June 19, 1962 J. F. GRADO 3,040,136

ELECTRO-MECHANICAL TRANSDUCER

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FIG. 2.

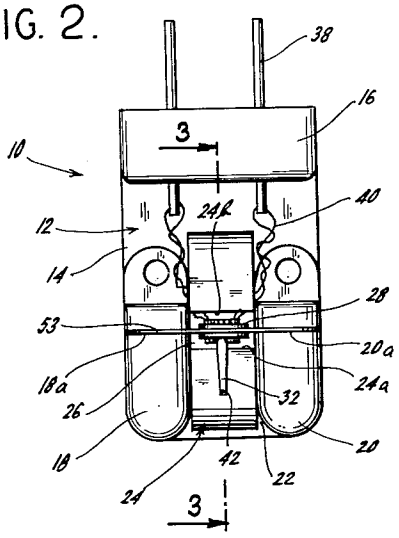
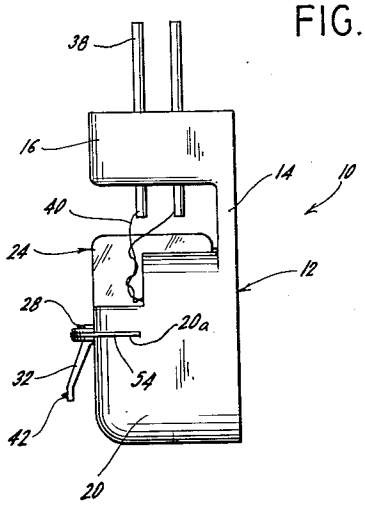


FIG. 1.



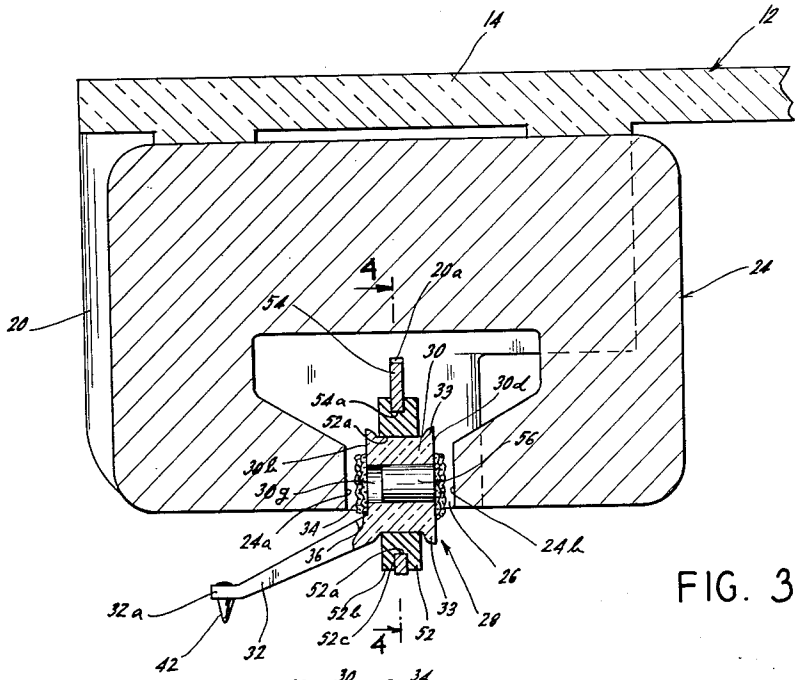


FIG. 3.

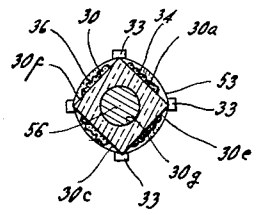


FIG. 4.

INVENTOR.
JOSEPH F. GRADO
BY
Amster + Levy
ATTORNEYS

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FIG. 5.

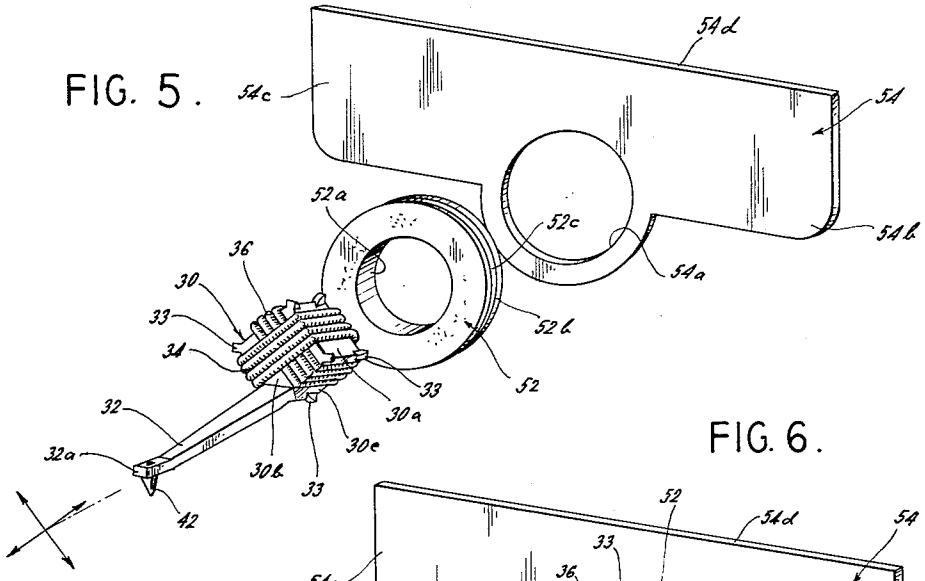


FIG. 6.

