April 29, 1952 C. F. E. GARREAU 2,594,414

HEAD FOR MAGNETIC RECORDERS

Filed Feb. 2, 1949 2 SHEETS—SHEET 1

Fig. 1.

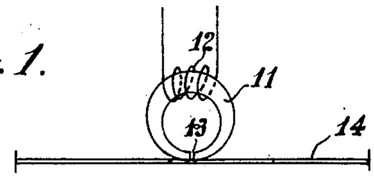


Fig. 2

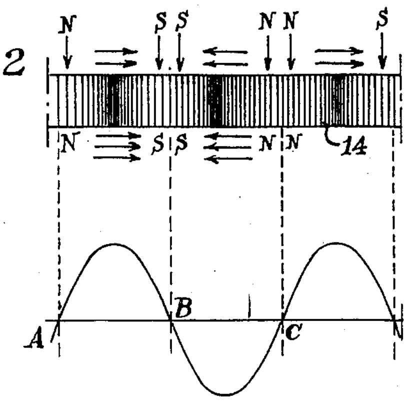


Fig. 3

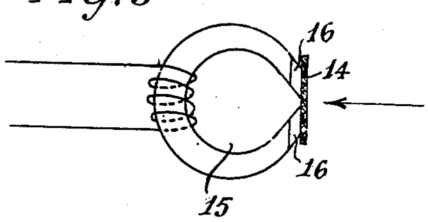


Fig. 4

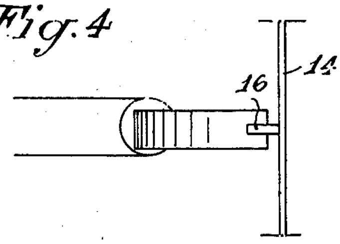
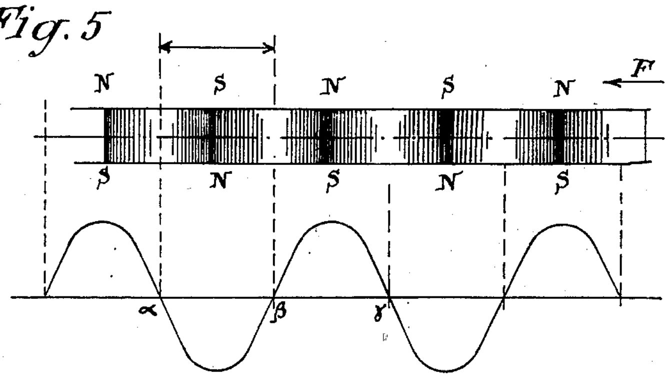


