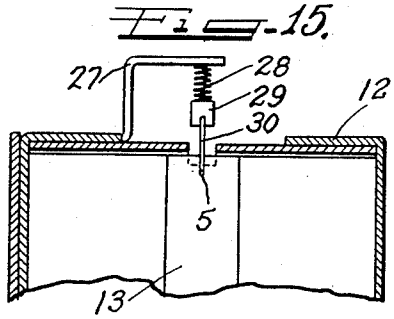


Fig. 15.



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Patented June 13, 1944 2,351,007

UNITED STATES PATENT OFFICE

2,351,007

MAGNETIC RECORDING HEAD

Marvin Camras, Chicago, Ill., assignor to Armour Research Foundation, Chicago, Ill., a corporation of Illinois

Application August 10, 1942, Serial No. 454,217

12 Claims. (Cl. 179—100.2)

This invention relates to improvements in magnetic recorder heads for use in connection with magnetic recording devices in which sound is recorded and ultimately reproduced, if desired, with a recording medium in the nature of an elongated paramagnetic member, such as a wire, tape, or the equivalent, the invention having many advantageous features of construction as will be apparent to one skilled in the art.

In the past, both round wire and flat tape were used in magnetic recorders, but with the old types of recording heads the flat tape proved more efficient than the wire and the wire was virtually abandoned. However, wire has distinct advantages over the use of tape. One of these advantages is compactness, tape being of such size as to require a spool or reel five to seven times the diameter of a wire reel of equivalent capacity. Another advantage resides in low cost, the cost per minute of recording in the use of wire being only a very small fraction of the cost per minute of recording with tape. In addition, wire is available in longer continuous pieces than is tape. It is therefore more desirable to use wire than tape on most occasions.

In the previously known magnetic recorder heads, the wire or tape passed along across the top of the magnetic pole pieces. With such construction, there was more contact on the surface of the pole pieces than was the case with the round wire. In neither instance, however, was there any reasonable distribution of magnetic flux through the recording medium. There would be a rather dense distribution in the wire or tape immediately adjacent the magnetic pole pieces, and practically nothing in the outside region of the wire or tape. Thus, fidelity of a high degree, and in most instances of even a practical degree, was not feasibly obtainable.

It has now been determined that wire may be used with equally as satisfactory electro-magnetic results as tape, and with much more satisfactory mechanical and economical results. It has further been determined that the poorest form of recorder is the one in which the elongated recording medium travels over the upper surface of the magnetic pole pieces, the type used in the past. The form which is most ideal from an electro-magnetic point of view is that in which the electro-magnet is provided with a hole through the pole pieces, and the recording medium travels through that hole, and a substantially uniform pattern of flux lines throughout the recording medium results. However, for many uses ultimate fidelity is not required, and the pole type recording magnet has certain mechanical inconveniences such as the recording medium that cannot be disengaged from the magnetic head except at the ends of the recording medium, and a new reel of recording medium is difficult to thread through the small diameter hole, which is only a very small fraction larger than the recording medium itself. When it is recalled that the recording medium in the form of a wire is usually only a few thousandths of an inch in diameter, frequently the size of a human hair, such threading difficulty is apparent. It is therefore desirable to strike a satisfactory medium, in certain cases, between the first and unsatisfactory form of magnet and the ideal hole-type magnet, and this medium must of course very much more closely approach the hole-type magnet than the old and unsatisfactory type where the recording medium rides over the faces of the pole pieces.

With the foregoing in mind, it is an important object of the instant invention to provide a magnetic recorder head in which the recording medium may very easily be threaded, or disengaged from the head, at any point along the recording medium, and high fidelity is obtainable.

Another object of the invention resides in the provision of a magnetic recorder head in which round wire may be used with equal fidelity as tape.

Still another object of the invention is the provision of a magnetic recorder head which provides the mechanical advantages of ease in threading of the recording medium and at any point along the recording medium and the further electro-magnetic advantage of magnetizing the recording medium to such a uniform extent that the variations, shading off, and distortions are such that they cannot be detected by the ear under ordinary circumstances, especially in speech recording and reproduction.

