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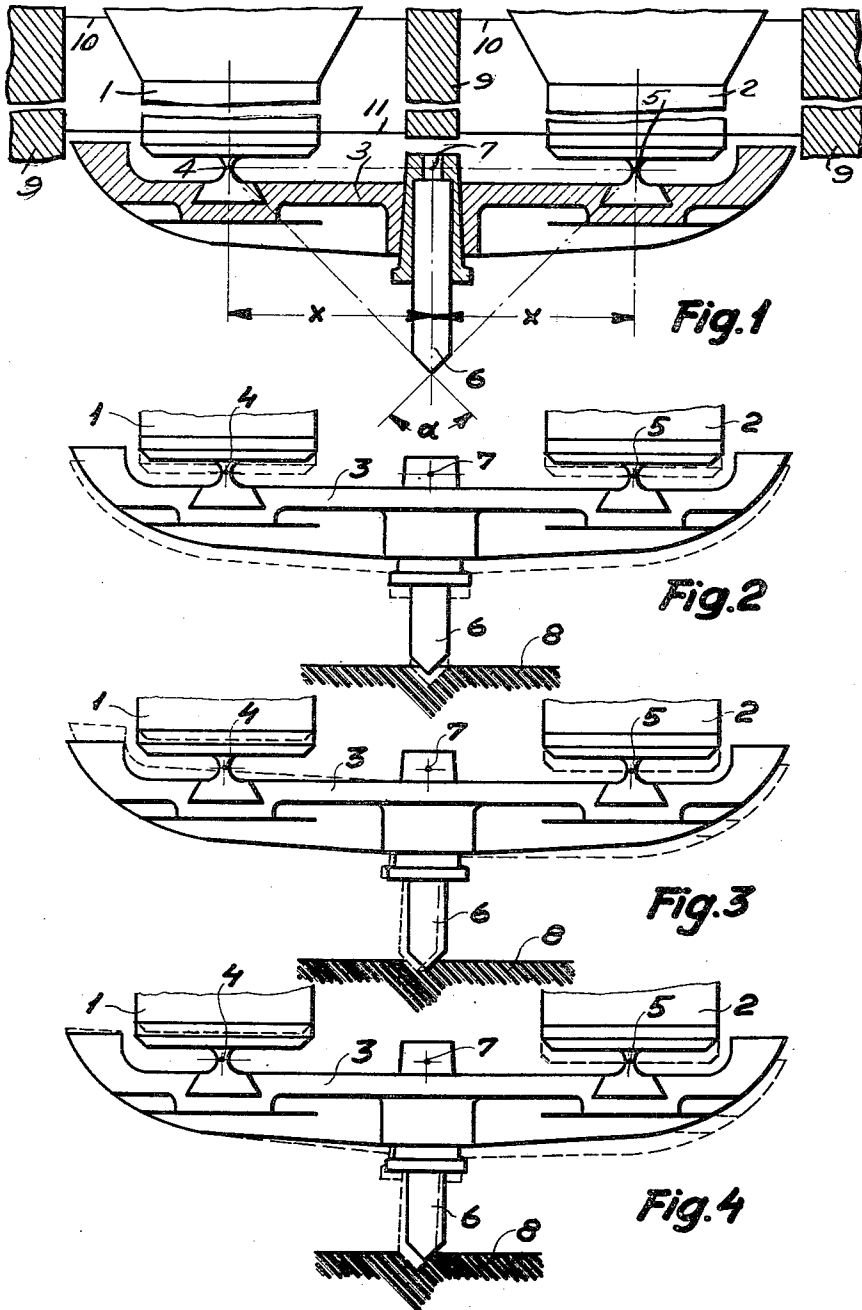
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3,051,798

DEVICE FOR THE RECORDING OR REPRODUCTION OF SOUND TRACKS

Filed March 2, 1959

2 Sheets-Sheet 1



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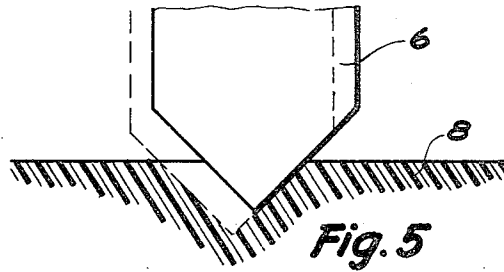


