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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in or relating to Pick-Ups for Sound Recordings having a Groove for Mechanically Oscillating a Stylus.

We, THE DECCA RECORD COMPANY LIMITED, a British Company, of Decca House, 9 Albert Embankment, London, S.E.11, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to pick-ups for sound recordings in which the pick-up has a stylus which is mechanically oscillated in travelling along a groove in the recording and in particular to pick-ups for use with sound recordings in which the groove is arranged to oscillate the stylus in two orthogonal directions in a plane perpendicular to the direction of the groove at a point of contact with the stylus. Such recordings are used if two sets of recorded signals are to be reproduced simultaneously as, for example, is required in certain systems of stereophonic sound reproduction. The recording of the two sets of signals in a single groove with two different directions of oscillation ensures simultaneous reproduction; in the pick-up it is necessary to derive and separate the two sets of signals from the oscillations of a single stylus. One set of signals may be recorded as a lateral cut and the other as a hill-and-dale but it may be preferred in some cases to record the two sets so that the two orthogonal deflections are at right angles to one another, each at 45° to the plane which is normal to the surface of the record and containing the direction of the groove at the point of contact of the stylus.

According to this invention, a pick-up for reproducing two sets of sound signals recorded on a single track in a sound recording having a grooved track which affects oscillation of a reproducing stylus in two orthogonal directions lying in a plane perpendicular to the direction of the groove at the point of contact of the stylus comprises a stylus and armature assembly which is resilient or resiliently supported to permit of movement of the stylus in the two said orthogonal directions and arranged to cooperate with at least three separate pole pieces of a magnetic circuit arranged so that the flux through the armature is divided into different shunt paths through the various separate pole pieces, and coils coupled with the different shunt paths to be responsive to the changes of flux therein, the pole pieces being so disposed with respect to the armature that the division of the flux between the various paths differs for the two different directions of oscillation of the stylus. This form of pick-up constitutes a variable reluctance pick-up, all the aforementioned pole pieces being magnetically of the same polarity and forming shunt magnetic paths and the movement of armature varying the reluctance of the different paths. In this arrangement, although the members carrying the flux through the coils must not be saturated, the flux in the armature can saturate the armature without distorting the reproduction, so facilitating the construction of a light weight armature assembly.

It is possible to use only three poles providing three separate shunt paths. For example, considering the surface of the recording at the point of contact with the stylus as being horizontal, there may be arranged first and second poles, one on each side of the

armature above the surface of the recording in a plane parallel to the surface thereof and a third pole above the armature. If the recording has one set of signals recorded as a hill-and-dale cut and the other as a lateral cut, the oscillations of the stylus due to the lateral cut would not affect the flux through the third pole but would vary the relative flux through the other two poles, provided these poles were suitably positioned with respect to the direction of oscillation, so that coils coupled to the first and second poles and connected in series opposition would reproduce only the lateral cut signals. Similarly a coil coupled to the third pole would reproduce the hill-and-dale signals but would not be affected by the lateral cut signals. If the signals are recorded at 45° to the plane normal to the surface as described above, then one set of signals would increase the flux in the first and third poles and decrease the flux in the second pole and *vice versa*, whilst the other set of signals would increase the flux in the second and third poles and decrease the flux in the first pole and *vice versa* so that by arranging series-connected coils on the first and third poles with the appropriate number of turns so that they cancel out any signals for one direction of cut but add the signals for the other direction of cut and by arranging coils on the second and third poles so that they cancel out any signals for the second direction of cut but add the signals for the first direction of cut, it is possible to reproduce the two sets of signals separately. It will be readily apparent that such a three-pole pick-up could be used with a recording having signals cut at 45° to the plane of the recording by employing other arrangements of windings, for example, utilising windings of all three poles for each set of signals.

Such a three-pole arrangement, however, is liable to cause second harmonic distortion and it is generally preferable to employ four poles rather than three poles. These may be arranged so that the armature moves towards the first and away from the second pole and *vice versa* whilst remaining at equal distances from the third and fourth poles for oscillations of the armature due to signals of one direction of cut and moves towards the third and away from the fourth and *vice versa* whilst remaining at equal distances from the first and second poles for oscillations of the armature due to signals of the other direction of cut and, in such an arrangement, a first pair of coils may be wound in series on the first and second poles to reproduce one set of signals and the second pair of coils wound in series on the third and fourth poles to reproduce the other set of signals. Alternatively the four poles may be arranged so that the armature moves towards the first and second poles and away from the third and fourth poles and *vice versa* for oscillations of the armature due to signals of one direction of cut and moves towards the first and third poles and away from the second and fourth poles and *vice versa* for oscillations of the armature due to signals of the other direction of cut and, in this arrangement, for each of the two signals to be reproduced, coils may be arranged on all four poles, the coils being connected in series in appropriate senses to cancel the unwanted signals.

In general, for each of the two signals to be reproduced, coils may be arranged on all poles at which the appropriate flux is developed, the coils being connected in series in appropriate senses to cancel the unwanted signals.

