July 1, 1941. F. PFLEUMER 2,247,847

RECORDING AND REPRODUCING DEVICE FOR MAGNETIC SOUND WRITING

Filed July 23, 1938

Fig. 1.

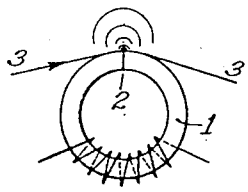


Fig. 2.

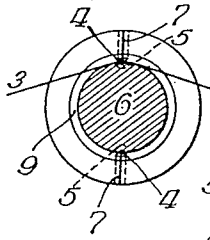


Fig. 3.

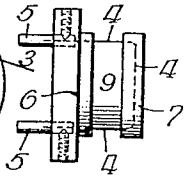


Fig. 7.

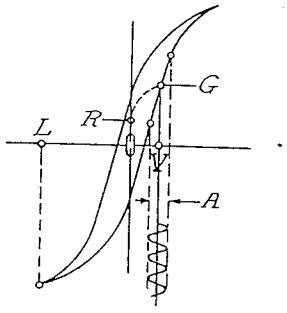


Fig. 4

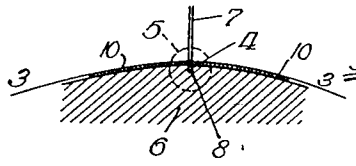


Fig. 5

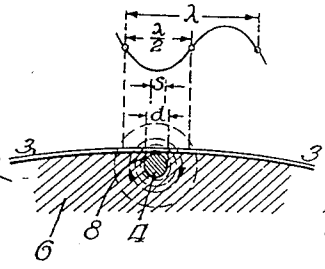


Fig. 6.

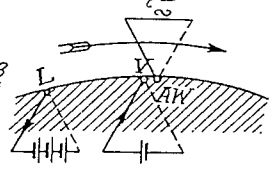


Fig. 8.

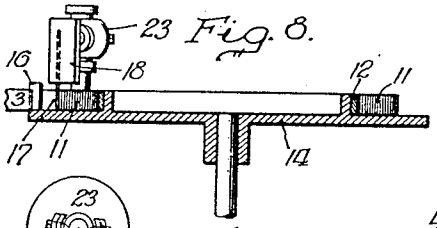


Fig. 9.

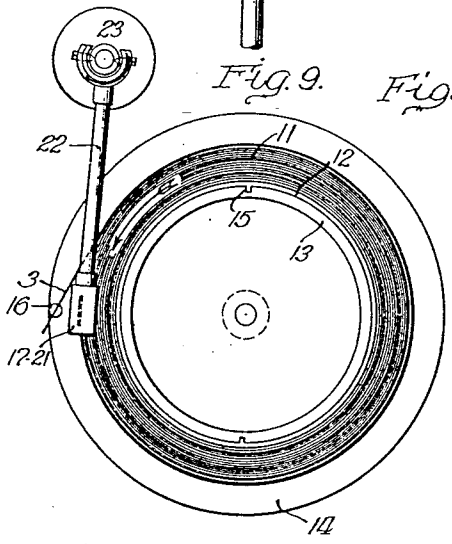


Fig. 10

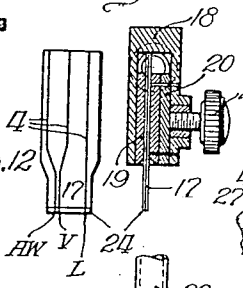


Fig. 13

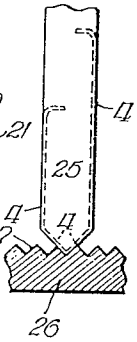


Fig. 14

Fig. 12

Fig. 11.

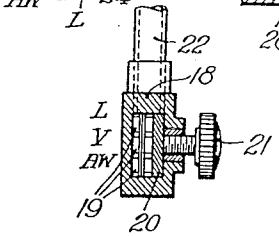
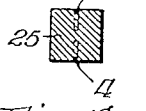


Fig. 15



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BY Richardson & Gwin
ATTORNEYS.

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UNITED STATES PATENT OFFICE

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RECORDING AND REPRODUCING DEVICE FOR MAGNETIC SOUND WRITING

Fritz Pfleumer, Dresden, Germany

Application July 23, 1938, Serial No. 221,040
In Germany July 23, 1937

13 Claims. (Cl. 179—100.2)

The present invention relates to apparatus for magnetic sound recording and reproduction in which the sound is recorded upon a wire or tape as alternating magnetization. Steel wires or tapes have been used for this purpose, as well as paper or film strips provided with a magnetizable layer. The sound recording, in these cases, takes place by passing the tape through the air gap of an electromagnet of special shape, the energization of the electromagnet being effected in correlation to the currents of a microphone. The reproduction and the removal of the magnetic recording is effected in a similar manner.