Fig. 5

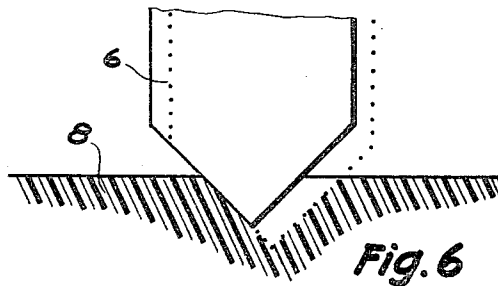


Fig. 6

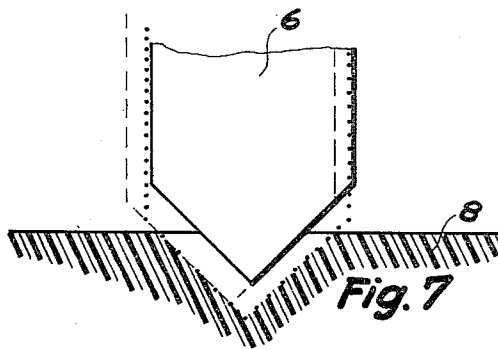


Fig. 7

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DEVICE FOR THE RECORDING OR REPRODUCTION OF SOUND TRACKS

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The present invention relates to an electromechanical recording and reproducing head of the type having two movable electromechanical members connected to a mechanical oscillating system, comprising an armature and a needle responsive to both vertical and lateral modulation.

The operating principles of devices of this class, for uses such as disc recording, are known. As a practical matter, however, the cross modulation produced by the mechanical interaction of the two electromechanical members through the armature has prevented satisfactory results from being obtained. Previous attempts to reduce this cross modulation have proceeded on the basis that the masses of the electromechanical members must be increased while the mass of the oscillating system must be reduced.

The results of these attempts have not been acceptable since the attendant increase in the dimensions and weight of the apparatus, together with the loss of mechanical rigidity of the armature, which limits the high frequency response of the head, have rendered these solutions to the problem both impractical and unsatisfactory.

Accordingly, it is an object of this invention to provide an electromechanical head structure which is not subject to the aforementioned problems and limitations.

Another object of the invention is to provide a recording and reproducing head which possesses a substantially uniform frequency response throughout the usable frequency spectrum.

A further object of the invention is to provide a head structure capable of response to both vertical and lateral modulation characteristics and which is substantially free from any cross modulation effects.

A still further object of the invention is to provide a head structure capable of recording or reproducing two channels with a single needle.

According to a preferred embodiment of the invention, an elongated armature with a needle mounted centrally thereon has an electromechanical member connected to the armature symmetrically on each side of the needle, the distance between each of the points of action of the two electromechanical members on the armature and the centre of gravity of said oscillating system being equal to

$$\sqrt{\frac{I}{M}}$$

where I is the moment of inertia of the oscillating system about an axis through the centre of gravity of said oscillating system perpendicular to the plane formed by the points of the needle and said two points of action of the electromechanical members on the armature, while M is the mass of the oscillating system. Energizing either or both of the electromechanical members produces mechanical oscillation of the armature which in turn causes the needle to be oscillated either vertically or laterally, or in both directions simultaneously.

In a preferred embodiment of the invention said centre of gravity is located substantially on a straight line through said two points of action.

Preferably a mechanical rigid elongated armature is used connected to two coils forming the two movable electromechanical members. It can thus be seen that

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this structure implies some increase in the mass of the armature beyond the minimum requirements for mechanical rigidity. On the other hand, however, the coil structures, which are considerably heavier than the armature, may be made as light as possible, thereby enabling an overall reduction in mass.

This preferred embodiment of the invention is illustrated in the accompanying drawings in which:

FIG. 1 is a front view of a part of a device according to the invention;

FIG. 2 is an oscillating system under the action of the two electromechanical members operating in in-phase relation;

FIG. 3 is the oscillating system under the action of the two electromechanical members operating in counter phase relation;

FIG. 4 is the oscillating system under the action of one of the two electromechanical members only, and

FIGS. 5, 6 and 7 illustrate various types of track recording under various combined actions of the electromechanical members.

In FIG. 1 a device is shown comprising two electromechanical members in the form of oscillating coils 1 and 2 having parallel directions of motion. Each of the oscillating coils is connected to an armature 3 at points of action 4 and 5, respectively. The armature 3 has a needle 6, the point of which is so located that the lines connecting the point of the needle 6 with each of the two points of action 4 and 5 form an angle of 90° . The coils 1 and 2 are supported conventionally in housing 9 by means of leaf springs 10 and 11 which are arranged radially in relation to the axis of the coils.

The armature 3 has a center of gravity 7 located on or near a straight line through the two points of action 4 and 5, and the armature is symmetrically constructed so that the two points of action 4 and 5 are located at the same distance x from the center of gravity on each side thereof.

FIG. 2 shows how such a device will cut into a record when the two oscillating coils 1 and 2 are operating in in-phase relation. The armature will then move vertically up and down, and in a record 8 a track will be cut with vertical or "hill-and-dale" modulation as indicated by dotted lines.

If the two oscillating coils 1 and 2 are operating in counter phase relation, the armature 3 will be moved as shown in FIG. 3. In view of the very small movements, the curvature of the paths of motion may be neglected and the point of needle 6 will therefore make a transverse movement only as shown by dotted lines, a transverse modulation being thereby effected.