In one embodiment of the invention, particularly for reproducing two sets of signals from a disc record, the poles are arranged in two pairs lying in two planes parallel to but spaced differently from the surface of the record and the armature is arranged so that it is in the region between the four poles and substantially equally spaced from all four poles.

The following is a description of a number of embodiments of the invention, reference being made to the accompanying drawings in which:—

Figure 1 is a perspective diagrammatic view of the magnetic assembly and armature and stylus of a pick-up, with coils indicated diagrammatically;

Figures 2, 3 and 4 are diagrams illustrating arrangements of coil connections for use in the pick-up of Figure 1;

Figure 5 is a perspective diagrammatic view similar to Figure 1 of another embodiment of the invention;

Figure 6 is a perspective diagrammatic view similar to Figure 1 of a third embodiment of the invention;

Figure 7 is an underside plan view of the pick-up of Figure 6 with the coils shown wound on the pole pieces;

Figures 8 and 9 are respectively side and end elevations of the pick-up of Figure 7; and

Figures 10, 11 and 12 are diagrams illustrating various different arrangements of coil connections in the pick-ups of Figures 5 to 9.

Figure 1 illustrates one form of pick-up particularly for reproducing two sets of signals from a disc recording. In this pick-up, there is provided a steel tubular armature 10 formed of mild steel which at one end is held in a rigid or resilient mounting illustrated diagrammatically at 11. The armature 10 extends parallel to the surface of the record in the direction of the groove at a point of contact with the stylus and, at the end remote from the mounting 11 carries a

sapphire or other jewel stylus 12. The armature 10 is resilient and preferably is resiliently mounted at 11 to give sufficient compliance permitting freedom of movement in all directions perpendicular to the direction of the groove. The magnetic assembly associated with the armature comprises three pole pieces 13, 14, 15 which are connected to a common magnetic yoke 16 leading to one pole of a permanent magnet 17. The other pole of this magnet is adjacent the end of the armature 10 which is held in the mounting 11 so that the magnetic path extends from the magnet along the armature and thence through the three pole pieces 13, 14, 15 and back through the yoke 16 to the magnet 17. The poles pieces 13 and 15 have portions arranged one on each side of the armature 10 and extending generally parallel to the surface of the disc recording whilst the pole piece 14 is situated above the armature 10 and extends in a direction normal to the surface of the recording. The armature normally is equidistant from the ends of the three pole pieces 13, 14, 15 and lies on the straight line between the pole pieces 13, 15. It will be seen that the flux through the pole pieces will be divided symmetrically with equal flux through the pole pieces 13 and 15. If the armature should be moved nearer any pole piece the flux through that pole piece will be increased. This form of pick-up thus constitutes a variable reluctance pick-up.

Damping of the armature 10 is provided if necessary by means of a resilient support, for example a rubber block 18 situated intermediate the ends of the armature and bearing against the armature.

Coils are wound on the pole pieces 13, 14, 15 to be responsive to the variations of the magnetic flux through these pole pieces and, as indicated diagrammatically in Figure 1 these coils which are shown as 20, 21 and 22, are preferably wound on parallel portions of the pole pieces.

The manner of interconnection of the coils to obtain the required outputs depends on the form of recording. If one of the signals is recorded as a lateral cut and the other as a hill-and-dale (i.e. vertical) cut, the oscillations of the armature for the two sets of signals are respectively in the directions of the arrows L and V in Figure 2 and the windings 20 and 22 on pole pieces 12 and 15 may be connected in series to provide the output representing the lateral cut signals and the winding 21 used to obtain the hill-and-dale signals as shown in Figure 2. More commonly, however, the two sets of signals are recorded at 45° to the plane normal to the surface of the recording and containing the direction of the groove at the point of contact of the stylus. The oscillations of the armature are thus in the directions indicated by the arrows in Figure 3. These two signals, in stereophonic sound recordings, are referred to as the left-hand (LH) and right-hand (RH) signals. Two alternative forms of coil connections for obtaining the LH and RH signals are illustrated in Figures 3 and 4. In Figure 3 the coil 20 on pole piece 13 is connected in series with a coil 21*a* on pole piece 14, whilst coil 22 is connected with a coil 21*b* on pole piece 13. The RH signal output is obtained between the terminals marked RH and common, whilst the LH signal output is obtained between the terminals marked LH and common. In the arrangement of Figure 4, the coils 21*a* and 21*b* of Figure 3 are combined into a single coil 21 to give a simpler construction.

It will be noted that in the construction of Figure 1, the magnetic flux can saturate the armature 10 without introducing any distortion so facilitating the construction of a light weight armature assembly. The flux however must not saturate the pole pieces 13, 14 and 15.