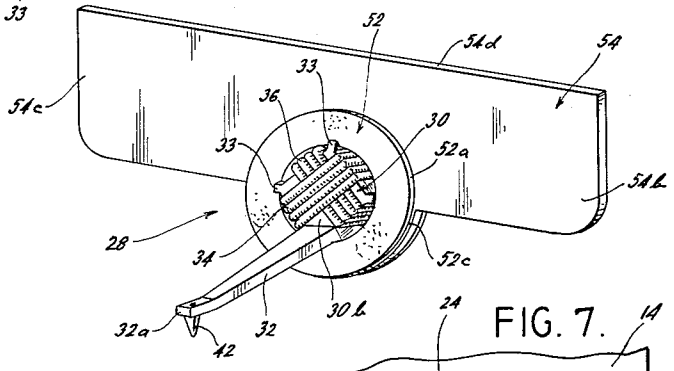


FIG. 8.

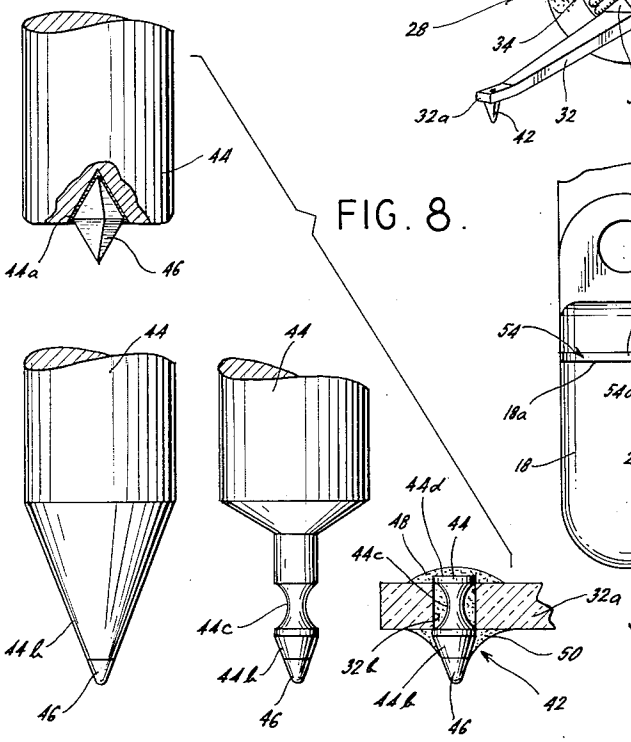
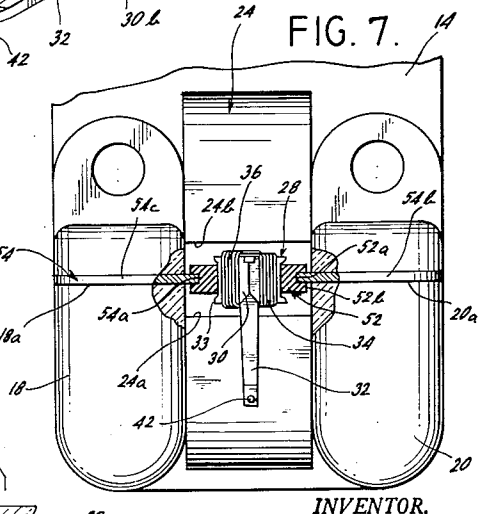


FIG. 7.



INVENTOR.
JOSEPH F. GRADO
BY
Amster + Levy
ATTORNEYS

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3,040,136

ELECTRO-MECHANICAL TRANSDUCER

Joseph F. Grado, 641 46th St., Brooklyn 20, N.Y.

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18 Claims. (Cl. 179—100.41)

The present invention relates generally to electro-mechanical transducers, and in particular to a moving-coil type of transducer or cartridge for stereophonic and monophonic reproduction.

Various types of electro-mechanical transducers of the moving-coil type have been available on the market for monaural or monophonic reproduction from records of the type formed with a laterally cut groove. Such moving coil type of transducers or pickups differ from other magnetic types, such as variable reluctance or moving iron pickups, in that the coil motion in the magnetic field incident to tracking of the record groove by the stylus produces a voltage output proportional to the velocity of the coil motion and not its displacement. Such transducers are inherently linear, comparatively rugged, and capable of sound reproduction with a high order of fidelity.

Broadly, it is an object of the present invention to provide a moving-coil type of electro-mechanical transducer suitable for both stereophonic and monophonic playback of records.

Rather rigid requirements are imposed upon the design of a stereophonic transducer or cartridge in order to obtain high fidelity in reproduction. The two stereophonic channels or outputs must be exactly alike, for any deviation of one channel or output relative to the other results in unbalanced sound which manifests itself as distortion in stereophonic playback. Coupled with this is the further requirement that such transducer or cartridge must be suitable for monophonic playback. The geometry of the stereophonic cartridge is such that if you have essentially the same moving mass as in a high quality monophonic cartridge the distortion will be considerably higher for stereophonic playback. In order for a stereophonic cartridge to play back with low distortion, the moving mass must be less than that of the monophonic counter part.