However, it has been found that when such magnets are used, magnetic dispersion cannot be suppressed entirely, so that the magnet affects the tape to be mangnetized not only at the desired point but also in a wider region. This causes, accordingly, additional undesired magnetizations which become audible during reproduction as interference noises. A truly natural reproduction is, therefore, impossible. Furthermore, the gap presents a variable magnetic resistance for different frequencies, so that the effective width of the gap has a different value for different frequencies. These disadvantages may be eliminated to a certain degree by special formation of the gap; however, a complete elimination of the disturbing effect of the magnetic dispersion is not possible.

As regards the reproduction of the sound records, it is to be observed that the amount of iron present at a particular time in the gap, the iron in the moving record tape, is very small in comparison to the amount of iron in the electromagnet of the reproducer. The reproduction is essentially influenced by the characteristics of this electromagnet and only high quality, very expensive kinds of iron can be used for this purpose. Otherwise there is danger that residual magnetism in the reproducer will cause strong interference noises during reproduction, in addition to bringing about a gradual weakening of the record itself.

According to the present invention, it has been found that magnets containing iron may be omitted entirely in recorders as well as reproducers, and that the magnetic field which lies in immediate proximity to and about an electrical conductor may be used exclusively for this purpose. According to the present invention, in both recorder and reproducer an arrangement is used the effective part of which consists of a single loop of very fine wire which is positioned in close proximity to the moving record tape. Further details of the apparatus and method of the present invention are explained in the following specification in connection with the drawing, in which:

Fig. 1 shows schematically a recorder or receiver as previously used;

Fig. 2 is a cross-section;

Fig. 3 is a side view of the recorder or reproducer according to the present invention;

Fig. 4 shows an enlarged portion of Fig. 2, bringing out further details;

Fig. 5 shows another enlarged portion of Fig. 2, illustrating more clearly the magnetic field distribution;

Fig. 6 is a schematically shown portion of a complete recording apparatus with removing and pre-magnetizing arrangements for the sound record tape;

Fig. 7 is a diagram indicating the magnetizing characteristics of the sound record tape;

Fig. 8 shows a modified form of a sound recording and reproducing arrangement, being a section through the movable part thereof;

Fig. 9 is a plan view of the parts shown in Fig. 8;

Figs. 10, 11, and 12 show details of the special pick-up unit of Fig. 8;

Fig. 13 is a front view;

Fig. 14 is a side view; and

Fig. 15 is a horizontal section of a sound pick-up needle adapted to be used in connection with magnetic records.

Referring now in greater detail to the drawing, Fig. 1 shows a recorder or reproducer of known construction in which the variable magnetization of an electromagnet 1 is used for recording sound while the sound record tape 3 is guided past the air gap 2. The circles drawn in with the gap as their center indicate the extent of the magnetic dispersion present in this arrangement. It is evident that the dispersion is a multiple of the actual width of the gap.

According to the invention, an electromagnetic arrangement is used which functions entirely without iron, a single loop 4 of a conducting wire being inserted into a recess of an insulating body 6, Figs. 2 and 3. The body 6 is provided with a cylindrical portion 9 over which the sound recording tape is guided in a direction perpendicular to the axis of the wire loop 4, which lies in a slot or recess 8 of the running surface 9, as shown in Fig. 4. The circuit connections for wire 4 are indicated at 5. To facilitate the insertion of the wire 4, the insulating body 6 is provided with slots 7.

In Fig. 4, the wire 4 is shown in vertical section, while the tape 3 is guided over this point in the plane of the drawing. When a steel tape or wire is used, a very thin sheet of insulation 10, such as mica, must be placed between the conductor 4 and the steel tape 3 in order to prevent the carrying-off of current by the steel tape. When the insulating body 6 consists of ceramic material, the wire 4 may be enamelled. How-

ever, when a film or paper tape is used which is provided with a magnetizable layer consisting, for example, of a binding agent and iron powder, the resistance of the layer is high enough to permit the omission of the insulating sheet. The tape **3** may, therefore, rest directly upon the wire **4**, as indicated in Fig. 5.

However, in order to obtain as perfect sound recording as possible, it is necessary to keep the diameter (cross-section) of the conductor **4** as small as is technically feasible. A diameter of approximately 1/30 to 1/50 of a millimeter is suitable. As shown in Fig. 5, the diameter *d* of the wire **4** is not appreciably greater than the width *s* (about 0.02 mm.), shown as a matter of example, of the air gap of electromagnetic devices normally used for sound recording. The circles drawn around conductor **4** in dotted lines indicate the magnetic field about the conductor. As evident from a comparison with Fig. 1, the effect on adjacent zones of the tape **3** is reduced to a minimum. In this connection, it must be taken into consideration that Fig. 5 constitutes a very considerable enlargement of the scale as compared with that of Fig. 1, as may be seen without much trouble from the width *s* of the gap shown.