Although the pick-up of Figure 1 having only three pole pieces is mechanically simpler to construct than a pick-up having four pole pieces, the use of three pole pieces may cause second harmonic distortion and it is preferable to employ four poles rather than three poles. One such construction employing four poles is illustrated in Figure 5. As before, the armature 10 is in the form of a resilient mild steel tube held in a rigid or resilient mounting 11 at one end and at the other end carrying a sapphire or other jewel stylus 12. The armature is arranged to extend parallel to the surface of the recording in the direction of the groove at the point of contact of the stylus. In the arrangement of Figure 5, a first pair of pole pieces 30, 31 are arranged one on each side of the armature extending in a direction parallel to the surface of the recording and normal to the direction of the groove at a level slightly below the armature, whilst a second pair of pole pieces 32, 33 are arranged one on each side of the armature extending in a direction parallel to the surface of the recording and normal to the direction of the groove at a level slightly above the armature. The armature is in its normal, undeflected condition substantially equidistant from all four pole pieces. As in the arrangement of Figure 1 the pole pieces are connected to a common magnetic yoke 16 leading to one end of permanent magnet 17 with the return magnetic path through armature 10. A resilient support (not shown) may also be provided intermediate the ends of the armature to give damping as in the arrangement of Figure 1.

Considering firstly the possible use of the pick-up of Figure 5 with a recording in

which one set of signals are recorded as a lateral cut and the other as a hill-and-dale cut, it will be seen that, for a lateral cut signal, the armature 12 will be moved towards the pole pieces 30 and 32 and away from the pole pieces 31, 33 and *vice versa*. Thus an electrical output signal representative of the lateral cut recording may be obtained by connecting four coils 34 to 37 on the four poles 30 to 33 respectively in series as shown in Figure 12, the windings being in such senses that the required signals are additive. This series connection of coils 34 to 37 provides cancellation of the hill-and-dale signals, if the coils are similar and the armature is normally equidistant from all four pole pieces. Similarly for a hill-and-dale signal the armature will move towards the poles 32 and 33 and away from the poles 30, 31 and *vice versa* and thus an electrical output signal may be obtained corresponding to a hill-and-dale cut on the recording by connecting four further coils 38 to 41 appropriately in series as also shown in Figure 12. These coils are connected so as to be additive for the wanted signals but provide cancellation of the unwanted signals. It will be readily apparent that other combinations of coils could be employed to obtain the two outputs and that, if necessary, only one coil need be provided on each pole piece.

As seen in Figure 5, the coils are all wound on parallel portions of the pole pieces extending in directions normal to the surface of the recording. The series connections for each output signal have to be such that the required signals are additive and the non-required signals are cancelled out. Inspection of Figure 12 will immediately show that these windings give a "hum-bucking" effect cancelling out any signals induced in the windings by stray magnetic fields provided the stray fields produce similar fluxes or suitably compensating fluxes in the various pole pieces.

For reproducing signals cut at 45° as described above, it is only necessary to have one coil on each of the pole pieces 30 to 33 of Figure 5 and one such arrangement is illustrated in Figure 10. It will be seen that the LH signal is developed by coils 50, 51 on pole pieces 30, 33, whilst the RH signals are developed by coils 52, 53, of pole pieces 31, 32. For the LH signal the armature 10 moves towards the pole pieces 30 and away from the pole piece 33 and remains equidistant from the two pole pieces 31, 32. Similarly for the RH signal the armature moves towards and away from the pole pieces 31, 32 and remains equidistant from the pole pieces 30, 33. With the connections shown, the required signals induced in the coils by the changes of flux are additive whilst the unwanted signals cancel one another. Again it will be noted that these coil connections give a "hum-bucking" effect cancelling out any signals induced in the windings by stray magnetic fields.

The arrangement of Figure 10 gives in-phase voltages at the LH and RH terminals for lateral displacement of the armature 10 such as would occur if the pick-up were used on a conventional type of recording having one set of signals recorded with a lateral cut. For some purposes, however, it may be desired to employ the pick-up of Figure 5 for reproducing lateral cut recordings and in this case the coils 50 to 53 may be connected in the manner shown in Figure 11. It will be seen that the outputs at the LH and RH terminals in Figure 11 for a lateral displacement of the armature 10 are out of phase so that the lateral cut signal may be taken from across the RH and LH terminals. The arrangement of Figure 11 gives LH and RH signals separately in a manner exactly similar to the arrangement of Figure 10.

Figures 6 to 9 illustrate a modification of the arrangement of Figure 5 in which the pole pieces 30 to 33 immediately adjacent the armature, although parallel to the surface of the recording at the point of contact of the stylus, do not extend in directions normal to the direction of the groove. These portions of the pole pieces are arranged at substantial angles to this direction to give a more compact construction and to provide less magnetic leakage between the pole faces than the arrangement of Figure 5. In Figures 6 to 9 there are illustrated four coils 50 to 53 which may be connected in the manners described with reference either to Figure 10 or Figure 11. Alternatively each pole piece may carry two coils, the eight coils being connected in the manner shown in Figure 12. Apart from the arrangement of the pole pieces, the construction and operation of the armature and stylus assembly of the pick-up of Figure 6 is similar to that of Figure 5.

Figures 7 and 8 illustrate, as shown in dashed lines at 55, an alternative position for the stylus which may be employed in some cases and which permits of a shorter armature assembly.