It is a further object of the present invention to provide an electromechanical transducer of the moving coil type which has an exceptionally low moving mass and is particularly suitable for reproduction of stereophonic and monophonic recordings. Specifically, it is within the contemplation of the present invention to provide a moving-coil type of stereophonic pickup which has a high order of efficiency in translation of mechanical motion into electrical energy such that low distortion and high fidelity reproduction may be realized when employing such pickup or cartridge.

In accordance with an illustrative embodiment demonstrating aspects of the present invention there is provided an electro-mechanical transducer which comprises a base, means on the base for producing a magnetic field in a magnetic gap bounded by pole faces, a moving-coil generating system including a common support having a stylus arm with first and second coils wound on said support and having the turns thereof geometrically substantially congruent and in substantial symmetry with each other, a stylus on the stylus arm, and means mounting the generating system with the first and second coils in the magnetic gap and with the turns thereof extending substantially at right angles to the pole faces. Since this type of transducer includes essentially only one balanced moving mass, it is possible to achieve substantially identical outputs from identical stereophonic channels with identical resonant frequencies and a low order of distortion with comparable high fidelity monophonic reproduction.

With a monophonic transducer the mass should be low

enough such that the vertical and lateral resonance of the transducer for monophonic reproduction occurs outside of the audio range or spectrum. If the mass of the stylus of such transducer is equal in all directions of movement, then the resonant frequency in all directions will occur at the same frequency. Since the pinch effect which is a vertically generated signal (disturbing to stylus action in the record groove) occurs at a frequency which is twice the modulated or lateral signal frequency, it becomes necessary to have separate masses for lateral and vertical signal generation. The vertical mass must be reduced over the lateral mass so that the pinch effect resonant frequency occurs at twice the lateral resonant frequency. This results in all resonant frequencies occurring at the same lateral frequency. Furthermore, to further reduce distortion I have found that it is desirable to introduce a mechanical low pass filter into the transducer to attenuate, at approximately 6 decibels per octave, all frequencies occuring above one octave below the lateral frequency at which the resonances occur. This attenuation results in a considerable reduction in the disturbance caused by the stylus contact with the groove at the resonant frequency, thereby providing reproduction which has a high order of fidelity. Further as generally understood, in stereophonic reproduction, the vertical signal becomes exaggerated at the higher frequencies of the audio range due to an increasing plastic resonance which becomes progressively worse from a pure lateral stylus movement to a pure vertical stylus movement. By appropriate design of the mechanical low pass filter, the attenuation may be established to equalize the increasing vertical plastic resonance such that an essentially flat frequency characteristic may be realized over the audio range in all planes of stylus movement.

In accordance with further aspects of the present invention, the controlled vertical filtering action is realized by dimensioning the vertical cross section of the stylus arm from the point of attachment for the stylus to the common support or coil bobbin to provide a progressive decoupling action between the stylus and the common support such as to completely decouple or attenuate vertical signals at the higher frequencies above the resonant frequency of the system. Such progressive filtering or decoupling of vertical signals materially reduces the distortion since most of the distortion in stereophonic recordings may be traced to vertical signals cut into such recordings, which vertical signals should not be accentuated. Essentially, a stylus constructed in accordance with the invention is characterized as being stiff or non-compliant to torsional and lateral movement and progressively compliant vertical movement at increasing frequencies whereby progressively increasing decoupling is attained for increasing frequencies above said predetermined value. For monophonic reproduction, the progressive decoupling of the vertical signal which is due to the pinch effect enables acceptable low distortion playback, particularly as compared to stereophonic cartridges which generate the full signal of vertical pinch effect. The quality of such monophonic reproduction may be made optimum by coupling the coils of the stereophonic transducer in phase opposition such that the vertical signals produced incident to the pinch effect will be cancelled out during such monophonic playback.

A further important factor in the design of transducers of this type is the realization of substantially equal linear compliance in all directions for the moving-coil system. In the reproduction of stereophonic sound, it is important that a light tracking force be applied since the true working compliance of the transducer or cartridge is dependent upon such tracking force. A light tracking force can only be used when the inertia of the moving mass is extremely low and the compliance very high, approximating

a free air compliance which is substantially equal and linear in all directions. Still further, a lowering of the inertia of the moving mass assures better transient response and corresponding lower distortion. Coupled with the above, is the further requirement that the moving-coil system, after mounting and during use, maintain its orientation in the magnetic field of the cartridge and its 45°/45° orientation to the plane of the record.

It is a further object of the present invention to provide a transducer for both stereophonic and monophonic reproduction which has substantially equal compliance in all directions, with a relatively high true working compliance enabling the use of a relatively low tracking force for sound reproduction. Advantageously, such low tracking force reduces stylus and record wear.

In accordance with this aspect of the present invention, a yieldable grommet in the form of an annulus surrounds the common support of the moving-coil generating system and mounts such moving-coil generating system within the magnetic gap. With such grommet it is possible to have substantially equal amounts of mounting material in all directions from the axis of the generating system, with the true working compliance approaching free air compliance.