Fig. 5



INVENTOR:
CHARLES F.E. GARREAU
By Worth Wade
ATTORNEY

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Fig:6

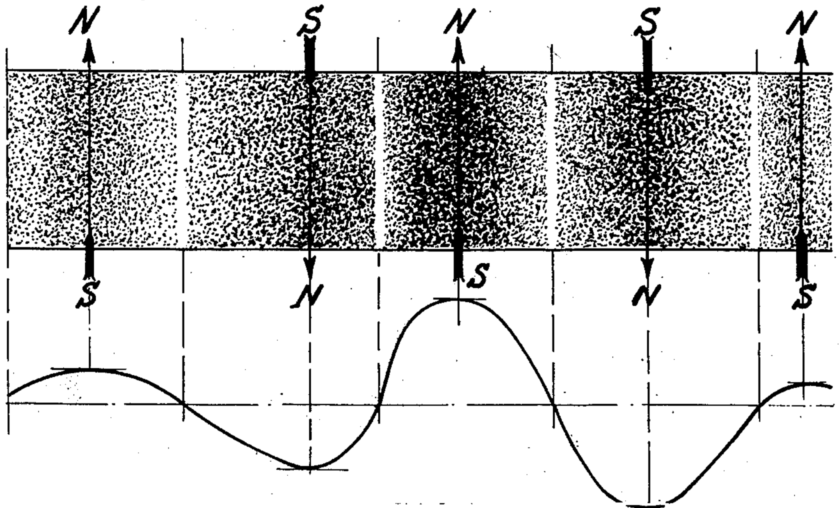


Fig 7

Fig. 8

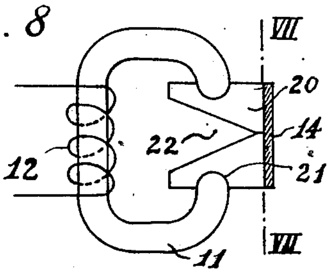


Fig. 9.

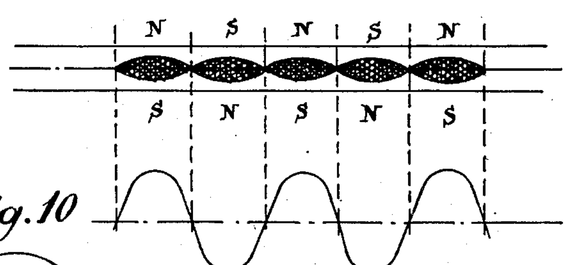
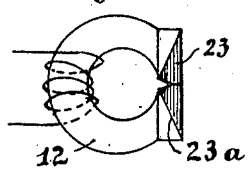


Fig. 10



INVENTOR:
CHARLES F. E. GARREAU
By Worth Wade
ATTORNEY

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HEAD FOR MAGNETIC RECORDERS

Charles F. E. Garreau, Paris, France

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5 Claims. (Cl. 179—100.2)

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It is already known to record sounds by magnetization of magnetic supports moving in front of a magnetizing apparatus in which a magnetic field varying in terms of the modulation is produced.

In the most recent process of this kind, a strip of nonmagnetic substance forming a support, is used, and on top of it is spread a thin layer of magnetic substance in fine particles, strongly bound to the support, and the strip is moved in front of a recording head formed by a magnetic tore energized by the modulated current flowing through an appropriate coil and provided with a slit of small width located in a diametrical plane of the tore, perpendicularly to the direction of unwinding of the strip.

Owing to the direction of the variable magnetizing field relatively to the magnetic strip, the elementary magnets of the recorded strip are directed along the length of the strip. The length of these magnets, varying according to the frequency, is always very short, whereas their width is that of the strip, i. e. 6.5 millimetres, according to the commonly adopted dimensions. In the case of high frequencies, the length of the magnets may reach extremely low values relatively to their width, this being an important disadvantage, both for the loudness of sound and for the conservation of recording through time.

The object of the present invention is to cope with these disadvantages by giving the elementary magnets a length far greater than their width, particularly in the case of high frequencies.

The variable magnetic field produced by the sound recording head of the invention is laterally directed, that is, it is perpendicular to the direction of movement of the strip, so that the length of the elementary magnets lies laterally, whereas their width is along the unwinding direction.

The recording by means of a magnetic field laterally directed, which will, for the purpose of simplifying, be named "lateral recording," ensures the following advantages:

(a) For all common audiofrequencies and for common moving speed of the magnetic strip, the ratio of length to width of elementary magnets may be greater, than 1, and this ratio increases with frequency, by giving the strip better magnetic qualities;

(b) It is possible to have for the elementary magnets, a constant length independent of the frequency and equal to the width of the strip;

(c) The poles of elementary magnets laid side by side are alternated, this allowing a better conservation of recording.

The invention also comprises a sound reproducing head for reproducing records made on a magnetic strip with the lateral process, the reproducing head being roughly identical to the recording one.