WHAT WE CLAIM IS:—

1. A pick-up for reproducing two sets of sound signals recorded on a single track in a sound recording having a grooved track which effects oscillation of a reproducing stylus in two orthogonal directions lying in a plane perpendicular to the direction of the groove, which pick-up comprises a stylus and armature assembly which is resilient or is resiliently supported to permit of movement of the stylus in two said orthogonal

directions and arranged to co-operate with at least three separate pole pieces of a magnetic circuit arranged so that the flux through the armature is divided into different shunt paths through the various separate pole pieces, and coils coupled with the different shunt paths to be responsive to the changes of flux therein, the pole pieces being so disposed with respect to the armature that the division of the flux between the various paths differs for the two different directions of oscillation of the stylus.

2. A pick-up as claimed in Claim 1 wherein, assuming the surface of the recording at the point of contact with the stylus as being horizontal, there are provided first, second and third poles, the first and second poles being arranged one on each side of the armature above the surface of the recording in a plane parallel to the surface thereof and the third pole being above the armature.

3. A pick-up as claimed in Claim 2 and for use with a recording having one set of signals recorded as a hill-and-dale cut and the other as a lateral cut, wherein coils are coupled to the first and second poles and connected in series opposition to reproduce the lateral cut signals and wherein a coil is coupled to the third pole to reproduce the hill-and-dale signals.

4. A pick-up as claimed in Claim 2 and for use with a recording having signals recorded at 45° to the plane normal to the surface of the recording and containing the direction of the groove at the point of contact of the stylus, wherein series connected coils are arranged on the first and third poles with the appropriate number of turns so that they cancel out any signals for one direction of cut but add the signals for the other direction of cut and wherein series connected coils are arranged on the second and third poles so that they cancel out any signals for the second direction of cut but add the signals for the first direction of cut.

5. A pick-up as claimed in Claim 4 wherein one coil on the second pole is common to both pairs of series connected coils.

6. A pick-up as claimed in Claim 1 wherein four poles are provided arranged so that the armature moves towards the first and away from the second and *vice versa* whilst remaining at equal distances from the third and fourth poles for oscillations of the armature due to signals of one direction of cut and moves towards the third and away from the fourth and *vice versa* whilst remaining at equal distances from the first and second poles for oscillations of the armature due to signals of the other direction of cut.

7. A pick-up as claimed in Claim 6 wherein a first pair of coils are wound in series on the first and second poles to reproduce one set of signals and a second pair of coils are wound in series on the third and fourth poles to reproduce the other set of signals.

8. A pick-up as claimed in Claim 1 wherein four poles are provided arranged so that the armature moves towards the first and second poles and away from the third and fourth poles and *vice versa* for oscillations of the armature due to signals of one direction of cut and moves towards the first and third poles and away from the second and fourth poles and *vice versa* for oscillations of the armature due to signals of the other direction of cut.

9. A pick-up as claimed in Claim 1 or Claim 2 or Claim 8 wherein, for each of the two signals to be reproduced, coils are arranged on all the poles at which the appropriate flux is developed, the coils being connected in series in appropriate senses to cancel the unwanted signals.

10. A pick-up as claimed in Claim 8 wherein, for each of the two signals to be reproduced, coils are arranged on all four poles, the coils being connected in series in appropriate senses to cancel the unwanted signals.

11. A pick-up as claimed in any of Claims 6 to 8 or Claim 10 wherein the poles are arranged in two pairs with the end portions thereof lying in two planes parallel to but spaced differently from the surface of the recording and wherein the armature is arranged to have at least a portion in the region between the four poles and substantially equally spaced from all four poles.

12. A pick-up as claimed in Claim 11 wherein the two pairs of poles are arranged so that the end portions of the two poles of each pair converge towards the armature but are not aligned.

13. A pick-up as claimed in any of Claims 6 to 8 or 10 to 12 wherein the poles have parallel portions and wherein the coils are arranged on these parallel portions to cancel out any signals induced in the coils by stray magnetic fields.

14. A pick-up as claimed in any of the preceding claims wherein the armature is supported on or constituted by a tube extending parallel to the direction of the groove, which tube is resilient and/or resiliently mounted to give freedom of movement of the armature in a plane perpendicular to the direction of the groove, the tube being supported at one end and carrying the stylus at the other end.

15. A pick-up for reproducing two sets of sound signals substantially as described with reference to Figures 1 and 2 or Figures 1 and 3 or Figures 1 and 4 of the accompanying drawings.

16. A pick-up for reproducing two sets of sound signals substantially as described

with reference to Figures 5 and 10 or Figures 5 and 11 or Figures 5 and 12 of the accompanying drawings.

17. A pick-up for reproducing two sets of sound signals substantially as described with reference to Figures 6 to 9 and Figure 10 or Figure 11 or Figure 12 of the accompanying drawings.

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PROVISIONAL SPECIFICATION.

Improvements in or relating to Pick-Ups for Sound Recordings having a Groove for Mechanically Oscillating a Stylus.