Another feature of this invention resides in the provision of a magnetic recorder head in which the recording medium travels through a slot in the pole pieces of the electro-magnet, which slot is preferably of a depth several times the diameter or thickness of the recording medium.

Also a feature of the invention resides in the provision of a magnetic recorder head utilizing an electro-magnet having a slot-type passageway for the recording medium, which passageway is perpendicular to the pole faces.

It is also an object of this invention to provide a magnetic recorder head especially con-

structed to minimize the effect of stray magnetic fields on the recording medium.

A further feature of the invention resides in the provision of a magnetic recording head having a slot-type passageway in the paramagnetic core member, constructed so as to insure proper contact between the recording medium passing through the slot and the paramagnetic core member.

It is also a feature of the invention to provide a magnetic recorder head having a slot-type passageway for the recording medium, in which means are provided for retaining the recording medium well within the slot against accidental dislodgment during operation.

The invention also provides a magnetic recorder head in which the magnetic pole pieces are so constructed as to concentrate the magnetic field at the gap therebetween, and also in which an optimum length of recording gap may be utilized to produce a high ratio of recording field to stray field.

Also an object of the invention is the provision of a magnetic recorder head in which cumulative effect of the stray magnetic fields is minimized by the use of pole pieces of unequal length.

A further object of the invention resides in the provision of a magnetic recorder head embodying a slot-type passageway for the recording medium, the structure being so arranged as to relatively closely approach the ideal situation where the recording medium passes directly through a hole in the magnetic pole pieces.

While some of the more salient features, characteristics and advantages of the instant invention have been above pointed out, others will become apparent from the following disclosures, taken in conjunction with the accompanying drawings, in which:

Figure 1 is a fragmentary front elevational view of a magnetic recording device utilizing a recording head embodying principles of the instant invention;

Figure 2 is an enlarged fragmentary top plan view of a recording head with the recording medium traveling therethrough, the head embodying principles of the instant invention;

Figure 3 is a part sectional, part side elevational view of the structure of Figure 1;

Figure 4 is a side elevational view of the structure seen in Figures 1 and 3;

Figure 5 is a fragmentary part sectional, part elevational view illustrating a slightly different form of the magnetic pole pieces, the construction of Figure 5 being usable if desired with any of the variations of magnetic recording heads shown in the drawings;

Figure 6 is a fragmentary side elevational view of a magnetic recorder head utilizing bayonet form of slot;

Figure 7 is a fragmentary top plan view of the structure of Figure 6 illustrating the passage of the recording medium through the head;

Figure 8 is a side elevational view of the character of Figure 6 but taken from the opposite side of the structure of Figure 7;

Figure 9 is a side elevational view of a magnetic recorder head having a different form of bayonet slot therein;

Figure 10 is a fragmentary top plan view of the structure of Figure 9 illustrating the passage of the recording medium through the head;

Figure 11 is a part elevational view taken from opposite side of the structure of Figure 10 from the showing in Figure 9;

Figure 12 is a fragmentary side elevational view of a magnetic recorder head utilizing pole pieces of different lengths and illustrating the passage of the recording medium through the head, the structure in this figure being usable in any of the other variations of recorder heads illustrated in the drawings, if so desired;

Figure 13 is a part sectional, part elevational view of a magnetic recorder head embodying principles of the instant invention, but being constructed so as to sacrifice to some extent certain mechanical advantages, while obtaining extremely high fidelity;

Figure 14 is a part sectional, part side elevational view of a mechanical recorder head similar in construction to the showing in Figures 1, 2 and 3 but utilizing a member extraneous to the head to hold the wire within the slot and prevent the entrance of dirt into the slot;

Figure 15 is a part sectional, part end elevational view, in fragmentary form, of the structure of Figure 14, showing the magnet itself in elevation and the casing around the magnet in section.

In all of the figures of the drawings, with the exception of Figures 1 and 15, the recorder heads are illustrated for the purpose of clarity with the outer housing or casing removed.