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The pole-piece of a sound magnetic transducer according to the invention is constituted by a thin magnetic plate formed by magnetic particles kept in position between two non magnetic supports thus making a kind of sandwich system. The magnetic particles are advantageously embedded in a convenient binder enabling to cast on one of the supports a layer of setting magnetic paste which is brought to the required thickness and covered by a second support. It is thus possible, by using sufficiently fine magnetic particles, and sufficiently thick nonmagnetic supports to obtain a pole-piece having an elongated and very thin magnetic portion, embedded in a nonmagnetic support, in contact through its very small thickness with the magnetic strip and providing an appreciable support area for the strip during recording.

According to the shape given to such a pole-piece, it is possible to obtain either a recording of variable magnetizing density and of constant magnet length, or a recording of constant density and of variable magnet length, or still a mixed recording of variable density and of variable magnet length.

The foregoing objects and advantages will be made fully apparent from the following specification given by way of nonlimitative example, reference being had to the accompanying drawings, in which:

Fig. 1 is a diagram of a recording head utilizing the known process.

Fig. 2 shows the arrangement of the elementary magnets of a magnetic strip on which has been recorded, by the known process, a sound giving rise to a modulated current represented by curve ABC in that figure.

Fig. 3 is a diagrammatical elevation of a sound magnetic transducer utilizing the lateral process.

Fig. 4 is a plane-view corresponding to Fig. 3.

Fig. 5 shows similarly to Fig. 2 the arrangement of magnets on a strip recorded by the lateral process.

Fig. 6 is a diagram of a laterally recorded variable density strip.

Fig. 7 is a section along line VII—VII of Fig. 8 showing the sandwich arrangement of the pole-pieces.

Fig. 8 is a diagram showing the arrangement and shape of pole-pieces for lateral recording of variable density and constant length.

Fig. 9 shows the arrangement and shape of the elementary magnets on a recorded strip of constant density and variable length.

Fig. 10 shows the arrangement and shape of pole-pieces for constant density recording.

In the known process of recording in which the magnets lie in the direction of movement of the magnetic strip, the recording head (Fig. 1) mainly comprises a tore 11 of magnetic substance around which is provided a coil 12 energized by the current modulated by the vibrations to be recorded.

A narrow slit 13 perpendicular to the direction of movement of magnetic strip 14, is provided in the magnetic circuit; in this slit is set up a variable field locally magnetizing the magnetic substance carried by strip 14 which regularly moves while being supported by both pole-pieces limiting slit 13.

The recording acquired occupies the whole width of the magnetic strip and is composed of small elements of magnets of constant width equal to that of the strip, and whose length varies with the recorded frequency, the density of magnetization being roughly proportional to the sonorous power.

Let the variable current arising from the modulation be represented by curve ABC of Fig. 2; the half period represented by part AB of this curve will give rise to a magnet whose north pole will, for instance, be at the left, whereas the half period represented by part BC of the curve will give rise to a magnet whose north pole will be situated at the right. In Fig. 2, the magnetic flux flowing through these magnets, are seen to be in opposition, this being prejudical to the good conservation of the recording which, moreover, can never reach a high loudness owing to the extremely reduced length relatively to the width of these magnets, especially in the case of high frequencies, this giving rise to very important magnetic leakages.

In the process used with a sound magnetic transducer according to the invention, the variable magnetic field produced by the modulated current is directed laterally with respect to the magnetic strip (Figs. 3 and 4), the recording head 15 being, relatively to strip 14, at 90° from the position it has in the known process, and comprising, instead of a slit, projecting pole-pieces 16, so that the obtained elementary magnets are directed in such a way that their length lies along the width of the magnetic strip. It is thus possible to obtain for these magnets, a constant length equal to the width of the recording head, the generally reduced width of these magnets varying with the frequency whereas their density of magnetization is roughly proportional to the loudness of the sound to be recorded, at least when the pole-pieces are not saturated.