We, THE DECCA RECORD COMPANY LIMITED, a British Company, of 1—3 Brixton Road, London, S.W.9, do hereby declare this invention to be described in the following statement:—

This invention relates to pick-ups for sound recordings in which the pick-up has a stylus which is mechanically oscillated in travelling along a groove in the recording and in particular to pick-ups for use with sound recordings in which the groove is arranged to oscillate the stylus in two orthogonal directions in a plane perpendicular to the direction of the groove at a point of contact with the stylus. Such recordings are used if two sets of recorded signals are to be reproduced simultaneously as, for example, is required in certain systems of stereophonic sound reproduction. The recording of the two sets of signals in a single groove with two different directions of oscillation ensures simultaneous reproduction; in the pick-up it is necessary to derive and separate the two sets of signals from the oscillations of a single stylus. One set of signals may be recorded as a lateral cut and the other as a hill-and-dale but it may be preferred in some cases to record the two sets so that the two orthogonal deflections are at right angles to one another, each at 45° to the plane which is normal to the surface of the record and containing the direction of the groove at the point of contact of the stylus.

According to this invention, a pick-up for reproducing two sets of sound signals recorded on a single track in a sound recording having a grooved track which affects oscillation of a reproducing stylus in two orthogonal directions lying in a plane perpendicular to the direction of the groove at the point of contact of the stylus comprises a stylus and armature assembly resiliently supported for movement in the two said orthogonal directions and arranged to co-operate with at least three separate pole pieces of a magnetic circuit arranged so that the flux through the armature is divided into different shunt paths through the various separate pole pieces, and coils coupled with the different shunt paths to be responsive to the changes of flux therein the pole pieces being so disposed with respect to the armature that the division of the flux between the various paths differs for the two different directions of oscillation of the stylus. This form of pick-up constitutes a variable reluctance pick-up, all the aforementioned pole pieces being magnetically of the same polarity and forming shunt magnetic paths and the movement of armature varying the reluctance of the different paths. In this arrangement, although the members carrying the flux through the coils must not be saturated, the flux in the armature can saturate the armature without distorting the reproduction, so facilitating the construction of a light weight armature assembly.

It is possible to use only three poles providing three separate shunt paths. For example, considering the surface of the record at the point of contact with the stylus as being horizontal, there may be arranged first and second poles, one on each side of the armature above the surface of the record in a plane parallel to the surface thereof and a third pole above the armature. If the recording has one set of signals recorded as a hill-and-dale cut and the other as a lateral cut, the oscillations of the stylus due to the lateral cut would not affect the flux through the third pole but would vary the relative flux through the other two poles, provided these poles were suitably positioned with respect to the direction of oscillation, so that coils coupled to the first and second poles and connected in series opposition would reproduce only the lateral cut signals. Similarly a coil wound on the third pole would reproduce the hill-and-dale signals but would not be affected by the lateral cut signals. If the signals are recorded at 45° to the plane normal to the surface as described above, then one set of signals would increase the flux in the first and third poles and decrease the flux in the second pole and *vice versa*, whilst the other set of signals would increase the flux in the second and third poles and decrease the flux in the first pole and *vice versa* so that by winding series-connected coils on the first and second poles with the appropriate number of turns so that they cancel out any signals for one

direction of cut but add the signals for the other direction of cut and by winding coils on the second and third poles so that they cancel out any signals for the second direction of cut but add the signals for the first direction of cut, it is possible to reproduce the two sets of signals separately. It will be readily apparent that such a three-pole pick-up could be used with a recording having signals cut at 45° to the plane of the recording by employing other arrangements of windings, for example, utilising windings of all three poles for each set of signals.

Such a three-pole arrangement, however, is liable to cause second harmonic distortion and it is generally preferable to employ four poles rather than three poles. These may be arranged so that the armature moves towards the first and away from the second pole and *vice versa* whilst remaining at equal distances from the third and fourth poles for oscillations of the armature due to signals of one direction of cut and moves towards the third and away from the fourth and *vice versa* whilst remaining at equal distances from the first and second poles for oscillations of the armature due to signals of the other direction of cut and, in such an arrangement, a first pair of coils may be wound in series on the first and second poles to reproduce one set of signals and the second pair of coils wound in series on the third and fourth poles to reproduce the other set of signals. Alternatively the poles may be arranged so that the armature moves towards the first and second and away from the third and fourth poles and *vice versa* for one direction of oscillation and towards the first and third poles and away from the second and fourth poles and *vice versa* for the other direction of oscillation and in this arrangement, for each signal to be reproduced, coils may be wound on all four poles.

In general, for each of the two signals to be reproduced, coils may be arranged on all poles at which flux is developed, the coils being connected in series in appropriate senses to cancel the unwanted signals.

In one embodiment of the invention, particularly for reproducing two sets of signals from a disc record, the poles are arranged in two pairs lying in two planes parallel to but spaced differently from the surface of the record and the armature is arranged so that it is in the region between the four poles and substantially equally spaced from all four poles. The two poles nearer the surface of the record will, for convenience, be referred to as the first and second poles and the other two poles as the third and fourth poles, the third pole lying on the same side as the first pole of a plane containing the direction of the groove but perpendicular to the surface of the record. The four poles and armature might all be disposed substantially in a plane normal to the direction of the groove. Preferably, however, considering the assembly as being viewed in plane normal to the surface of the record, the first pole, stylus and second pole lie on a straight line which is at 45° to the direction of the groove and at right angles to the straight line through the third pole, stylus and fourth pole. The armature may be supported on or constituted by a tube extending parallel to the direction of the groove, which tube is resilient or is resiliently mounted to give freedom of movement in all directions in a plane perpendicular to the direction of the groove. This tube is conveniently a steel tube forming part of the armature assembly, the tube carrying a sapphire or other jewel stylus at one end and being clamped or resiliently supported at the other end. Preferably, to provide sufficient compliance in both directions of oscillation, the tube is not only resiliently mounted but is also itself resilient and this tube may conveniently be formed of mild steel. Any necessary damping may be provided by one or more resilient bushes or blocks or other supports along the length of the tube or by viscous damping. Considering a recording in which the two sets of signals are recorded in directions at 45° to the surface of the record, two coils may be wound respectively on the first and fourth poles in series to reproduce one set of signals and two further coils wound on the second and third poles in series to reproduce the other set of signals. The magnetic circuit in this particular embodiment is arranged so that the magnetic paths extend from the pole pieces parallel to one another in a direction normal to the surface of the record and preferably closely adjacent to one another and the coils are wound on these parallel portions of the magnetic circuits. It will be seen that, with this construction, the above-mentioned connections of coils will give a "hum-bucking" effect in respect of any stray magnetic fields in the region of the coils provided the stray fields produce similar fluxes in the two coils of each series connected pair. If the record has one set of signals recorded as a hill-and-dale cut and the other as a lateral cut, a first pair of windings coupled to the third and fourth poles may be connected in series additively, this pair being arranged in series with a second pair of series-connected windings on the first and second poles for reproducing the hill-and-dale cut signals, the series of the windings being such that the required signals are additive. For producing the lateral cut signals there may be provided a third pair of windings coupled respectively with the first and third poles and connected additively in series, which third pair of wind-

ings is connected in series with a fourth pair of additively-connected windings wound on the second and fourth poles respectively. Provided the windings are all arranged on parallel closely adjacent portions of the magnetic circuits they will give a "hum-bucking" effect cancelling out any signals induced in the windings by stray magnetic fields.

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Fig. 1.

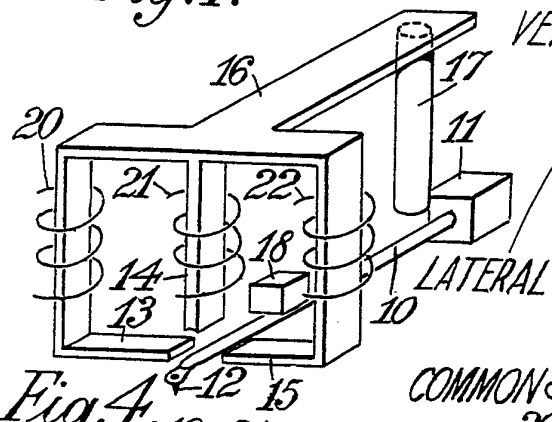


Fig. 2.

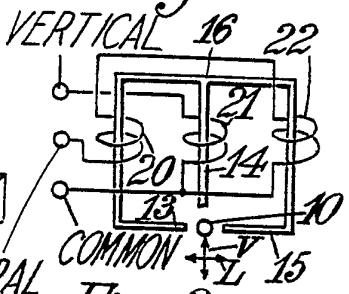


Fig. 3.

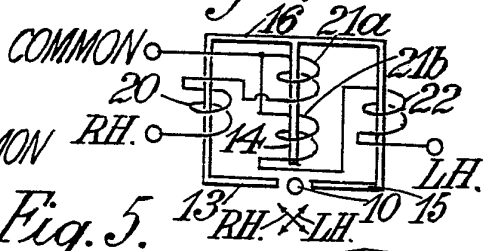


Fig. 4.

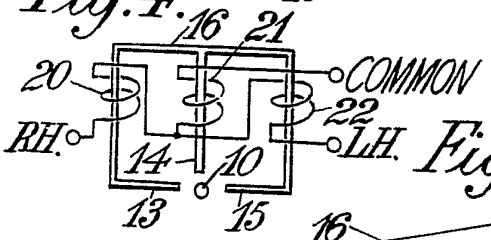
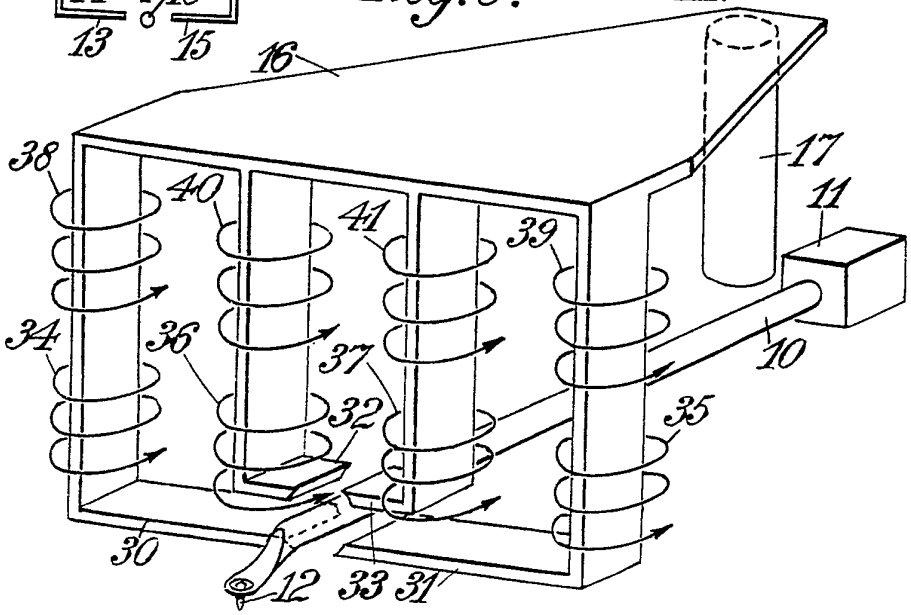
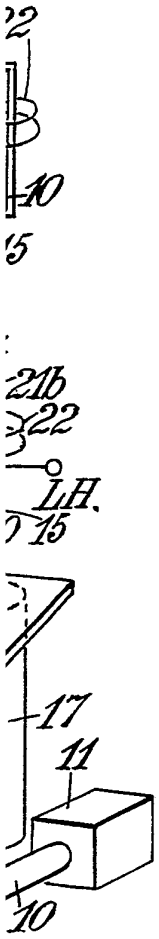


Fig. 5.



847138 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 1 & 2



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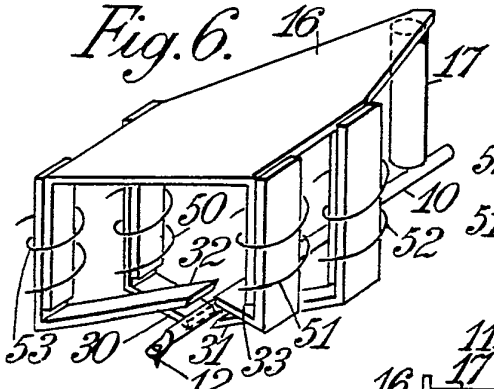

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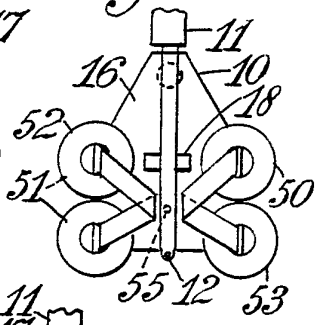

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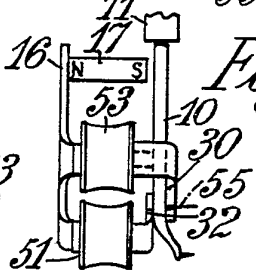

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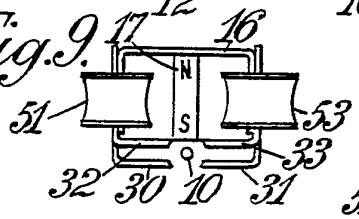

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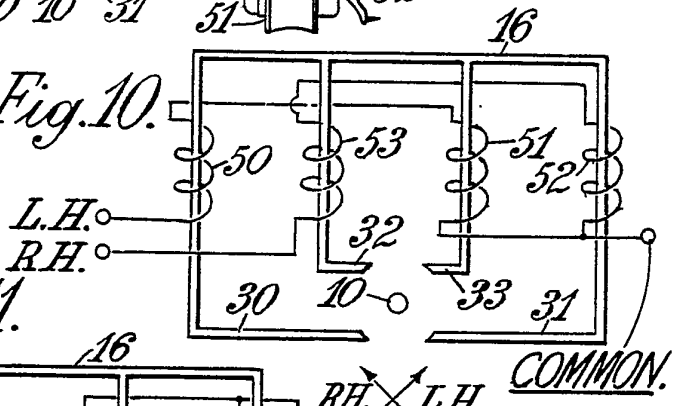

