United States Patent

Grado

[15] **3,683,128**

[45] **Aug. 8, 1972**

[54] **FLUX-BRIDGING STEREOPHONIC PICKUP**

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[22] Filed: **June 29, 1970**

[21] Appl. No.: **50,624**

[52] **U.S. Cl.** ....**179/100.41 K**

[51] **Int. Cl.** **H04r 11/12**

[58] **Field of Search**.............179/100.41 Z, 100.41 K

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Assistant Examiner—Raymond F. Cardillo, Jr.
Attorney—Amster & Rothstein

[57] **ABSTRACT**

A phonograph pickup for the reproduction of stereophonic and/or monaural sound recordings in which signals are induced without substantially disrupting the flux path of the several operating gaps and wherein a flux-bridging member is operatively connected to the moving stylus of the pickup and disposed in proximity to the first and second operating gaps, but out of a direct flux path between such gaps, to effectively shorten the fixed gap length of one of the operating gaps and to correspondingly effectively lengthen the gap length of the other of the operating gaps and to induce corresponding signals in the pickup related to such stylus motion.

8 Claims, 9 Drawing Figures

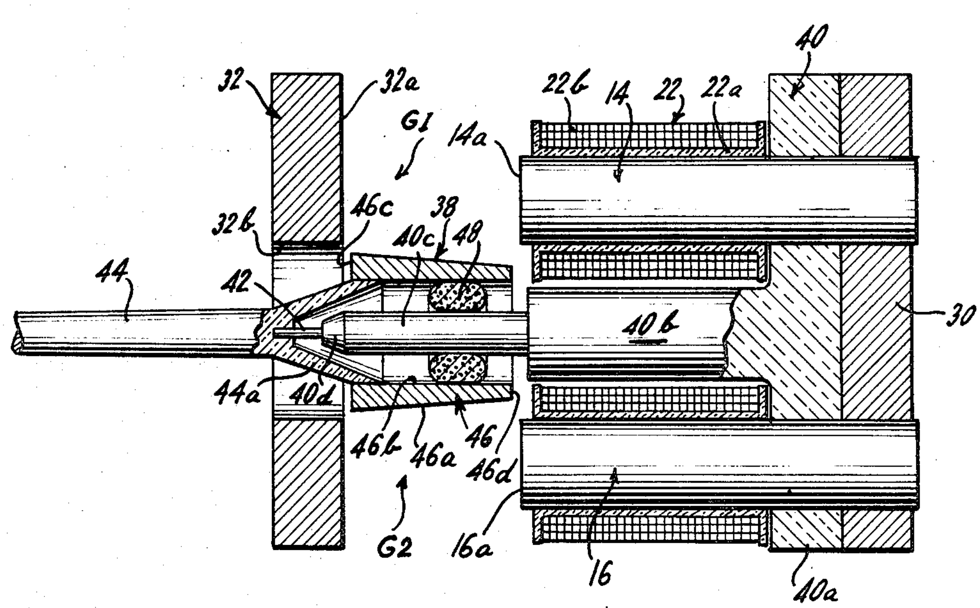

FIG. 2.

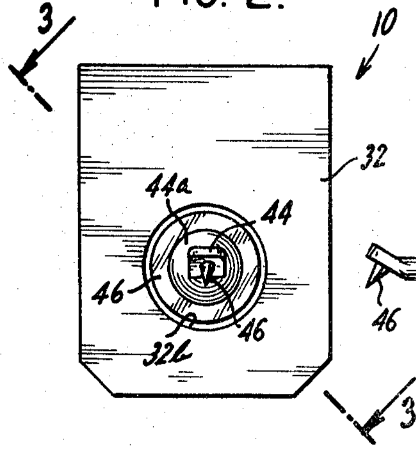

FIG. 1.

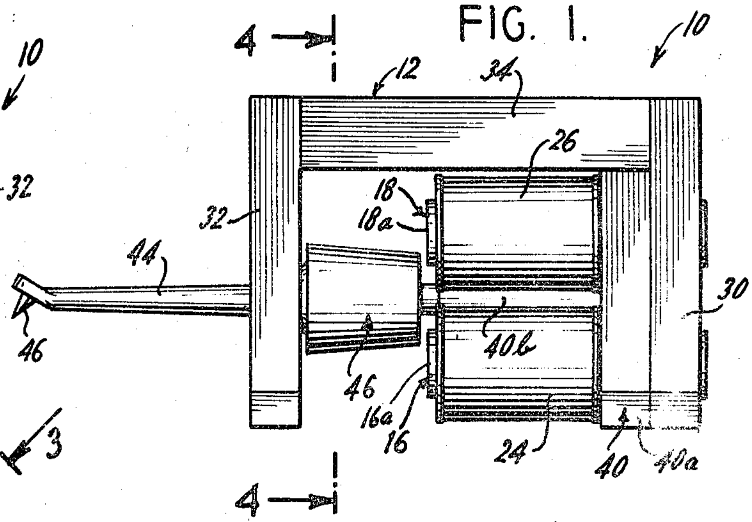

FIG. 3.