As shown on the drawings:

In the illustrated embodiment of this invention there is shown a magnetic recording device including a casing 1 having a front panel 2 upon which may be mounted the magnetic recording head embodying principles of the invention. It will be understood, of course, that the magnetic recording device embodies various mechanisms and an electrical circuit consistent with the recording and reproduction of sound, but which apparatus is not necessary to be illustrated and described in the instant application.

Near one side of the panel 2 a rotatable spool or reel 3 is mounted, and a similar reel or spool 4 is mounted near the opposite side of the panel 2. The reels 3 and 4 carry a recording medium, which in the illustrated instance is in the form of a relatively small wire 5, and this wire is wound back and forth from one reel to the other depending upon the desired direction of operation. If a recording is to be made, the wire is wound off the spool 3 and on to spool 4. The same direction is used for reproducing a recording on the wire. Between the making of a recording, and the reproduction of that recording, the wire may be rewound on spool 3 and unwound from spool 4 to the extent of the length of the recording, and then the apparatus may be started again in the forward direction for purposes of reproduction.

Assuming that the wire is being wound from spool 3 to spool 4, in the direction of recording and reproduction, the wire passes through a level winding member 6 associated with the reel 3, thence through an erasing or demagnetizing head 7, around a guide pulley 8, and through a magnetic recording head generally indicated by numeral 9, thence around another guide pulley 10, through a level winding member 11, and on to reel 4. If a recording is already on the wire as it travels in the above manner during the making of a new recording, the previous recording will be erased by the demagnetizing head 7, and the wire will be magnetized in accordance with the new recording as it passes through the recording head 9. If a reproduction is being made as the wire travels from reel 3 to reel 4, the de-

magnetizing head 7 is cut out of service, and the recording may be audibly reproduced by apparatus not disclosed in the drawings.

As seen in Figure 1, the recording head is preferably encased within a suitable housing 12 merely as a matter of convenience in mounting and protection to the recording head. In most of the figures in the drawings the recording head will be illustrated for purposes of clarity without the housing 12.

That form of recording head seen in Figures 2, 3 and 4 of the drawings includes a core 13, preferably laminated, which may be made in separate halves thus producing a break at 14 solely for the purpose of convenience in manufacture, although the core may be made with each lamination in one piece. A coil 15 is disposed about the lower leg of the core 13, and this coil preferably surrounds the break 14 if there is such a break. The core is so shaped as to prevent confronting pole pieces 16 and 17 with a gap 18 therebetween.

It will be noted that the pole pieces 16 and 17 are each tapered laterally on both sides as indicated at 19 in Figure 2, and are further each tapered vertically on the undersides thereof as indicated at 20 in Figure 3. Such tapering of the pole pieces concentrates the magnetic flux in the immediate region of a slot 21 at the gap 18 extending longitudinally through the pole pieces. As illustrated, this slot is perpendicular to the upper faces of the pole pieces and is preferably of a depth several times the diameter of the recording medium 5.

The effective recording or magnetization of the wire 5 takes place in the immediate vicinity of the gap 18. Thus, it is desirable to concentrate the magnetic field at the gap, and in the illustrated instance this is accomplished by the above described tapering of the pole pieces. It is also desirable to select the optimum width of gap. This is dependent to some extent on the size of the wire used, and on the amount of tapering of the pole pieces, and can thus be proven by experiment when changes in the size of the magnet, variance in taper, size of recording medium, etc. occur. In the illustrations, the gap is exaggerated for the purpose of clarity, and it has been found satisfactory to use a gap between one and two-thousandths of an inch with a wire diameter of four or five-thousandths and with the pole pieces tapered at substantially the angle illustrated. If the gap is too narrow or too wide the spurious or stray magnetic fields occurring at each end of the slot 21 increase, and the field at the center of the head over the gap 18 broadens. A narrow field at the gap and the elimination of the stray fields at the corners of the core 13 to as great an extent as possible are desired. Thus, by a combination of tapering of the pole pieces and the selection of the optimum air gap, very satisfactory results are obtained with a narrow magnetic field at the gap and a very low spurious or stray field at the ends of the slot 21. Thus, only very small portions of the wire are successively magnetized during a recording, the effect of stray fields is materially reduced, and ample fidelity results.