The above brief description, as well as further objects, features and advantages of the present invention will be more fully appreciated by reference to the following detailed description, of a presently preferred but illustrative embodiment, when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a side elevational view of an electro-mechanical transducing device suitable for stereophonic and monophonic reproduction demonstrating features of the present invention;

FIG. 2 is a bottom plan view of the device shown in FIG. 1;

FIG. 3 is a fragmentary sectional view on an enlarged scale taken substantially along the line 3—3 of FIG. 2 and looking in the direction of the arrows;

FIG. 4 is a sectional view taken substantially along the line 4—4 of FIG. 3 and looking in the direction of the arrows;

FIG. 5 is an exploded perspective view showing the moving-coil generating system, the mounting grommet, and the mounting plate in unassembled condition;

FIG. 6 is a perspective view showing the components illustrated in FIG. 5 as assembled;

FIG. 7 is a fragmentary bottom plan view on an enlarged scale and with parts broken away, showing the details of the means for mounting the moving-coil generating system in the magnetic field; and

FIG. 8 is a series of fragmentary elevational view on an enlarged scale and with parts broken away, showing the successive steps of constructing and mounting a stylus on a stylus arm in accordance with features of the present invention.

Referring now specifically to the drawings, there is shown my improved electro-mechanical transducing device suitable for both monophonic and stereophonic reproduction, which has been generally designated by the reference numeral **10**, and includes a molded base or housing **12** of substantially conventional construction. The base or housing **12** includes a substantially horizontally-extending top wall **14** having at the rear side thereof a depending rear wall **16** and at opposite sides thereof depending side walls **18**, **20** which define therebetween a longitudinally extending guideway **22** which is open at its bottom, forward and rearward ends. Accommodated within the guideway **22** is a permanent magnet **24** which produces the requisite magnetic field and includes a yoke-shaped body of an appropriate magnetic material (i.e. Alnico) having opposed pole faces **24***a*, **24***b* which extend substantially transversely of the elongated base or housing **12** and define therebetween a magnetic gap **26** which extends substantially longitudinally of the housing or support **12**.

Mounted within the magnetic gap **26** is a moving-coil generating system, generally designated by the reference numeral **28**, which produces two substantially identical stereophonic output signals as will hereinafter be described. The moving-coil generating system includes a substantially cubical common support **30** having a forwardly projecting stylus arm **32** at the lower forward corner thereof. The common support **30** and stylus arm **32** are integrally molded out of an appropriate material, such as plastic, with the flats or faces **30***a*, **30***c*, **30***e* and **30***f* extending in planes oriented at 45° to the horizontal and with the faces **30***b*, **30***d* extending in vertical planes and adapted to be mounted in planes parallel to the gap-defining faces **24***a*, **24***b* of the permanent magnet **24**. The stylus arm **32** projects or cantilevers from the lowermost front corner of the common support **30** at the junction or corner of the faces **30***d*, **30***c*, **30***e*.

At each of its corners, except for the corner where the stylus arm **32** emerges, the common support **30** is formed with integral projections or ears, such as the ear designated by the reference numeral **33**, whereby the flats or faces **30***a*, **30***b*, **30***c* and **30***d* and the respective projections **33** define a first winding bobbin adapted to receive a first moving coil **34**; and the flats or faces **30***e*, **30***b*, **30***f* and **30***d* and the respective projections **33** define a second winding bobbin adapted to receive a second moving coil **36**. Since in the preferred form, the common support is cubical, the respective faces or flats which define the winding bobbins are mutually perpendicular or at right angles to each other, with the respective moving coils **34**, **36** oriented for 45°/45° movement. In a preferred form of the invention, each of the moving coils **34**, **36** includes of the order of 800 turns of silver-copper alloy wire of the order of .0004 of an inch in diameter which is preferably triple gold-plated against corrosion and insulated. A typical size for the generating armature **30** is of the order of .070 inch from side to side of each flat or face.

The requisite output connections to the respective moving coils **34**, **36** is achieved by the provision of four terminal elements or contact pins (i.e. pin **38**) which are mounted on the rear wall **16** of the housing or support **12** which serves as a terminal strip. The contact pins have respective electrical connections to the ends of the coils **34**, **36** (i.e. connection **40** from contact pin **38**). To facilitate making the proper electrical connections to the contact pins or terminal elements, the contact pins are color-coded. For monophonic reproduction, the moving coils **34**, **36** may be readily coupled to each other in phase opposition to completely cancel the vertical signals generation incident to the pinch effect.