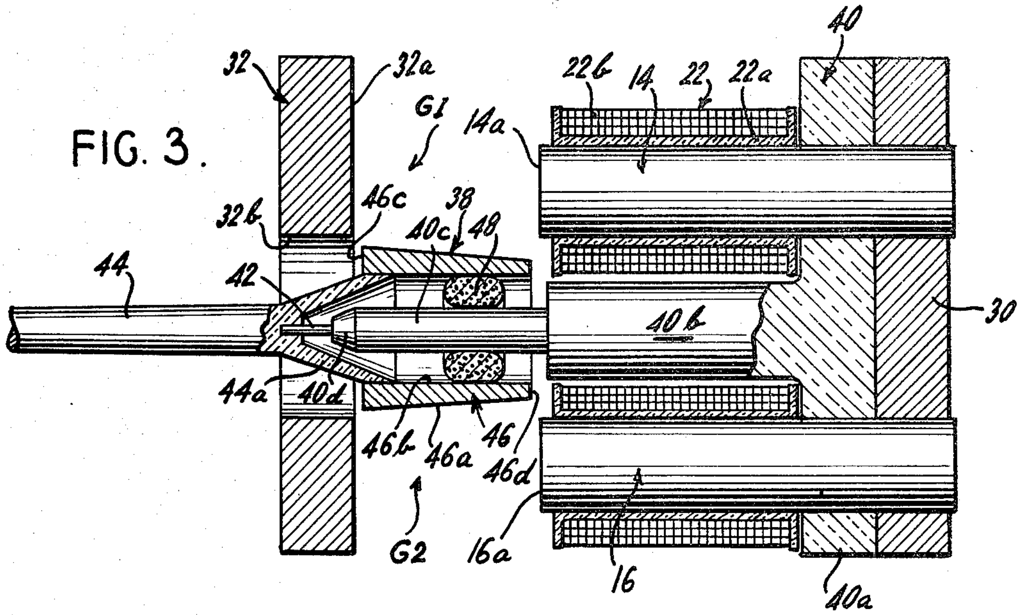

FIG. 4.

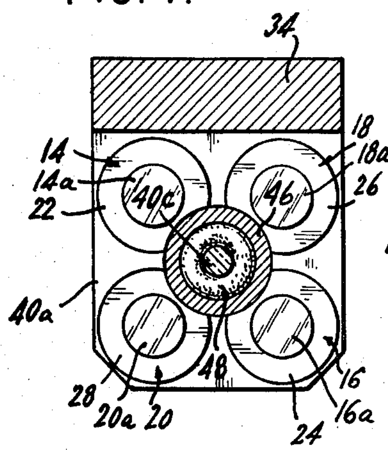

FIG. 5.

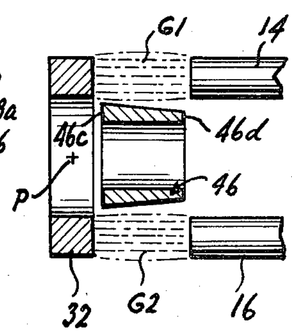

FIG. 6.

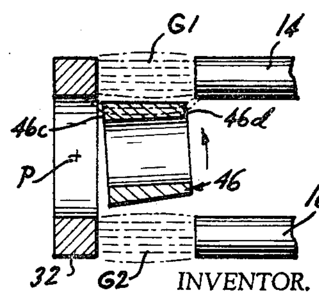

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FIG. 7.