FIG. 4 illustrates how the armature will move, if only one of the oscillating coils is operating. Provided that the above-stated condition

$$x = \sqrt{\frac{I}{M}}$$

is fulfilled, an action of the oscillating coil 2 at the point of action 5 will cause the armature to pivot about the point of action 4, and the point of the needle 6 will therefore perform a movement which may be considered rectilinear in a direction forming an angle of 45° with the horizontal plane. Thereby a sound track as shown in FIG. 5 will be recorded, and it appears from FIG. 6 how the corresponding recording of a sound track will be effected when the oscillating coil 1 is operating alone.

The combined movements will appear from FIG. 7 where, two independent modulations may be recorded in a two-channel system for instance, for stereophonic reproduction.

It will be seen from FIG. 2 that by "hill-and-dale" movement each of the two oscillating coils will be loaded

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by half of the mass of the armature, i.e. by $M/2$. When the needle is moving transversely as shown in FIG. 3, and if the armature is so designed that

$$x = \sqrt{\frac{I}{M}}$$

the load will become

$$\frac{I}{2x^2} = \frac{I \cdot M}{2 \cdot I} = \frac{M}{2}$$

i.e. the same load as for "hill-and-dale" movement.

In FIG. 4 the armature is operated by one of the oscillating coils only. Still provided

$$x = \sqrt{\frac{I}{M}}$$

the armature will pivot about the point of action of the other coil, and no power will be transferred thereto.

A one-sided action of a force P at the point of action 5 will, according to the laws of physics, impart a movement to the armature composed of two components, i.e. a translatory movement in the direction of the force P thereby setting up a resistance of inertia equal to an opposite the direction of the force P , and, owing to the fact that the resistance of inertia will act in the center of gravity 7, a rotation of the armature about the center of gravity set up by the torque $P \cdot x$. The point 5 will therefore have two accelerations i.e.

$$\alpha_1 = \frac{P}{M}$$

owing to the translatory movement, and

$$\alpha_2 = \frac{P}{I} = \frac{P}{Mx^2} = \frac{P}{M}$$

owing to the rotation, the effective mass in the point 5 during pivoting about the center of gravity being equal to the moment of inertia divided by x^2 . It will be seen that when the armature is designed according to the invention, the two components of acceleration will have the same size, and the resulting acceleration in the point 5 will therefore be

$$\alpha_1 + \alpha_2 = \frac{2P}{M}$$

while the acceleration in the other point of action 4 will be $\alpha_1 - \alpha_2 = 0$, the accelerations having here opposite directions. This means that the resulting movement of the armature will become a rotation about the point of action 4.

It will also appear from the above statements that the load of the operating oscillating coil will be

$$\frac{I + Mx^2}{4x^2} = \frac{Mx^2 + Mx^2}{4x^2} = \frac{M}{2}$$

because the moment of inertia of the oscillating system by rotation about the point 4 is $I + Mx^2$. It will be understood that the load of masses will be the same for all the types of motion mentioned, and cross modulation is avoided by the fact that one of the oscillating coils only will set up a pure rotation or pivoting of the os-

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cillating system about the point of action of the other coil on the armature.

While the invention has been illustrated and described in one embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

Having described my invention, I claim:

1. In an electromechanical recording and reproducing device, a mechanical oscillating system comprising an elongated armature including a needle mounted centrally thereon, a plurality of electromechanical members connected to the armature symmetrically on each side of said needle, the connection between each of the electromechanical members and the armature being so arranged that the armature is carried by said electromechanical members and that two fixed and sharp points of action are defined through which no turning moment may be transmitted, the armature being further provided with extensions extending outwardly from said points of action, said extensions being so arranged that the center of gravity of the armature is positioned substantially on a straight line through the two points of action so that the distance between each of the two points of action and said center of gravity is equal to

$$\sqrt{\frac{I}{M}}$$

where I is the moment of inertia of the armature about an axis through said center of gravity perpendicular to the plane formed by the point of the needle and said two points of action, while M is the mass of the armature.

2. In a device of the class described, a mechanical oscillating system comprising a mechanical rigid elongated armature with a needle mounted on said armature at the center of gravity thereof, a coil connected to the armature symmetrical on each side of the center of gravity defining a point of action therefor, the distance between each of the points of action of the two coils on the armature and the center of gravity of said oscillating system being equal to

$$\sqrt{\frac{I}{M}}$$

where I is the moment of inertia of the oscillating system about an axis through the centre of gravity of said oscillating system perpendicular to the plane formed by the points of the needle and said two points of action of the coils on the armature, while M is the mass of the oscillating system.

3. In a device of the class described, and according to claim 2, wherein said center of gravity is located substantially on a straight line through said two points of action.

References Cited in the file of this patent

UNITED STATES PATENTS

2,025,388	Henning	Dec. 24, 1935
2,027,168	Harrison	Jan. 7, 1936
2,093,540	Blumlein	Sept. 21, 1937
2,864,897	Kaar	Dec. 16, 1958

FOREIGN PATENTS

688,804	Great Britain	Mar. 11, 1953
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