Mounted on the forward or terminal end **32***a* of the stylus arm **32**, which terminal end is seen to extend substantially horizontally, is the stylus assembly, generally designated by the reference numeral **42**. The stylus assembly **42** is seen best in the lower right hand showing of FIG. 8 and includes an elongated support **44** fabricated of metallic material and a stylus element **46** of diamond, sapphire, or the like. The enlarged progressive showings of FIG. 8 illustrate the sequential steps by which the stylus assembly **42** is constructed in accordance with further aspects of the present invention, although other methods of manufacturing the stylus assembly **42** are within the contemplation of the present invention. Initially, the elongated metallic support **44** is in the form of a continuous cylinder from one end thereof to the other and is formed with a seat or depression **44***a* at its under surface within which there is mounted the stylus element **46** in its rough or unformed condition. The stylus element **46** may be bonded to the support **44** in position to project therefrom by any known method. Thereupon the subassembly of the elongated support **44** and the stylus element **46** are formed with a substantial conical shape **44***b*

at its forward end with the apex of the conical shape providing the required tip on the stylus element **46**. The stylus assembly **42** is completed by forming the same with a reduced neck **46***c* in the remaining cylindrical portion thereof and by cutting away the unused portion of the elongated support at the end remote from the stylus element **46** to form the end face **44***d*. The terminal or leading end **32***a* of the stylus arm **32** is formed with a through bore **32***b* opening into or communication with the top and bottom faces of the arm, which bore is of a diameter slightly less than the diameter of the cylindrical portion of the support **44** such that the support **44** may be inserted into the bore **32***b* with a snap action or force fitting. Such snap action is facilitated by the yieldable characteristics of the stylus arm and by the undercutting of the cylindrical portion of the stylus support **44**. The joinder of the stylus assembly **42** to the stylus arm **32** is completed by the application of bonding layers **48**, **50** to the top and bottom surfaces of the stylus arm about the contiguous portions of the stylus assembly **42**. Preferably the bonding layers **48**, **50** are of a homogenized epoxy resin, preferably of the same composition as the resin employed in the molding of the stylus arm **32**, which homogenized epoxy resin layers **48**, **50** are applied in accordance with techniques which are generally understood. After mounting, for all intents and purposes the stylus assembly **42** is unitary with the stylus arm **32** such that the armature **30**, stylus arm **32** and stylus assembly **42** constitutes a single moving mass.

Means are provided for mounting the moving-coil generating system **28** on the support **12** with the signal generating or output coils **34**, **36** disposed in the magnetic gap **26**, and with the turns thereof extending substantially at right angles to the pole faces **24***a*, **24***b* and in the required 45°/45° orientation for discrete stereophonic signal generation in accordance with the groove of the 45°/45° recording. The mounting means includes a yieldable grommet **52** in the form of an annulus or toroid which grommet preferably is fabricated of an elastomeric material. The annular or toroidal grommet **52** may be made from a rubber which is compounded to minimize any cold flow or hardening tendencies. The characteristics of the grommet **52** are selected to assure the return of the stylus element **46** to the center of the record groove such that the record groove may carry the stylus element past the dead-center position with respect thereto. It will be appreciated that the use of yieldable mounting means which includes substantially the same amount of mounting material in all radial directions from the axis of the generating system **28** contributes to achieving equal compliance factors in all directions.

In order to achieve the assembly of the annular or toroidal grommet **52** about the common support **30**, specifically in the mounting saddle defined by the flats or faces **30***a*, **30***e*, **30***c* and **30***f* and the adjacent projections **33**, the cross section of these faces are built up to a diameter substantially equal to the inner diameter of the grommet **52**. As seen in FIG. 4, this is achieved by the application of an insulating coating, such as varnish, which is generally designated by the reference numeral **53**, over the coil turns traversing and overlying the faces **30***a*, **30***e*, **30***c* and **30***f* such that the cross-section of the cubical support **30** in the plane presented to the grommet is built up to be substantially complementary to the inner peripheral or annular surface **52***a* of the mounting grommet **52**.

The mounting means further includes a mounting plate or bracket **54** having a circular grommet-seating aperture **54***a* intermediate its end and oppositely directed wing sections **54***b*, **54***c*. The diameter of the grommet-seating aperture **54***a* is smaller than the diameter of the outer peripheral surface **52***b* of the annular grommet **52** such that the grommet is placed in radial compression when assembled with the mounting bracket. The outer peripheral surface **52***b* of the mounting grommet is provided with a slit-like circumferentially extending groove **52***c*, with the base or bottom wall of the slit-like groove being of a diameter somewhat larger than the diameter of the grommet-seating aperture **54***a*. Accordingly, when the grommet **52** is received within the grommet-seating aperture **54***a*, with the portions of the mounting plate or bracket **54** bounding the aperture **54***a* being accommodated within the slit-like groove the grommet **52** is precisely oriented within the seating aperture **54***a* and respective compression seals are provided between the inner periphery **52***a* of the grommet **52** and the built-up diameter of the generating armature **30** and the inner periphery **52***b* and the mounting plate **54**.