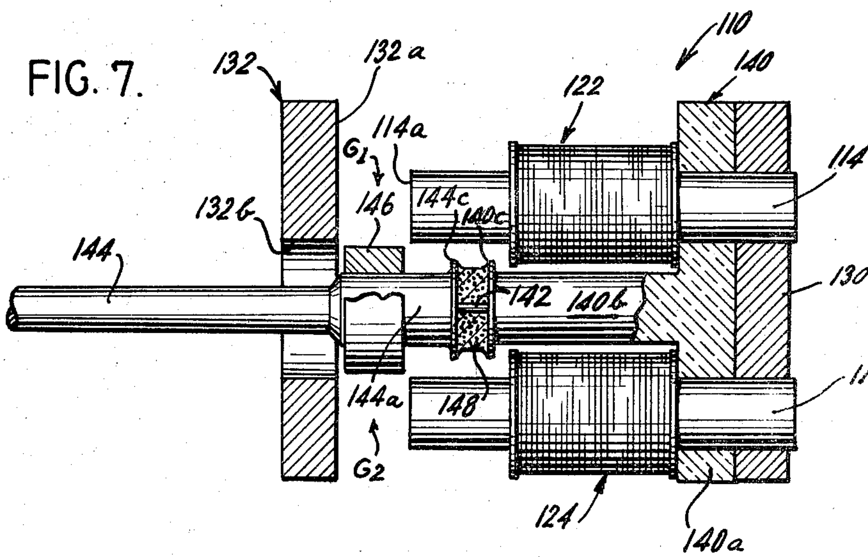
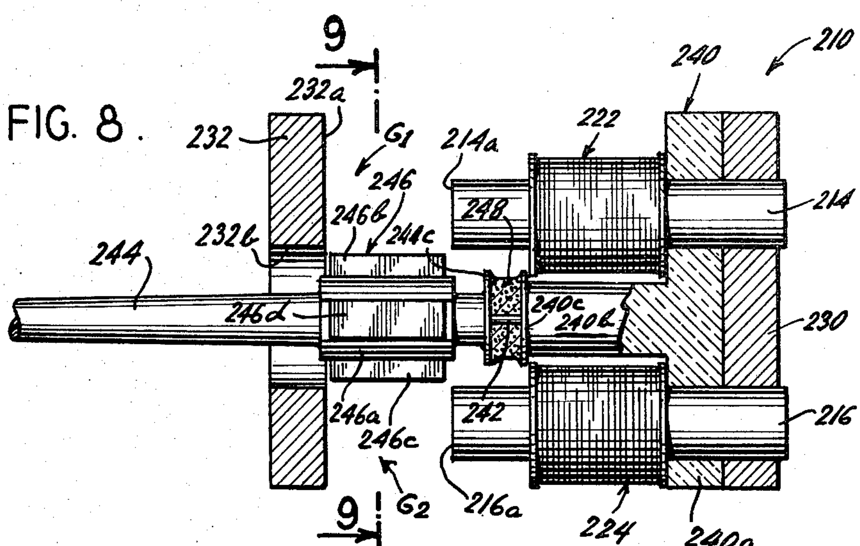


FIG. 8.



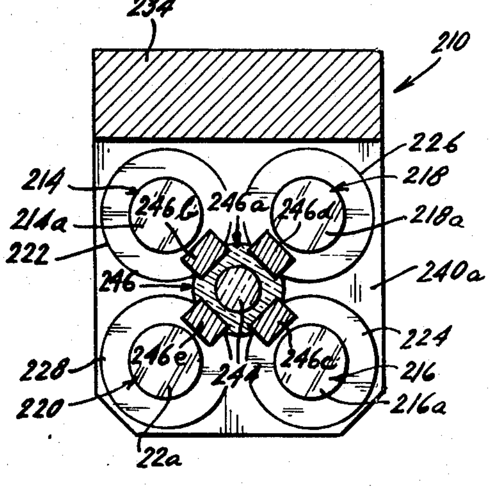


FIG. 9.

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FLUX-BRIDGING STEREOPHONIC PICKUP

The present invention relates generally to phonograph pickups, and, in particular, to an improved phonograph pickup or electromagnetic cartridge for the reproduction of stereophonic and/or monaural sound recordings.

Cartridges of conventional structure usually include a cartridge housing on which is mounted a stylus-armature assembly which includes a cantilever-supported stylus lever having the requisite compliance such that the stylus thereof may track the usual 45°–45° groove of a stereophonic recording disc. An appropriate magnetic structure is provided including first and second pairs of coils, with each coil pair being connected in series. The pairs of coils have signals induced therein which are related to the two modulations derived by the stylus from the stereophonic record groove. Signals or voltages are usually induced in the coils through the provision of a moving iron mass or armature which is disposed within a magnetic gap defined by the permanent magnetic and pole pieces of the magnetic structure.