Fig. 5 shows the general arrangement of these elementary magnets with respect to a curve $\alpha\beta\gamma$ representing the modulated current flowing through the recording head. Assuming that the alternation represented by portion $\alpha\beta$ of the curve gives rise to a magnet whose north-south direction lies left to right with respect to direction F of movement of the magnetic strip, the next alternation represented by $\beta\gamma$ will give rise to a magnet situated near the preceding one, parallel to it, and directed from right to left, the width e of each magnet varying with the frequency and greatly magnified in the figure because of the requirements of the drawing, being placed along the direction of movement.

The successive poles of the various magnets are alternated on the edges of the recording, so that the magnetic leakage lines may close outside without causing an important weakening of the recording.

The difficulty in the realization of the lateral recording process lies in the manufacture of a recording head liable to produce, on the magnetic strip, elementary magnets distant enough from one another, to accurately reproduce high frequencies, the recording head to be used having to be of the very reduced width projecting pole-pieces kind.

Assuming the strip moves in front of the recording head at a velocity of 500 millimetres/second which is an important velocity, the wavelength of the recording corresponding to high frequency sounds, for instance of about 10,000 periods/second, will be equal to

$$\frac{500}{10,000}$$

i. e. 50 microns, the half wavelength being therefore 25 microns.

For a magnetic recording to be satisfactory, the width of the recording poles must necessarily be equal to about ⅕ of the smallest recorded half wavelength; in the above case, the width of the poles should not be greater than 5 microns.

In order to obtain magnetic poles of such a small thickness, it is not possible to resort to usual means and the invention aims at obtaining them, starting from powdery magnetic substance kept between appropriate supports. On a plate of nonmagnetic substance 17 perfectly surfaced (Fig. 7) are spread a powdery magnetic metal paste enabling to obtain a very high value of induction, and a binder ensuring a perfect adhesion to the support. After setting, the thickness of magnetic layer 18 is reduced by surfacing to the required value, and this magnetic layer is covered by a second plate 19 perfectly surfaced which may be kept on the whole arrangement by a layer of binder, for instance. A complex element is thus obtained whose cross-section comprises a rectilinear magnetic portion of very small width and whose side constitutes an appreciable surface support on which the magnetic strip may rest during recording or reproduction.

The magnetic element thus obtained may be machined to the convenient shape to form pole-pieces 20 (Fig. 8) meant, as will be shown later, for one of the possible methods of recording; these pole-pieces may be energized by any magnetic system, for instance by a tore-shaped magnetic circuit 11 around which is placed a coil 12 through which flows the modulated current, the whole arrangement forming the recording head, the strip driving device being left out of account.

Thanks to the lateral recording process, two distinct recording methods may be considered which have a direct similarity to sound recording processes utilizing a photo-electric cell for reproduction.

(1.) Operation at variable density magnetization:

The geometric dimensions of the pole-piece or magnetizing plate, as well as its energizing means, may be such that the field magnetizing the magnetic strip be directly proportional to the energizing field over the whole length of the plate. In that case, the recording on the magnetic strip may be represented by a succession of magnets of constant length, equal for instance to the width of the magnetic strip, but whose intensity of magnetization varies with the modulation and whose width varies with the frequency (Fig. 6).

(2.) Operation at constant density of magnetization and variable width:

The dimensions and shape of the magnetizing plate, as well as its energizing means, are such that the metal/binder complex utilized be at saturation point for the maximum magnetization of the magnetic mixture spread over the recording strip.

For a given shape of this plate, this saturation may take place first towards the centre of the plate for small depths of modulation, and hence of magnetization and increase in length in terms of the power.

In that case, recording on a magnetic strip may be represented by a succession of magnets of variable length, of constant intensity of magnetization and of variable width in terms of the frequency, these magnets being shown in Fig. 9 by the lenticular hatched surfaces.

For recording at variable intensity, the pole-piece is arranged so as to have a surface as large as possible of contact with the energizing magnetic circuit and to concentrate the magnetic flux as regularly as possible over the whole useful length of the magnetizing plate. Fig. 8 shows a magnetic recording head designed for this method of operation, pole-piece **20** fitting on the rounded tips **21** of a tore-shaped magnetic circuit comprising a V-shaped median notch **22** extending up to the neighbourhood of strip **14** to be recorded.