When the sound record tape is permitted to glide directly over wire **4**, the latter is mechanically stressed under certain circumstances. For this reason, and since the wire must be of as small a diameter as possible, as mentioned above, it is advisable to make this wire of very hard material, such as osmium, iridium, tungsten, tantalum, or the like.

In order to produce a sufficiently intensive magnetic field about the wire **4**, the recording current may be intensified by a step-down transformer. A simple transformation is permissible because the loop has but a small ohmic and inductive voltage loss. This voltage loss is by far lower than in ordinary windings. For reproduction, the current of the wire **4** may be sent through a step-up transformer.

The magnetic resistance of the air around a wire of the mentioned diameter is essentially higher than in the case of an iron core or iron bridge such as used in arrangements of known construction. However, this does not require as a result greater energy for producing the recording field. In recording devices of known construction, only a small fraction of the magnetic field (about 1/50) is used for magnetizing the tape, while the greatest portion of the field is lost in the gap **2** acting as a shunt.

When a tape with pulverized iron is used for sound recording, the internal resistance of this tape is so high that the field strength cannot be increased appreciably even by a bridge of the lowest magnetic resistance. On the other hand, the shunt consisting of the gap **2** for the flux of power lines through the recorder, reduces essentially this flux so that a receiver with iron bridge according to Fig. 1 does not show any advantages, concerning the delivered intensity, over the device of the present invention.

In electromagnetic recording of sound it is assumed that high and low frequency tones result in the same voltages at the microphone. When the self-induction of the recording device is held very small, currents of the same intensity also result, even for different frequencies and, therefore, magnetic fields of the same strength. However, this is not correct concerning the reproduction with known reproducers, because a high frequency $n.f$ produces a tension at the reproducer which is n-times higher than with a low frequency f. In a pick-up of the present invention, however, the compensation is produced automatically. This may be explained in connection with Fig. 5. Assume that the wave length of a tone recorded upon the tape be lambda (λ). The corresponding frequency has an air resistance corresponding to this wave length while lower frequencies with a wave length of, for instance, $n.\lambda$, have only the nth part of the air resistance. The higher frequency, however, passes the conductor in the same interval n-times as many times as the low frequency so that for both frequencies the same product of field strength times frequency results, i. e., the same voltage at the terminals of the reproducer.

In Fig. 7, for instance, the magnetizing characteristic of a sound record tape is shown in the form of the well known hysteresis curve. In order to prevent distortion, the working point must be placed on the straight portion of the magnetizing curve, i. e., the sound record tape must receive an additional constant magnetization. The working point then lies at G in the straight portion of the magnetizing curve while it would lie at R without the application of constant premagnetization. This point is determined by the residual magnetism of the sound recording tape. In order to obtain this constant magnetization, a direct current may be superimposed on the microphone current, or a special premagnetization may be provided for immediately before the sound recording. Such an arrangement is shown in Fig. 6. In this case, a plurality of wires are embedded in recesses of the insulating body **6**, of which AW corresponds to wire **4** of Figs. 2 to 5. This wire serves for the energization of the magnetic alternating field for the sound recording. A very small distance apart from this wire, a wire V is indicated parallel thereto, which produces the premagnetization. For this purpose, the wire is connected to a source of direct current, as shown schematically in Fig. 6. The clearance must be sufficiently small so that the direct magnetic field is still retained in the sound record tape at the time when the alternating current magnetization takes place by wire AW. At a considerable distance therefrom a wire L is provided for the removal of any possible residual magnetization upon the sound record tape. This wire also is connected to a source of direct current, as shown schematically in Fig. 6. The distance from the wire AW provided for the recording must be sufficiently large to permit the return of the direct field into the residual condition R. The working points of the different premagnetizations are indicated in Fig. 7 by the same letters as the corresponding current conductors of Fig. 6.

Another important advantage of the invention results from the fact that the recorders and reproducers require but little space so that a pick-up is possible even from discs resembling phonograph records, or from spiral spools of record tape without requiring their unrolling. Fig. 8 shows a section and Fig. 9 a plan view of an arrangement by means of which sound can be picked up from such spiral spools of tape, the movable parts being shown only and the drive mechanism having been omitted. Upon a plate **14** a solid ring **13** is provided with notches cooperating with projections **15** of a removable ring **12**. The sound record tape is wound upon this removable ring **12** in the shape of a spiral. The end **3** of this tape is clamped into a holder **16** at the edge of the plate. The reproducer is pro-