In a typical stereophonic cartridge of the type including a moving iron mass, each channel includes two pole pieces carrying respective coils connected in series. A magnetic armature is arranged relative to the faces of the pole pieces to be symmetrically disposed relative thereto and is in a magnetic circuit, the armature either being disposed in an independently completed gap having opposed polarities or itself serving as the opposite pole of the gap relative to the pole pieces. As the armature moves, the gap between one pole face and the armature increases while the gap between the armature and the other pole face decreases, with the armature itself bridging the flux between the two coil poles. Depending upon the configuration of the armature and the associated pole pieces, the flux path assumes various directions which introduces the possibility of magnetic distortion (i.e., magnetic hysteresis). The problems of magnetic distortion become more pronounced and more significant at the higher end of the frequency spectrum and may result in substantially total signal distortion. At low frequencies, the mechanical motion occurs at a slower rate and the corresponding magnetic distortion is easily accommodated in the magnetic circuit. However, as the frequencies increase, the flux changes in the magnetic circuit are not easily accommodated and therefore become distorted. This situation becomes even more extreme on a ratio basis as frequencies increase. In stereophonic reproduction where the separation signal is as much as 30 decibels below the primary signal, magnetic distortion can lead to a virtually distorted residual signal. It would be highly desirable to be able to construct a pickup of either the monaural or stereophonic type in which the signals could be induced with minimal changes in the flux path, particularly if it was possible to accomplish this in a working environment having low mass and high compliance with the capability of being manufactured on a mass production basis at relatively low unit cost.

It is an object of the present invention to provide an improved electromagnetic cartridge for the reproduction of monoaural and stereophonic recording which realizes one or more of the aforesaid objectives. Specifically, it is within the contemplation of the present invention to provide a pickup wherein the signals are induced without substantially disrupting the flux path of the several operating gaps.

It is a further object of the present invention to provide a cartridge design having the other usual desirable attributes including low torsional mass, high efficiency, optimum symmetry of mechanical motion and the capability of mass production reproduceability.

In accordance with an illustrative embodiment demonstrating objects and features of the present invention, there is provided an electromagnetic cartridge having a moving stylus and a magnetic structure including pole pieces terminating in opposed faces defining first and second operating gaps, with the respective pairs of opposed faces being of opposite polarity. First and second coils are mounted on said first and second pole pieces and connected in series. A flux-bridging means is operatively connected to the moving stylus and disposed in proximity to said first and second operating gaps, but normally out of a direct flux path between the opposite polarity opposed faces of each of said operating gaps. The flux-bridging means moves in response to stylus motion to effectively shorten the fixed gap length of one of the operating gaps and to correspondingly effectively lengthen the gap length of the other operating gap and to induce corresponding signals related to stylus motion.

In the present stereophonic cartridge, the flux-bridging means is disposed outside of the profile of the pole pieces defining the two pairs of operating gaps. As the stylus tracks the stereophonic record groove, it will produce corresponding motions of the flux-bridging means which motions from the standpoints of the respective pairs of operating gaps will be independent of each other, that is, the flux-bridging means inherently produces a vector resolution of the stylus motion such that one pair of operating gaps will be related to one stereophonic channel and the other pair of operating gaps will be related to the other stereophonic channel. Considering any particular stylus excursion, the flux-bridging means will move toward one of the pole pieces, thereby introducing additional magnetic material along the flux path of the corresponding operating gap, effectively shortening that first gap by increasing the flux density in the first gap and inducing a corresponding voltage in the coil for that first gap and pole piece. The movement of the flux-bridging means effectively lengthens the second gap of the gap pair by decreasing the flux density in the second gap by an amount substantially equal to the increase of flux density in the first gap. Furthermore, the flux-bridging means move substantially perpendicular to all flux paths.

The flux-bridging means can operate either in the fringe gap of the gap pair or it can be moved further into the gaps of the gap pair. The distortion increases as the flux-bridging means goes further into the gaps. Thus, for purposes of distortion it is advantageous, although not necessary, to operate in the fringe gaps.

Still further advantages are realized with the present cartridge design, either stereophonic or monaural. In a typical cartridge, it is highly desirable to have a flat frequency response over the audio range (i.e., from 20 to 20,000 cycles per second). If the frequency response is not flat, it will manifest itself in certain portions of the audible range and will distort the playback quality of the original recording. Further, if the moving mass of such cartridge is not damped, there is often a resonant peak which, depending upon the cartridge design, may occur in the audible range or beyond 20,000 cycles per second. If such peak occurs within the audible range, it is undesirable since it directly manifests itself as distortion; and, even if it occurs outside of the audible range, it will indirectly manifest itself as distortion because a peak at above 20,000 cycles per second will reflect distortion into the audible range. It has therefore become the practice to damp the generator mass to reduce the resonant peak wherever it may occur. However, in such typical damped cartridge, the damping effect starts at lower frequencies and tilts the total response curve, the lowering of the resonant peak at the higher frequencies usually manifests itself as non-linearity at mid-frequencies.