For recording at constant intensity of magnetization, the magnetizing plate must be saturated first at the centre and this saturation zone increase on either side of this central portion when the flux created by the modulation increases in the magnetic circuit. The corresponding pole-piece **23** (Fig. 10) will be arranged so as to present towards its centre only a small surface of contact with the magnetic energizing circuit **11** and lateral surfaces **23***a* progressively moving away from this circuit **11**. The flux flowing through circuit **11** thus very quickly saturates the central part of pole-piece **23** and when this flux increases, the length of the saturated plate progressively increases.

Anyhow, it is possible to realize a mixed process enabling to improve the results of these recording processes.

As a matter of fact, for low levels of modulation and with a constant density recording apparatus, it is possible to realize the variable density operation in the median portion of the strip. The plate is not immediately saturated and, before reaching that stage, it undergoes magnetization proportional to the energizing value.

The following mixed operation may therefore be considered:

(*a*) For a very low modulation level, the magnetization of the strip is proportional to the magnetizing field, the length of the elements of magnets located at the centre of the strip being very small (variable density operation).

(*b*) For a higher modulation level and up to the maximum: operation according to the constant density system, with variable length of elements of magnets, constant intensity of magnetization, and of course variable width in terms of the frequency, as in both preceding cases.

The sound reproducing head is designed according to the principle of the recording head at variable density, the translation for the various modulation systems described above being effected through an identical process in every case. The metal/binder complex only must have different properties, the energizing fields being of different value.

Moreover it is obvious that the strip magnetic layer will have to be adapted to the recording system just described, i. e. by means of long elements of magnets of small width. The magnetic paste will have to be made of substances satisfying those requirements.

It is understood that alterations may be brought to the recording magnetic heads just described, particularly by substituting equivalent technical means, without departing from the scope of the invention.

It is equally understood that before recording, the strip must, as in every magnetic process, be brought to a no field magnetic state. Besides, the lateral recording process just described may be combined with the known fading process by means of high frequency current and it is not excluded to combine it with the high frequency polarization process.

What I claim is:

1. In a magnetic transducer apparatus for laterally recording on or reproducing sounds from a movable thin magnetic strip, a transducing head including an electrical coil and a magnetic core for magnetically coupling said thin magnetic strip to said coil, said core having tips bridged with a single projecting pole-piece formed by a thin magnetic plate kept in position between two plates of nonmagnetic substance, said pole-piece being secured to said tips and arranged and adapted to be kept with its thickness in contact with said strip in a direction at right angles to the direction of movement of said strip.

2. A magnetic transducing head as claimed in claim 1 in which said thin magnetic plate is made of a mixture of a comminuted magnetic substance with a binder therefor.

3. A magnetic transducing head as claimed in claim 1 in which the width of said thin magnetic plate measured in the direction of movement of said recording strip is not greater than

$$\frac{1}{100,000}$$

of the velocity of said strip.

4. A magnetic transducing head according to claim 1 in which said core has rounded tips in contact with said thin magnetic plate, said plate having an area of contact with said rounded tips at least equal to the area of contact between said thin magnetic plate and said recording strip, said thin magnetic plate having on its side remote from said recording strip a V-shaped notch located between said tips and extending up to the neighborhood of its opposite side.

5. A magnetic transducing head according to claim 1 in which said thin magnetic plate is in contact with said core tips through an area located in the central part of the length of said plate which is small with regard to the area of contact between said thin magnetic plate and said recording strip, said thin magnetic plate being provided with lateral surfaces facing said tips and progressively moving away from said tips, whereby the flux flowing through said magnetic core quickly saturates the central zone of said plate and when the flux increases the length of the saturated zone increases.

CHARLES F. E. GARREAU.

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