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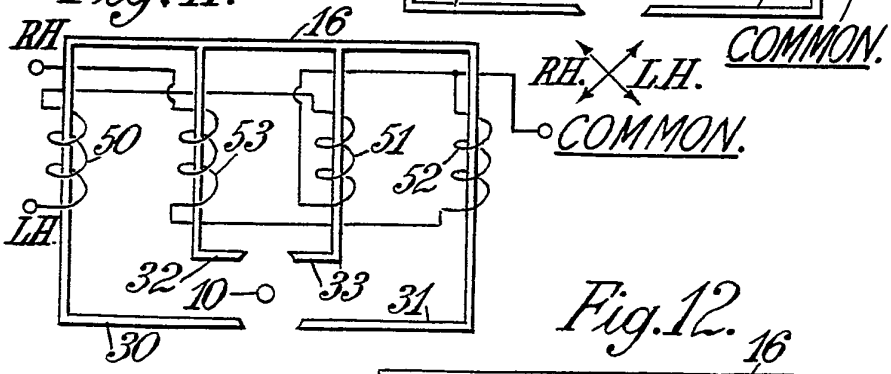
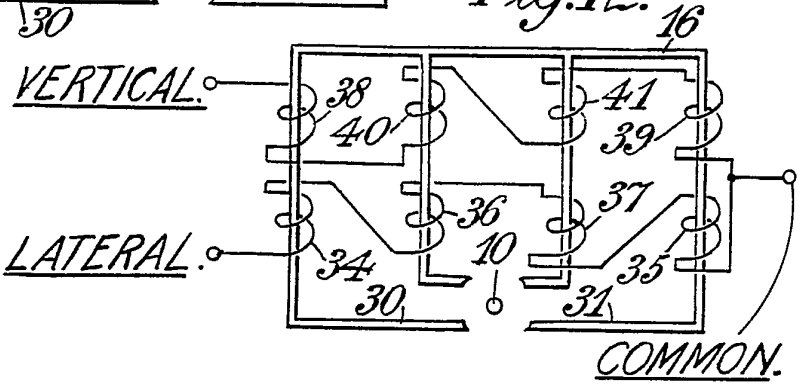
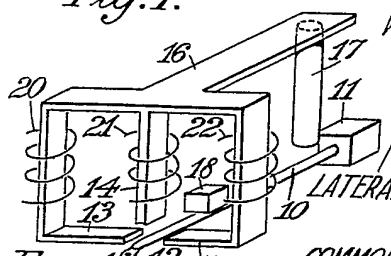


Fig. 12.



847138 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 1 & 2

Fig. 1.



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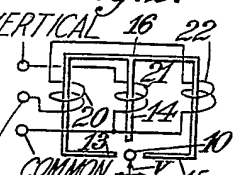

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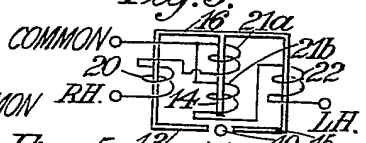

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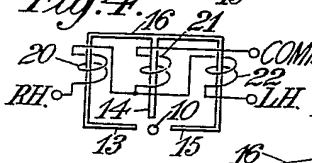

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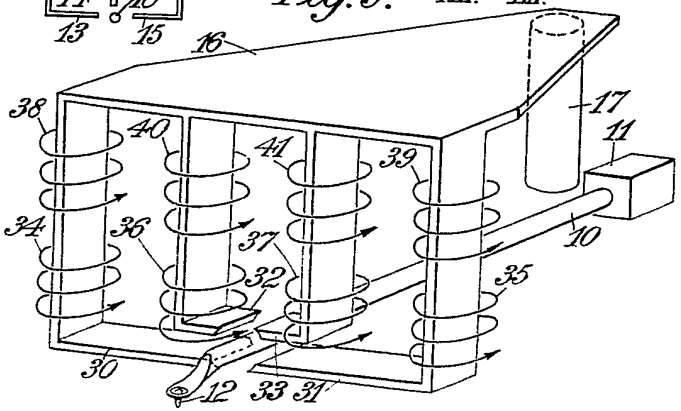

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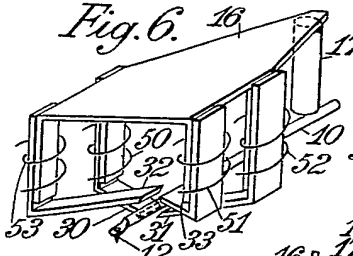

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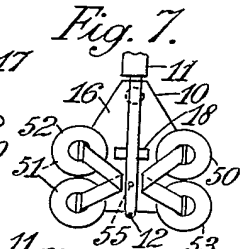

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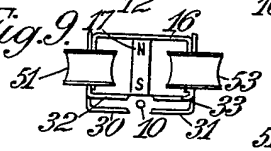

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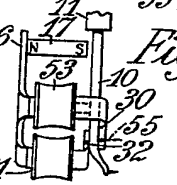

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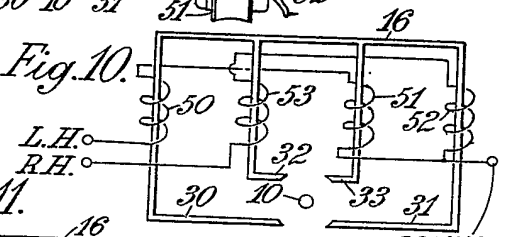

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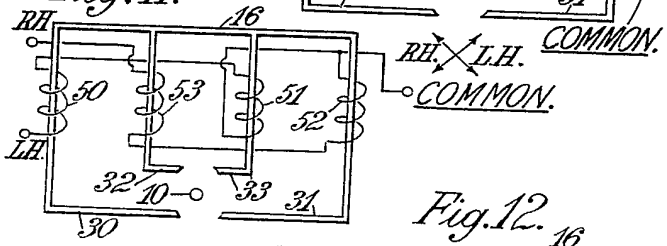

Fig. 12.