In the present cartridge, it has been found that no elastomeric material is needed for damping purposes and an essentially flat frequency response is provided over the entire audible frequency range. Additionally, there is a controlled magnetic damping which occurs at high frequencies only and creates a roll-off in frequency above the upper end of the audio spectrum which roll-off reduces the voltage output at such higher frequencies so that the commensurate feedback of the distortion in frequency above the audible frequencies is reduced substantially in the audible range. For example, if the design is such that the tip mass resonance is at 70,000 cycles per second, whatever distortion would be reflected at subharmonics is substantially diminished.

Still further, in a conventional cartridge, the amplitude of the resonant peak due to tip mass is controlled completely by the elastomeric damping material and the consistency of such damping material is a large factor in total quality control. However, in the present design, this parameter is far less important and the present design enables the tip mass to be removed to 70,000 cycles and response to 20,000 cycles to be essentially flat. If conventional elastomeric damping and conventional cartridge design were used to reduce the resonant peak at 70,000 cycles, non-linearity in the mid-frequency (1–10 kc) would occur. However, by removing the criticality of the elastomeric damping factor, a flat frequency response was achieved to 20,000 cycles. To this end, the position of the generator within the four magnetic gaps, but being out of the gap profile and the corresponding direct flux path, becomes an important factor in reducing the amplitude of the resonant peak and in fact further reduces the voltage output above the 20,000 cycle area. Since the flux bridger motion operates essentially at right angles to the flux direction, the flux now creates a magnetomotive force in controlling the position of the flux bridger. The result is a magnetic damping action on the flux bridge which is highly controllable and naturally constant in stability. The amount of magnetomotive force applied to the flux bridger which is controllable in the first instance by the current through the coils and/or the permeability of the flux bridger will determine the frequency at which roll-off will begin to occur and the rate of roll-off thereafter. Thus, by appropriate selection of these controlling parameters, it is possible to achieve magnetic damping commencing at the upper end of the audible spectrum without affecting frequency response in the mid-band and also to thereafter provide for a rapid drop-off in signal output and the corresponding elimination of undesirable feedback of distortion in the frequency above the audible spectrum into the audible spectrum.

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

FIG. **1** is a longitudinal elevational view of a typical stereophonic cartridge or pickup embodying features of the present invention, shown removed from the normal cartridge housing that would be associated therewith;

FIG. **2** is a front elevational view, taken from the left in FIG. **1**;

FIG. **3** is a sectional view taken at substantially 45° to the horizontal and along the lines **3—3** of FIG. **2** and looking in the direction of the arrows, with parts broken away and sectioned and on an enlarged scale;

FIg. **4** is a sectional view taken substantially along the line **4—4** of FIG. **1** and looking in the direction of the arrows;

FIG. **5** is a diagrammatic and schematic showing of the operating gaps of the pickup intended to aid in an understanding of the function of the flux-bridging member;

FIG. **6** is a view similar to FIG. **5**, but showing the flux-bridging member in a typical pickup position during operation;

FIG. **7** is a view similar to FIG. **3**, but of a modified stereophonic cartridge or pickup embodying further features of the present invention;

FIG. **8** is a sectional view similar to FIG. **3**, but of a still further modified stereophonic cartridge or pickup embodying still further features of the present invention; and,

FIG. **9** is a sectional view taken substantially along the line **9—9** of FIG. **8**, but turned to an erected position as compared to FIG. **8**.

Referring now specifically to the drawings, and in particular to FIG. **1**, there is shown an improved electromagnetic cartridge or pickup for stereophonic reproduction, generally designated by the reference numeral **10**, which may be removably mounted within an appropriate housing which in turn is mounted on the tone arm of a turntable or record player, as is generally understood. For a typical mounting arrangement, reference may be made to co-pending application Ser. No. 873,368, filed Nov. 3, 1969, and entitled "Toroidal Armature Stereophonic Pickup."

Cartridge **10** includes a balanced magnetic structure **12** which includes four pole pieces **14**, **16** and **18**, **20** terminating in pole piece faces **14*a***, **16*a*** and **18*a***, **20*a***. Pole pieces **14**, **16** provide a first diametrically opposed pair having their longitudinal center lines in a substantially common plane at 45° to the horizontal (see 45° section of FIG. **3**); and pole pieces **18**, **20** provide a second diametrically opposed pair in which the pole pieces have their longitudinal center lines in a substantially common plane at 45° to the horizontal and at right angles to the first pair. A first pair of coils **22**, **24** is mounted on the first pair of pole pieces **14**, **16** and connected in voltage adding and hum cancelling relation to each other; and a similar second pair of coils **26**, **28** is mounted on the second pair of pole pieces **18**, **20** and connected in voltage adding and hum cancelling relation to each other. Typically, each of the coils **22**, **24** and **26**, **28** includes a coil bobbin, such as **22***a*, which is fabricated of a non-ferrous material and a coil proper, such as **22***b*. Opposed pairs of coils are of substantially identical configuration to avoid introducing any electrical imbalance in the coil arrangements and symmetry.