vided with an arm 22 secured by a universal joint 23 in a well known manner, and carrying the pick-up device proper 18. The latter is shown in different views, Figs. 10, 11, and 12. The essential parts are the thin plates 17, of mica or ceramic material, about which the wires AW for recording and reproduction, V for premagnetization, and L for removal, are arranged in such a manner that they are freely exposed on their outside and thus touch the tape 11 directly, while the return connections lie between the two plates 17 by which they are insulated. In the holder 18, corresponding terminal clamps 19 are provided which are indicated in Fig. 11 at AW, V and L, in accordance with the wires to which they belong. The contacts 19 are rigidly secured in member 18 at the left hand side as viewed in Fig. 11, while, on the right hand side, they are rigidly secured to a clamping plate 20, which may be loosened or tightened by means of a clamping screw 21. As may be seen from Figs. 10 and 12, the pick-up device is given the shape of a flat small plate. It may, therefore, glide easily between coils of the spirally wound record tape 11 and pick up the magnetic recording from the tape without necessitating the unrolling thereof. When the plates 17 are sharpened at the end as at 24 (Fig. 10), the pick-up device may be inserted into the spool of tape 11 at any desired point.

In a very similar manner, the device may be used for pick-ups from discs resembling phonograph records. This is shown in Fig. 13, where 26 indicates an enlarged section of such a magnetic phonograph record disc, the grooves being indicated at 27. For the pick-up, a needle 25 is used in this case with the wire 4 inserted or molded into the external surfaces thereof. Fig. 14 shows a side view and Fig. 15 a cross-section of the needle 25 for better illustration of the arrangement of the wire 4 therein. In this case, but one single wire 4 is provided, this figure referring to a reproducing device. For reproducing, but one wire is necessary because the premagnetization of the tape has taken place already during recording and because a removal immediately after reproduction is not desirable in most cases. As may be seen from Fig. 13, the conductor 4 stands with its effective part perpendicular to the groove circle and may, therefore, be used for picking up longitudinal magnetization present in the groove.

I claim:

1. In a magnetic sound recording and reproducing device, a conductor of small diameter forming part of a sound current circuit, a movable length of ferrous record material, said record material being the only magnetizable material in the magnetic field surrounding said conductor, and means for supporting said conductor and a continuously changing portion of the moving record material in close proximity, with the conductor extending across the line of travel of the material.

2. In a magnetic sound recording and reproducing device, a single loop of current conducting wire of small diameter, iron free supporting means for said loop, a movable length of ferrous record material, said loop constituting the sole means for producing magnetic flux passing through said record material, and means including said supporting means for guiding said material past said loop, outside thereof, and in a direction substantially perpendicular to the plane thereof, whereby the material passes through the field surrounding one side of the loop but is substantially uninfluenced by the field surrounding the other side.

3. A device as claimed in claim 1, in which the diameter of the conductor does not exceed .05 millimeter.

4. A device as claimed in claim 1, in which the conductor is insulated and the record material is in contact with it.

5. In a sound recorder or reproducer, a single conductor carrying sound currents, a moving strip of record material, and means for guiding said strip through the field surrounding said conductor, the said field being wholly free of iron except for the iron in said strip.

6. In a sound recorder or reproducer, a single conductor carrying sound currents, a strip of steel movable at right angles to said conductor, means for supporting said conductor and the adjacent section of said strip in close proximity, and a thin strip of insulating material to prevent the steel strip from contacting said conductor.

7. In a sound recorder or reproducer, a single conductor carrying sound currents, a strip of ferrous record material having a high linear resistance and movable past said conductor at right angles thereto, and means for supporting said conductor and the adjacent section of said strip in contact with each other.

8. In a magnetic sound recording and reproducing device, a supporting body of insulating material over which a length of record material may be passed, and a plurality of separate conductors embedded in the surface of said body and adapted to be passed over successively by a given section of said material, said conductors extending at an angle to the direction of motion of said material.

9. A device as claimed in claim 8, and including means for passing a direct current through one of said conductors to premagnetize the record material.

10. A pick-up device for use with a spirally wound strip of record material, said device comprising a tongue formed of two thin strips of insulating material and adapted for insertion between adjacent coils of record material, and a single loop of wire extending lengthwise around one of said strips with one leg between such strip and the other strip.

11. A pick-up device for use with a spirally wound strip of record material comprising a loop of wire adapted for insertion between adjacent coils of said strip, and means for supporting said loop so that one leg thereof lies closer to the record material than the other.

12. A pick-up as claimed in claim 10, in which the tongue is sharpened or tapered at the end for ready insertion between the coils of the record.

13. A pick-up device for use with a grooved disc carrying a magnetic record, said device comprising a member having a point adapted to ride in the groove of the record, and a loop of wire extending around said point just beneath the surface.

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