It will further be noted from the showing in Figure 4 that the recording medium 5 is embedded to a considerable extent in the core or magnet 13, and that accordingly the magnetization of the wire closely approaches the ideal situation of the wire passing through a hole in the magnet. With a hole there is a uniform pattern of flux density throughout the wire. With a relatively deep slot as illustrated, there is substantially uniform distribution of flux through the wire, but the distribution will be of greater density at the bottom of the wire than at the top. However, this non-uniformity of flux distribution is of such low magnitude that any variations, noises, shading off, etc. caused thereby will not be detected by the human ear under ordinary circumstances. In short, for most uses, especially speech recording and reproduction, the magnetization of the wire in the slot very closely approximates the magnetization of the wire passing through a hole in the magnet. It is obvious that the magnetization of the recording medium 5 in the slot 21 will be of considerably greater magnitude and much more uniform distribution than would be the case if the wire traveled over the upper face of the pole pieces.

It should further be noted that the wire may be removed from the slot 21 at any time desired without the necessity of then winding the wire entirely off one of the reels 3 or 4 so as to reach an end of the wire. Likewise, threading of a new wire into the slot is extremely easy. The end of the new wire may be passed through the level wind member 6, threaded in the demagnetizing head 7 which usually has a comparatively large aperture, passed around the guide pulleys 8 and 10, through the level wind 11, and attached to the spool 4. After the wire has been securely placed in position in that manner, it is a very simple expedient to drop an intermediate portion of the wire in the slot 21.

Another advantage of the construction seen in Figure 2, 3 and 4 resides in the fact that a relatively long surface of wire is in contact with the pole pieces 16 and 17 during use, so that wear of the wire is greatly minimized.

In Figure 5 I have illustrated a construction which insures positive contact of the wire with the pole pieces adjacent the gap 18, if circumstances require the use of such construction. In this instance, the same paramagnetic core 13 is provided with the pole pieces 16 and 17 and a similar gap 18 therebetween. A slot 22 for the reception of the recording medium is provided leading downwardly or inwardly from the upper faces of the pole pieces. In this instance, the bottom of the slot is curved as indicated at 23 so that the region of highest curvature is at the side of the gap 18, thus insuring positive contact of the wire with the magnet core in the region of most effective magnetization.

In Figures 6, 7, and 8 I have illustrated a construction of magnetic recording head wherein the wire is held at the bottom of the slot against accidental or unintentional misplacement of the wire out of the slot. In this instance, the same form of magnet is illustrated including the core 13, coil 15, and pole pieces 16 and 17 with the gap 18 therebetween. The pole pieces are also preferably tapered inwardly as indicated at 19, and also tapered as indicated at 20 in Figure 3. In this instance, however, a slot is provided in the pole pieces in the nature of a bayonet slot 24. This bayonet slot 24 is provided with tapering horizontal legs. The horizontal leg portions of the slot extend in opposite directions at opposite sides of the gap 18. Thus, in the region of the gap 18 the bayonet slot will be in the nature of a straight slot of the character seen in Figures 2, 3 and 4, and the horizontal leg of the slot gradually increases in width toward the outer ends of the pole pieces 16 and 17 in both

directions away from the gap 18. The increasing width of the horizontal leg of the slot on one side of gap 18 is opposite to the increasing width of the horizontal leg on the other side of the gap, so that the recording medium 5 passes through the head of the magnet, that is both pole pieces 16 and 17, at an angle to the axis of the pole pieces.

By virtue of this construction, in order to remove the wire from the magnetic head, it is necessary to twist both protruding portions of the wire in a clockwise direction until the wire is disposed parallel to the axis of the pole pieces, and thus lift the wire out of the vertical leg of the bayonet slot. Accordingly, the wire will be trapped at the bottom of the slot during ordinary usage and prevented from accidental displacement. The magnetization of the wire in the slot 24 is equivalent to that in the previously described slot 21.

At this time, it may be well to mention that all of the recording medium accommodating slots mentioned herein are preferably of just sufficient size to accommodate the recording medium without hindering the sliding movement of the recording medium through the magnetic head.

If so desired, the bayonet slot may be made entirely parallel with the axis of the pole pieces 16 and 17. This construction is illustrated in Figures 9, 10 and 11. In this instance, the same type of magnetizing head is shown, but the pole pieces are equipped with a bayonet slot 25 and the horizontal portion of the slot extends in the same direction on both sides of the gap 18. When this construction is used, it is preferable to somewhat offset the bayonet slot so that the vertical portion thereof is to one side of the center line through the pole faces, and the horizontal portion of the slot terminates approximately at the medium plane through the pole faces. This permits the wire 5 to pass centrally through the gap 18 and centrally through the confronting ends of the pole pieces, as was the case in the previously described embodiment. The wire is therefore in the region of highest flux density when magnetized.

In order to remove the recording medium 5 from the structure seen in Figures 9, 10 and 11, the wire must be shifted sidewise until the vertical portion of the bayonet slot 25 is reached and then it may be lifted out of the magnetizing head. Again, the magnetization of the wire and the reproduction from a magnetized wire will be of the same quality as above set forth.

In Figure 12 I have shown a recorder head including a core 13, and pole pieces having the same taper, slot 21, and gap 18 therebetween as above described in connection with Figures 2, 3 and 4. In this instance, however, the pole pieces designated 16*a* and 17*a* are of unequal length. The pole piece 17*a* is shown somewhat longer than the pole piece 16*a*. This difference in length of the pole pieces tends to further minimize the effect of stray magnetic fields and prevent those stray fields from becoming cumulative.

It is quite obvious that the structures of Figures 5 and 12 may be utilized with any of the other magnetic recorder heads above described or to be described later herein, if so desired.

If, for some reason, such as careful recording of certain musical productions, higher fidelity is desired an arrangement such as shown in Figure 13 may be utilized. In this figure, the magnet is of the same character as above explained in connection with Figures 2, 3 and 4 with the exception that an additional magnetizing coil 26 is disposed around the pole pieces over the gap 18 therebetween and the adjacent portions of the slot 21, opposite to the coil 15. If so desired, the coil 15 may be omitted. With this arrangement, more complete and more uniform magnetization of the recording medium results and the effect of stray magnetic fields is further minimized. The mechanical advantage of easy threading of the recording medium in the magnetic head still remains, although this threading must be done at the end of the wire rather than in an intermediate position. It is easy to thread the end of a wire through the large aperture in the coil 26, and then position the wire in the slot 21, but the threading must be done and the wire cannot be removed from the slot except when completely unwound from one of the reels, or after a breakage of the wire. It will be noted, however, that by virtue of the position of the coil 26, there is less likelihood of an accidental or unintentional misplacement of the wire out of the slot 21, even though this slot is merely a straight slot and not a bayonet slot of the character described in connection with Figures 6 to 11 inclusive.

If it is desired to use extraneous means to prevent dirt from entering the slot through which the recording medium travels and to positively prevent accidental or unintentional misplacement of the recording medium out of the slot, the structure like that illustrated in Figures 14 and 15 may be utilized, and this structure may be combined with all of the other embodiments previously described herein, if so desired.

In the instance of Figures 14 and 15 the magnet is the same as that described in connection with Figures 2, 3 and 4. On the casing 12 of the magnet one or more dog leg brackets 27 are provided which extend over the slot 21 but are spaced thereabove. To each bracket one end of a spring 28 is attached, and the other end of the spring engages a block 29. Each such block 29 is grooved in its underface to receive therein a shim 30 of a size to just fit within the groove 21 in the pole pieces 16 and 17. The shim is consequently urged downwardly toward the recording medium 5 by virtue of the pressure resulting from one or more springs 28, and holds the recording medium well down within the groove 21, prevents the recording medium from accidentally becoming dislodged out of the groove, and prevents the entrance of dirt and other extraneous matters into the groove. The shim 30 may be made either of non-paramagnetic material or of paramagnetic material, both materials operating satisfactorily.

From the foregoing, it is apparent that I have provided novel construction for a magnetic recorder head, and it will be especially noted that the head is extremely economical to produce. Further, the head results in excellent magnetization of a recording medium, permits threading in or removal of the magnetic recording medium without the necessity of utilizing an end of the medium for that purpose, and is so constructed as to concentrate the flux in the region of maximum magnetization and minimize the effect of spurious or stray magnetic fields. It will further be noted that while the recording head possesses mechanical advantages and economical advantages, it also possesses the advantage of providing a relatively high concentration of magnetic flux in a very small magnetizing area on the recording medium which results in a recording of high fidelity and of relatively high uni-

formity over the cross section of the medium. It will be further appreciated that while I have illustrated a round wire as a recording medium herein, a tape or some other elongated element might well be used as the recording medium, with an obvious alteration in the shape of the slot to accommodate the tape.

It will, of course, be understood that various details of construction may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. In a magnetic recording head, a U-shape paramagnetic core having directly confronting pole pieces with a non-magnetic gap therebetween, said pole pieces tapering laterally toward said gap to concentrate the magnetic field at the gap, and said pole pieces having a groove therein to accommodate a traveling recording medium.

2. In a magnetic recording head, a U-shape paramagnetic core having directly confronting pole pieces with a non-magnetic gap therebetween, said pole pieces tapering laterally toward said gap to concentrate the magnetic field at the gap, and said pole pieces having a groove therein to accommodate a traveling recording medium, said groove being of such depth and location that the recording medium will travel substantially centrally through the confronting faces of said pole pieces.

3. In a magnetic recorder head, a U-shape paramagnetic member having a slot herein forming a passageway for a traveling recording medium, said slot being of a depth exceeding the thickness of the recording medium, and retainer means arranged to keep the recording medium in the slot.

4. In a magnetic recorder head, magnetizing means having a slot therein to accommodate a recording medium, and a resiliently urged shim in said slot over the recording medium.

5. In a magnetic recorder head, magnetizing means including a pair of confronting pole pieces with a non-magnetic gap therebetween, said pole pieces having a slot therein to accommodate a recording medium, and the bottom of said slot being curvate with the highest part thereof adjacent said non-magnetic gap.

6. In a magnetic recorder head, magnetizing means having a slot therein to accommodate a recording medium, said slot being in the form of a bayonet slot to maintain the recording medium well within the slot against unintentional misplacement.

7. In a magnetic recorder head, magnetizing means including a pair of confronting pole pieces with a non-magnetic gap therebetween, said pole pieces having a slot therein to accommodate a recording medium, said slot being in the form of a bayonet slot with the horizontal portion of the slot gradually increasing in depth from the non-magnetic gap toward the outer ends of the pole pieces.

8. In a magnetic recorder head, magnetizing means including a pair of confronting pole pieces with a non-magnetic gap therebetween, said pole pieces having a slot therein to accommodate a recording medium, said slot being in the form of a bayonet slot with the horizontal portion of the slot gradually increasing in depth from the non-magnetic gap toward the outer ends of the pole pieces, such increase in depth being in opposite directions from the axis of the pole pieces on opposite sides of said non-magnetic gap.

9. In a magnetic recorder head, magnetizing means having a slot therein to accommodate a recording medium, said slot being so shaped as to cause the recording medium to follow a path at an angle to the axis of said pole pieces but cross the non-magnetic gap substantially centrally of the confronting faces of said pole pieces.

10. In a magnetic recorder head, magnetizing means including a pair of confronting pole pieces with a non-magnetic gap therebetween, said pole pieces having a slot therein to accommodate a recording medium, said slot being in the form of a bayonet slot positioned so that the bottom of the horizontal part thereof is substantially in the median plane of said pole pieces.

11. In a magnetic recorder head, a U-shape magnet including a pair of confronting pole pieces with a non-magnetic gap therebetween, said pole pieces having a slot therein to accommodate a recording medium, one of said pole pieces being longer than the other to prevent stray magnetic fields becoming cumulative.

12. In a magnetic recorder head, a paramagnetic core shaped to provide confronting pole pieces with a non-magnetic gap therebetween, said pole pieces being shaped to provide a path for a traveling recording medium, and a coil surrounding said pole pieces and said path over said non-magnetic gap, said path being in the form of an inwardly extending slot, and said pole pieces tapering inwardly toward said non-magnetic gap.

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