The plural pole pieces **14**, **16** and **18**, **20** are part of the balance magnetic structure **12** which also includes a rear magnetic plate **30** serving as a pole piece support (see FIGS. **1** and **3**), a front magnetic plate **32** disposed in spaced parallel relation to the rear magnetic plate **30** and a permanent magnet **34** interconnected therebetween.

The rearward face **32***a* of the front magnetic plate **32** is in spaced parallel relation to the forward faces **14***a*, **16***a* and **18***a*, **20***a* of the respective pole pieces which pole piece faces are in coplanar relation and respectively cooperate with face **32***a* to define four operating gaps symmetrically disposed about the longitudinal center line of the pickup, with the gaps for pole faces **14***a*, **16***a* being respectively designated at G_1 and G_2. Similar third and fourth operating gaps are formed by pole piece faces **18***a*, **20***a* and the corresponding confronting portions of face **32***a*. As seen in FIGS. **5** and **6**, the profiles of the respective pole pieces **14**, **16** and **18**, **20** and the corresponding confronting portions of front magnetic plate **32** substantially define the radial extent of the respective operating gaps which are somewhat larger than the physical size of the pole piece faces due to fringing of the magnetic fields across the respective gaps, as is generally understood.

Extending axially of the pickup **10** and symmetrically disposed with respect to the magnetic structure **12** is a stylus-flux bridger assembly, generally designated by the reference numeral **38**, which is mounted on a stylus-flux bridger support, generally designated **40**. As seen in FIG. **3**, the support **40** may be fabricated of a single molded plastic piece and includes a base **40***a* coextensive with the rear magnetic plate **30** through which the pole pieces pass, an axially extending post **40***b* extending between the pole pieces and an axially extending post extension **40***c* of smaller diameter than the post and projecting beyond the pole pieces. The leading end of post extension **40***c* terminates in a conical tip **40***d* which in turn carries an axially extending flexible pin **42** providing a fulcrum for stylus lever **44**. Stylus lever **44** projects through central cutout **32***b* in the front magnetic plate **32** and at its forward end carries the usual tip or stylus **46**. At its rearward end, stylus lever **44** is formed with a substantially conical mounting section **44***a* into which post extension **40***c* and pin **42** extend, with pin **42** being appropriately anchored in the stylus lever **44** to provide a well defined pivot for the stylus lever **44** in the region of the conical mounting section, typically at the location P in FIGS. **5** and **6**. Stylus lever **44** may be fabricated of any appropriate non-ferrous material, such as plastic or aluminum.

Operatively connected to the stylus lever **44** is a flux-bridging member **46** which is disposed in proximity to the four operating gaps of the pickup but out of a direct flux path between the opposite polarity faces of each of the operating gaps (see for example, FIGS. **5** and **6** with respect to gaps G_1, G_2). The flux-bridging member **46** moves in response to stylus motion to effectively shorten the fixed gap effect on the companion operating gap.

Although in the illustrative embodiment, the flux-bridging member **46** has been illustrated as a single toroid in cross-section, a similarly functioning cartridge could be designed wherein each gap includes an individual magnetic gap-bridging bar mounted on a common non-magnetic support. In this segmented arrangement, each bridging bar for each gap would constitute an individual magnetomotive unit relative to the pickup. However, the action of such a segmented flux-bridging member will be essentially the same as that of the illustrative embodiment except possibly for better isolation of respective flux paths and correspondingly reduced interaction between channels. Practical experience indicates that the cost and inconvenience in the manufacture of such a segmented flux-bridging member are not justified for the corresponding minor improvement in cartridge performance, but in those situations where even higher orders of channel isolation is justified from a cost standpoint, it is contemplated that a segmented flux-bridging member would attain more perfect length of one of the operating gaps of each pair and to correspondingly effectively lengthen the fixed gap length of the other of said operating gaps, it being appreciated that the stylus motion automatically produces a vector resolution of that motion in relation to the four gaps of the stereophonic pickup.