As seen best in FIGS. 1 to 3 inclusive, the opposite side walls **18**, **20** of the housing **12** are formed with transversely-extending slots **18***a*, **20***a* which are disposed in a common plane substantially equally distant from the pole faces **24***a*, **24***b* of the magnet **24**. The slots **18***a*, **20***a* are of a width substantially equal to the thickness of the mounting bracket **54** and are of a height such that when the edge **54***d* of the mounting bracket **54** bottoms on the slot **18***a*, **20***a*, the moving-coil generating system **28** is properly positioned vertically in the magnetic gap **26**. The overall length of the mounting bracket **54** is substantially equal to the overall width of the housing **12**; and upon laterally or transversely adjusting the mounting bracket in relation to the housing, the proper lateral orientation may be imparted to the moving-coil generating system **28**. When the moving-coil generating system is properly oriented, both vertically and laterally in relation to the magnetic gap and the respective pole faces **24***a*, **24***b* of the permanent magnet **24**, the mounting bracket **54** is fixed in position by the use of an appropriate elastomeric adhesive which will readily adhere to the base or housing **12** which in turn is fabricated of a highly damped material, such as a rubber impregnated styrene. A typical elastomeric adhesive for bonding the mounting bracket **54** to the base or housing **12** is Pliobond which is a commercially available product. Further, I have found that if the yieldable mounting grommet **52** is given a permanent deformation toward one pole face, substantial equalization will be brought about in variations in the compliance of the material from which the mounting grommet is fabricated, which variations occur incident to changes in ambient conditions. For example, in warm weather the grommet material may become more compliant. In accordance with this aspect of the invention, a permanent pressure is imparted to the mounting grommet **52** toward one pole face by the provision of a plug **56** of magnetically susceptible material which is mounted in an axially extending bore **32***g* formed in the common support **30**. As seen best in FIG. 4, the plug **56** of the magnetically susceptible material is offset in the magnetic gap **26** toward the pole face **24***b* of the magnet **24** which tends to impart a permanent pressure on the mounting grommet **52** toward the pole face **24***b* which take up compliance variations and result in a more perfect standardization of the mount for the moving-coil generating system. Typical magnetically susceptible materials are iron and Permalloy. Although, the common support **30** is initially displaced closer to one pole face than the other, this does not change or affect the stereophonic or monophonic signal output since the overall gap width is constant and motion components at right angles to the pole faces do not contribute to the signal-generating function. Since the common suuport **30** is fabricated of plastic in this illustrative embodiment, the presence of the plug **56** axially of the common support **30** and at right angles to the pole faces **24***a*, **24***b* enables the development of a greater flux concentration through the portion of the generating system which physically carries the coils **34**, **36**.

In order to reduce distortion the stylus arm **32** is con-

structed to serve as a mechanical low-pass filter which attenuates, at approximately six decibels per octave all frequencies occuring above one octave below the lateral frequency at which the resonances occur. This is achieved by making the portion of the stylus arm **32** intermediate the stylus assembly **42** and the common support **30** of progressively increasing vertical extent from the stylus assembly to the armature such that a progressive mechanical decoupling action occurs between the stylus assembly **42** and the common support **30** in response to increases in frequency over the prescribed audio range. The progressive increase in vertical extent of the stylus arm **32** is determined experimentally and established to introduce the desired attenuation in response to increases of frequency. The stylus arm **32** is arranged to have a vertical compliance which is less than the suspension compliance at the low end of the operating range of frequency, a vertical compliance which is greater than the suspension compliance at the high end of the operating range of frequencies, lateral and torsional compliances which are always less than the suspension compliance over the operating range of frequencies, and may have greater compliance in all planes at a prescribed frequency to completely filter the actual main resonant action of the stylus in the groove. Further the stylus is of progressively increasing lateral cross section from the point of support of the stylus assembly **42** toward the common support **30** to effectively reduce the lateral mass of the stylus arm, consistent of course with the compliance requirements.

In order to facilitate a more thorough understanding of the present nivention, a typical, but nonetheless illustrative sequence of assembly steps will now be described:

The stylus assembly **42** is secured to the stylus arm **32** of the moving-coil generating system **28** either before or after the winding of the coils **34, 36** over the respective mandrel or bobbins provided by the flats or faces of the common support **30**. Only a few turns of the coils have been shown in the drawings, but it will be appreciated that there are a large number of turns of exceptionally fine wire, with the coil turns crossing over each other at opposite flats **30*b***, **30*d*** of the common support **30**. Since the coils are wound on a common support and are geometrically substantially congruent, and it is possible to precisely form the common support, substantially perfect coil symmetry may be realized, with the coils oriented at righ angles to each other and at 45° to the horizontal. Although reference is made throughout the specification to orientation of the coils at substantially 90° relative to each other for maximum signal generation and channel separation, it will be appreciated that if the coils were symmetrically wound at angles less than 90° relative to each other, they will still function to produce two separate outputs, but under less optimum conditions of signal reproduction. After the completion of the moving-coil generating system **28**, the diameter of the cross section of the mounting saddle defined by the flats or faces **30*a***, **30*f***, **30*c***, **30*d*** is built up to be substantially equal to the diameter of the inner periphery **52*a*** of the mounting grommet **52**, which mounting grommet is of sufficient radial extent to provide respective compression seals between the inner periphery of the grommet and the built up section of the common support and the outer periphery of the grommet and the bounding portions of the aperture **54*a*** in the mounting bracket **54**. Upon completion of the subassembly illustrated in FIG. 6, the mounting bracket **54** is assembled within the housing **12** as seen best in FIGS. 1 to 3, care being taken to impart the requisite vertical and lateral orientation to the moving-coil generating system within gap **26** of the magnet **24**. Finally, the requisite electrical connections are made to the four coil ends by lead wires **40** to respective pins **38**, such electrical connections being preferably made by thermowelds and the use of silver contact pins.

Since both coils are rotationally and electrically balanced, and since there is only one moving mass within the single magnetic gap, there is maximum assurance that the reproduction from the respective stereophonic channels will be exactly alike. This in turn results in sound which is smooth and well defined and eliminates any false colorations in either of the stereophonic channels. The transducer, due to its relative simplicity in construction, may be made exceptionally rugged, completely reliable and capable of reproducing the recorded sound, virtually with the same quality as the master tape employed in the preparation of the stereophonic record. When used for monophonic reproduction, the present transducer results in fidelity which surpasses a comparable high quality monophonic transducer particularly when the output coils are connected in phase opposition such that the vertical signals produced incident to the pinch effect are cancelled out for such monophonic playback.

A latitude of modification, change and substitution is intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention herein.

What I claim is:

1. An electro-mechanical transducer comprising a base, a magnet mounted on said base and including opposed pole faces defining a magnetic gap, a first output coil, a second output coil, a common support mounting said coils substantially at right angles to each other with said common support and said coils providing a balanced moving mass with said coils having substantially identical mechanical and electrical properties, a stylus and stylus arm operatively connected to said common support, and means mounting said common support with said first and second coils in said magnetic gap and extending at right angles to said pole faces.

2. An electro-mechanical transducer comprising a base, a magnet mounted on said base and including opposed pole faces defining a magnetic gap, a first output coil, a second output coil, a common support mounting said coils substantially at right angles to each other, a stylus and stylus arm operatively connected to said common support, and means including an elastomeric grommet mounting said common support with said first and second coils in said magneic gap and extending at right angles to said pole faces.

3. An electro-mechanical transducer comprising a base, a magnet mounted on said base and including opposed pole faces defining a magnetic gap, a first output coil, a second output coil, a common support about which said coils are wound with the turns thereof at right angles to each other, a stylus arm integral with and projecting from said common support, and means including an elastomeric grommet mounting said common support with said first and second coils disposed within said gap and extending at right angles to said pole faces.

4. A stereophonic pickup cartridge comprising a support, means or producing a magnetic field in a magnetic gap bounded by pole faces, a moving-coil generating system including a support having a stylus arm and first and second coils wound on said support with the turns thereof in substantial symmetry with each other, a stylus on said stylus arm, and means having substantially equal compliance in all directions mounting said generating system with said first and second coils in said magnetic gap and with said turns extending substantially at right angles to said pole faces.

5. A stereophonic pickup cartridge comprising a base, means on said base for producing a magnetic field in a magneic gap bounded by pole faces, a moving-coil generating system including a support having a stylus arm integral therewith, and first and second coils wound about the faces of said support with the turns thereof in sub-

stantial symmetry with each other, a stylus on said stylus arm, and yieldable means having substantially equal compliance in all directions surrounding said support and mounting said generating system with said first and second coils in said magnetic gap and with said turns extending at right angles to said pole faces.

6. A stereophonic pickup cartridge comprising a base, means on said base for producing a magnetic field in a magnetic gap bounded by pole faces, a moving-coil generating system including a support having a stylus arm and first and second coils wound on said support with the turns thereof in substantial symmetry with each other, a stylus on said stylus arm, and suspension means having substantially equal suspension compliance in all directions mounting said generating system with said first and second coils in said magnetic gap and with said turns extending at right angles to said pole faces, said stylus having a beam compliance which is less than said suspension compliance and which is of progressively increasing compliance at higher frequencies, said beam compliance at said higher frequencies being greater than said suspension compliance such that there is a progressive mechanical decoupling at higher frequencies.

7. In a pickup for translating mechanical movement to electrical signals over a prescribed range of frequencies, a moving-coil system including a support, a stylus arm projecting from said support, and a stylus mounted on said stylus arm at a point spaced from said support, and means suspending said moving coil system with a substantially uniform suspension compliance for movement in response to actuation of said pickup, the portion of said stylus arm intermediate said stylus and support being of progressive increasing cross section from said stylus to said support to provide a progressive mechanical decoupling action between said stylus and support in response to increases in frequency over said prescribed range of frequencies, said stylus arm having a stylus arm compliance which is less than said suspension compliance at the low end of said prescribed range of frequencies and a stylus arm compliance which is greater than said suspension compliance at the high end of said prescribed range of frequencies.

8. In a pickup for translating mechanical movement to electrical signals over a prescribed range of frequencies, a moving-coil system including a support, a stylus arm integral with and projecting from said support, and a stylus mounted on said stylus arm at a point spaced from said support, and means suspending said moving coil system with a substantially uniform suspension compliance for movement in response to actuation of said pickup, the portion of said stylus arm intermediate said stylus and support being of progressive increasing cross section from said stylus to said support to provide a progressive mechanical decoupling action between said stylus and support in response to increases in frequency over said prescribed range of frequencies, said stylus arm having a stylus arm compliance which is less than said suspension compliance at the low end of said prescribed range of frequencies and a stylus arm compliance which is greater than said suspension compliance at the high end of said prescribed range of frequencies, said stylus arm having a lateral and torsional compliance which is less than said suspension compliance over said prescribed range of frequencies.

9. A stereophonic pickup comprising a base, a permanent magnet on said base including a yoke-shaped body terminating in opposed pole faces defining a magnetic gap, a cubical bobbin having a projecting stylus arm, a stylus secured to said stylus arm, a first output coil wound about four faces of said bobbin, a second output coil wound about four faces of said bobbin, the turns of said first output coil extending at right angles to the turns of said second output coil and crossing thereover at one pair of opposite faces of said bobbin, insulating means about the remaining faces of said bobbin building up said remaining faces such that the cross-section of said bobbin is substantially circular, an annular yieldable grommet encircling said bobbin with its inner periphery engaging the circular cross-section thereof, and means engaging the outer periphery of said grammet and movably suspending said bobbin in said magnetic gap with said one pair of faces of said bobbin extending parallel to said pole faces.

10. A stereophonic pickup comprising a base, a permanent magnet on said base including a yoke-shaped body terminating in opposed pole faces defining a magnetic gap, a cubical bobbin having a projecting stylus arm, a stylus secured to said stylus arm, a first output coil wound about four faces of said bobbin, a second output coil wound about four faces of said bobbin, the turns of said first output coil extending at right angles to the turns of said second output coil and crossing thereover at one pair of opposite faces of said bobbin, a grommet of elastomeric material encircling said bobbin with its inner periphery engaging said bobbin, and means engaging the outer periphery of said grommet and movably suspending said bobbin in said magnetic gap with said one pair of faces of said bobbin extending parallel to said pole faces.

11. A stereophonic pickup comprising a base, a permanent magnet including a yoke-shaped body terminating in opposed pole faces defining a magnetic gap, a moving mass fabricated of plastic and including a substantially cubical bobbin having an integral projecting stylus arm, a stylus, means including an homogenized plastic securing said stylus to said stylus arm, a first output coil wound about said bobbin, a second output coil wound about said bobbin, the turns of said first output coil extending at right angles to the turns of said second output coil, a grommet of elastomeric material encircling and engaging said bobbin, and means engaging said grommet and movably suspending said bobbin in said magnetic gap.

12. An electro-mechanical transducer comprising a base, a magnet mounted on said base and including opposed pole faces defining a magnetic gap, a first output coil, a second output coil, a common support of non-magnetic material mounting said coils substantially at right angles to each other, a stylus and stylus arm operatively connected to said common support, resilient mounting means movably mounting said common support on said base with said first and second coils in said magnetic gap and extending at right angles to said pole faces, and means for imparting a permanent pressure to said resilient mounting means urging the same toward one pole face.

13. An electro-mechanical transducer comprising a base, a magnet mounted on said base and including opposed pole faces defining a magnetic gap, a first output coil, a second output coil, a common support of non-magnetic material mounting said coils substantially at right angles to each other, a stylus and stylus arm operatively connected to said common support, resilient mounting means movably mounting said common support on said base with said first and second coils in said magnetic gap and extending at right angles to said pole faces, and means for imparting a permanent pressure to said resilient mounting means urging the same toward one pole face, the pressure-imparting means including on armature of a magnetically susceptible material extending at right angles to said pole faces and mounted on said common support in closer proximity to said one pole face than the other pole face.

14. An electro-mechanical transducer comprising a base, a magnet mounted on said base and including opposed pole faces defining a magnetic gap, a first output coil, a second output coil, a common support mounting said coils substantially at right angles to each other, a stylus and stylus arm operatively connected to said common support, and resilient mounting means having a substantially equal compliance in all directions movably mounting said common support with said first and second

coils in said magnetic gap and extending at right angles to said pole faces.

15. A stereophonic pickup cartridge comprising a base, means on said base for producing a magnetic field in a magnetic gap bounded by pole faces, a moving-coil generating system including a support having a stylus arm and first and second coils wound on said support in substantial symmetry with each other, a stylus on said stylus arm, and resilient mounting means having substantially equal compliance in all directions operatively connected to said support and mounting said generating system with said first and second coils in said magnetic gap and with said turns extending substantially at right angles to said pole faces.

16. An electro-mechanical transducer comprising a magnet including pole faces forming a magnetic gap, a first coil and a substantially congruent second coil each having a winding axis, a common support mounting said coils with their axes intersecting substantially at right angles, a stylus arm operatively connected to said common support, and means mounting said common support in said magnetic gap with said intersecting axes in a plane parallel to said pole pieces.

17. An electro-mechanical transducer comprising a magnet including pole faces forming a magnetic gap, a first coil and a substantially congruent second coil each having a winding axis, a common support mounting said coils with their axes intersecting substantially at right angles, a stylus arm operatively connected to said common support, and means mounting said common support in said magnetic gap with said intersecting axes in a plane parallel to said pole pieces, said mounting means including an elastomeric grommet grasping said common

support and having an axis of rotational symmetry normal to said plane and passing through the intersection of said coil axes.

18. A stereophonic pickup comprising a base, a permanent magnet including a yoke-shaped body terminating in opposed pole faces defining a magnetic gap, a moving-coil generating system including a support having at least six faces, a stylus arm projecting from said support and secured thereto, a stylus mounted on said stylus arm at a point spaced from said support, a first output coil wound about four faces of said support, a second output coil wound about four faces of said support and substantially congruent with said first output coil, the turns of said first output coil extending substantially at right angles to the turns of said second output coil and crossing thereover at one pair of opposite faces of said support, and resilient means mounting said support on said base with said first and second output coils in said magnetic gap and extending substantially at right angles to said pole faces.

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