The flux-bridging member **46** is in the configuration of a frustum of a cone and includes outer conical surface **46**a and inner cylindrical surface **46***b* and is dimensioned and arranged to be outside of the profile of the four operating gaps. Flux-bridging member is mounted on the conical mounting section **44***a* of stylus lever **44** at flat **44***b* which provides an annular mounting surface dimensioned to receive the inner cylindrical surface **46***b* of the flux-bridging member. This attachment may be accomplished in any convenient fashion, as for example, by the use of an interposed adhesive. As seen best in FIGS. **5** and **6**, the larger diameter end **46***c* of the flux-bridging member **46** is closest to the center of motion or pivot P for the stylus while the smaller diameter end is removed therefrom. Interposed between the flux-bridging member **46** and the small diameter post extension **40***c* is an elastomeric member **48** which serves to center the stylus-bridger assembly **38** in accordance with the principles which are well understood.

A typical sequence of operation will now be described to facilitate a more thorough understanding of the present invention:

Normally, the flux-bridging member **46** of the assembly **38** is disposed outside of the profile of the four pole pieces **14**, **16** and **18**,**20** which define the two pairs of series connected operating gaps for the illustrative stereophonic cartridge **10**. Stylus lever **44** projects forwardly of pivot P while the flux-bridging member **46** extends rearwardly therefrom, with the larger diameter end being closest to pivot and with the flux-bridging member presenting a progressively decreasing cross-section at points longitudinally removed rearwardly from pivot P. As stylus **56** on stylus lever **44** tracks the groove of the usual stereophonic record, it will produce corresponding motions of the assembly **38** and of flux-bridging member **46** which motions from the standpoint of the respective pairs of operating gaps will be independent of each other. Inherently, flux-bridging member **46** produces a vector resolution of the stylus motion such that one pair of operating gaps will be related to one channel of the stereophonic pickup (i.e., gaps G_1, G_2) and the other pair of operating gaps will be related to the other channel. Referring to FIGS. **5** and **6**, and considering any particular stylus excursion, the smaller diameter end of the flux-bridging member will move toward one of the pole pieces (i.e., pole piece **14** in FIG. **6**) thereby introducing additional magnetic material along the flux path of the corresponding operating gap (i.e., gap G_1) and effectively shortening that gap by increasing the flux density thereof and inducing a corresponding voltage in its coil (i.e., coil **22**). The companion operating gap (i.e., G_2) and pole piece which is connected in series is effectively lengthened by decreasing the flux density in the gap by an amount substantially equal to the increase of the flux density in gap G_1. The flux-bridging member moves substantially perpendicular to all flux paths. The flux-bridging member further advantageously operates in the fringe of the flux paths of gaps G_1 and G_2 (and gaps G_3 and G_4) for purposes of distortion, since the distortion increases as the flux-bridging member goes further into the gaps. However, it is to be noted that the flux-bridging member may go further into the gaps, if so desired.

Referring now to FIG. **7**, there is shown a further embodiment of an electromagnetic cartridge or pickup in accordance with the present invention, generally designated by the reference numeral **110**. Since in many respects, the cartridge **110** is identical in construction to the embodiment illustrated in FIGS. **1–6**, inclusive, it is numbered as part of a "100" series and the description thereof will be directed to the constructional differences between the principal embodiment and this modification. Rather than mount the stylus lever **144** at a pivot which is forwardly of the flux-bridging member **146**, in this embodiment, the pole pieces **114**, **116** and **118**, **120** extend forwardly of the axially extending post **140*b*** of the bridger support **140** and pivot pin **142** is disposed rearwardly of the flux-bridging member **146**. To this end, post **140*b*** terminates in a flange **140*c*** and similarly the cylindrical mounting section **144*a*** of the stylus lever **144** terminates in a confronting flange **144*c***. Pivot pin **142** extends axially of post **140*b*** and stylus lever **144** and is appropriately mounted at its opposite ends in parts **140**, and **144** with flanges **140*c***, **144*c*** being spaced from each other and the intervening space being filled with an elastomer **148**. Further, in this embodiment, flux-bridging member **146** is a simple cylinder of magnetic material mounted in appropriate relation to the several operating gaps, as previously described. Since the operation of the embodiment shown in FIG. **7** is substantially the same as that previously described, except for the different locations of the pivot and the configuration of the flux-bridging member, further description is dispensed with in the interest of brevity.

In FIGS. **8** and **9**, there is shown a still further embodiment of pickup demonstrating further features of the invention, generally designated by the reference numeral **210** and by a series of reference characters as part of a "200" series for convenience in identifying comparable parts. In this embodiment, pivot **242** for the stylus lever **244** is arranged rearwardly of the flux-bridging member **246** as illustrated in FIG. **7**, but the remainder of the pickup is essentially the same as the disclosed in the principal embodiment, except for the construction of the flux-bridging member **246**. In the previous embodiments, the flux-bridging member is a continuous toroid of magnetic material, while in the embodiment illustrated in FIGS. **8** and **9**, there is shown a cartridge design wherein the flux-bridging member **246** is segmented and includes individual magnetic means for the respective operating gaps. Specifically, in the segmented flux-bridging member **246**, there is provided a substantially cylindrical mounting member **246**a which is supported in any appropriate fashion on stylus member **244** and is fabricated of a non-magnetic material, such as an appropriate plastic. The mounting member **246*a*** carrying opposed pairs of flux-bridging bars **246*b***, **246*c*** and **246*d***, **246*e*** arranged in opposed relationship to each other and at the requisite 45° orientation, such that separate magnetic members are provided in proximity to the four operating gaps of the pickup but out of the direct flux path between the opposite polarity faces of each of the operating gaps. As in the previous embodiment, the flux-bridging member **246** moves in response to stylus motion such that the flux-bridging bars thereof effectively shorten the fixed gap length of one of the operating gaps of each pair and correspondingly effectively lengthen the fixed gap length of the other of the operating pairs. It will be appreciated that the segmented flux-bridging member **246** provides an individual magnetomotive unit relative to each gap of the pickup and it is therefore possible to achieve further isolation of the respective flux paths and correspondingly reduce interaction between channels. In those commercial situations where very high orders of isolation is required and the additional cost in manufacturing the segmented flux-bridging member is acceptable, this design attains a more perfect channel isolation.

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 present invention.

What I claim is:

1. A stereophonic cartridge comprising a support, a magnetic structure on said support including a permanent magnet and means including first, second, third and fourth pole pieces and a front magnetic member defining first and second operating gaps and third and fourth operating gaps, said first and second operating gaps extending symmetrically of a first plane and said third and fourth operating gaps extending symmetrically of a second plane and substantially at right angles to said first plane, a coil mounted on each said pole piece, the coils for said first and second operating gaps being connected in series and the coils for said third and fourth operating gaps being connected in series, a stylus assembly disposed symmetrically of and between said operating gaps and including a stylus lever having its lever axis normally parallel to the length dimension of said operating gaps, means mounting said stylus lever on said support for movement about a center of motion and a flux-bridging member operatively connected to said stylus lever and moving substantially perpendicular to all flux paths such that stylus motion and correspondeing motion of said flux-bridging member will effectively shorten the fixed gap length of one-operating gap of a series connected pair of coils and effectively lengthen the fixed gap length of the other operating gap of said series connected pair of coils said effective shortening and lengthening being substantially independent with respect to the other series connected pair of coils.

2. A stereophonic cartridge comprising a support, a magnetic structure on said support including a permanent magnet and means including first, second, third and fourth pole pieces and a front magnetic member defining first and second operating gaps and third and fourth operating gaps, said first and second operating gaps extending symmetrically of a first plane and said third and fourth operating gaps extending symmetrically of a second plane and substantially at right angles to said first plane, a coil mounted on each said pole piece, the coils for said first and second operating gaps being connected in series and the coils for said third and fourth operating gaps being connected in series, a stylus assembly disposed symmetrically of and between said operating gaps and including a stylus lever having its lever axis normally parallel to the length dimension of said operating gaps, means mounting said stylus lever on said support for movement about a center of motion and a flux-bridging member operatively connected to said stylus lever and dimensioned and positioned to be out of a direct flux path for each of said operating gaps but in the fringe fields thereof such that stylus motion and corresponding motion of said flux-bridging member moving substantially at right angles to all flux paths will effectively shorten the fixed gap length of one operating gap of a series connected pair of coils and effectively lengthen the fixed gap length of the other operating gap of said series connected pair of coils said effective shortening and lengthening being substantially independent with respect to the other series connected pair of coils.

3. A cartridge according to claim 2 wherein said flux-bridging means is cylindrical and is fabricated of an electromagnetic material.

4. A cartridge according to claim 2 wherein said flux-bridging means includes a support of a non-magnetic material and individual flux-bridging members of electromagnetic material arranged in proximity to each of said operating gaps.

5. A cartridge according to claim 2 including elastomeric damping means interposed between said flux-bridging member and said stylus at a point removed from said center of motion.

6. A cartridge according to claim 2 wherein said stylus lever extends forwardly from said center of motion and said flux-bridging member extends rearwardly therefrom.

7. A cartridge according to claim 6 wherein said flux-bridging member is frusto-conical and normally extends coaxially of said stylus lever.

8. A cartridge according to claim 6 wherein the large diameter end of said flux-bridging member is closest to said center of motion.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,683,128 **Dated** August 8, 1972

Inventor(s) Joseph F. Grado

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col 9, line 12 delete "correspondeing", insert --corresponding--.

Signed and sealed this 19th day of March 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents