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Description

This invention relates generally to inductive coupling and more particularly, to transformers where there is relative motion between the primary and secondary windings and minimal reaction forces therebetween.

The invention described herein has particular utility in applications where electrical power is coupled from a stationary location to a moving location with a minimum of interaction between the stationary and movable components. The invention is principally applied to transferring power across magnetically suspended interfaces, where small disturbance forces might affect the magnetic control forces, and where motions over as many as six degrees of freedom are required over a limited range.

Known technologies for coupling electro-magnetic energy across a moving boundary of interface consist of solenoid and rotary transformer type structures. In US -A-4,117,436, a transformer comprising primary and secondary windings axially disposed on a common axis and surrounded by a core of high permeability material is adapted to provide limited relative rotary motion between first and second transformer windings about the axis. The disadvantage of this device is the limited range of freedom of relative motion. Another structure is shown in US -A-4,321,572 in which a rotary transformer has a fixed primary winding and a secondary winding rotatable through a gap in the core structure. This arrangement principally allows full rotational freedom without allowance for motion about other axes. However, the presence of the air gaps in the core of Studer's invention deteriorates electrical performance by greatly reducing the magnetising inductance in relation to the leakage inductance, thereby requiring larger excitation currents and volume to perform a given power transfer, resulting in reduced efficiency.

The present invention improves over the prior art by providing a non-contacting structure that allows motion over six degrees of freedom, provides insignificant reaction forces with respect to the actual control forces applied to a stabilised structure attached thereto, requires no air gap in the core, and provides high efficiency over the required range of motion.

The present invention is defined in the appended claims and provides a power transformer having an enclosed magnetic core substantially without air gaps, a primary winding, and a secondary winding disposed within the core in a manner to permit relative motion between the first and second windings. The first winding is stationary, whilst the movable second winding is positioned radially with respect to the first winding with substantial directional freedom of motion over a limited range. This arrangement provides a substantially constant flux coupling between the two windings over the range of motion of the secondary.

In a preferred embodiment, support members are fixed to the secondary winding for supporting a movable structure, and the core is comprised of a cylindrical ferrite with an annular plate having apertures through which the supporting structure is coupled to the secondary winding.

In a further preferred embodiment, the invention is applied to a magnetically operative suspension for transferring power between stationary and movable structures.

An inductive coupler in accordance with the present invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:-

Figure 1A is a cross-sectional view of a conventional stationary transformer,

Figure 1B is a cross-sectional view of a rotary transformer with a rotatable core and secondary winding,

Figure 1C is a cross-sectional view of a rotary transformer with a stationary core and rotatable second winding,

Figure 1D is a cross-sectional view of the present invention showing a stationary core and movable secondary winding,

Figure 2 is a perspective view in cross-section of the core and coil structure of a preferred inductive coupler of the present invention,

Figure 3 is a plan view of the present invention,

Figure 4 is a cross-sectional view of the present invention taken along line 4-4 of Figure 3,

Figure 5 is a conceptual perspective view of a magnetic suspension system having an inductive coupler as in the present invention, taken in partial cross-section, and

Figure 6 is a cross-sectional view of a flux leakage pattern useful in understanding the present invention.

As above indicated, the inductive coupler of the present invention is particularly adapted for use with a magnetically suspended interface where power must be transferred to a suspended payload with a minimum of interaction with the suspension system. This is particularly critical where the suspension system is of the magnetic type. It is highly desirable to provide complete freedom of movement, albeit over a limited range, and to reduce any mechanical forces and electrical disturbances which may interact with the suspension system. Inductive coupling reduces friction losses because it eliminates sliprings and brushes or flexible wires and the like which increase the friction and reaction forces imposed upon the suspension system.

Furthermore, substantial power must be transferred with high efficiency, since it is intended for a space-environment application where heat dissipation is critical.

Referring now to Figure 1A, a conventional two-winding transformer is shown. A primary coil 10 and a secondary coil 12 are enclosed in a magnetically permeable core 14 such that a magnetic circuit is formed coupling the primary and secondary coils through the core. All parts are stationary with respect to each other and no air gap is required in the magnetic path of the core. Such a transformer may be constructed with a cubic volume or a cylindrical volume depending on whether the core is to be constructed of laminated material or a cast material such as a ferrite.

Figure 1B shows a conventional rotary transformer based on a cylindrical volume concept wherein one coil 16 and part of the magnetic core 18 rotate and one coil 20 and part of the core 22 are stationary. Air gaps 24 in the core allow rotary motion of the secondary with single-axis rotational freedom. The flux path 26 across the gaps causes significant disturbing forces when the rotor is moved from its centred location. This device is of the type described in US -A- No. 2,432,982.

A further improvement is illustrated in Figure 1C, representative of the disclosure of US -A 4,321,572 referred to above in which a magnetic core 28 surrounds stationary primary windings 30 and 31 affixed thereto with an air gap 32 in the core disposed to permit single-axis rotational movement of a second winding 34. Only the secondary coil 34 is movable and no core material is contained therein. The primary coils 30 and 31 and the iron core 28 remain stationary. The gap 32 is located internally in a channel extending traversely of an axial bore, thereby isolating the gap 32 from free space and reducing extraneous flux leakage. The coreless secondary 34 requires no relative motion or flux transfer between moving core paths and thus generates significantly lower forces on the moving body than the device of Figure 1B. However, the core gap 32 inhibits the electrical performance as described above and isolating the core gap 32 in the axial bore limits application with this transformer to a single axis of freedom.

In US -A- 4,117,436, the primary and secondary coils are axially aligned on a spindle to permit a limited range of single axis rotary motion. However, none of the structures shown in this reference permit the six degrees of freedom provided by the present invention.

Figure 1D is a cross-sectional view of the inductive coupler of the present invention. A magnetic core 36 is comprised of an annular cup-shaped housing 38 and a cover plate 40 with no air gap at the interface 42. A primary coil or winding 44 is stationary within the core 38. A secondary coil or winding 46 is positioned to allow free motion in all directions over a limited range. The secondary coil 46 supports structural members 48 and 50 affixed thereto with clearance holes 52 bored in the cover plate 40 in a manner which does not interrupt the magnetic circuit.

Since there is no magnetic material in the secondary coil 46, reluctance forces, which are those forces caused by magnetic flux crossing between iron sections separated by a gap, are eliminated. The reluctance force is the principal undesirable force contributor in the prior art and its elimination gives rise to a substantially better performance of the device.

The next significant undesirable force contributor is the interaction of the primary and secondary leakage fields in the coil space. When the secondary coil 46 is centred in the coil space, a symmetrically force balanced condition exists and no net force is exerted on the secondary coil. However, when the secondary coil 46 is translated either radially or axially, an undesirable force is exerted on the secondary coil with its magnitude proportional to the displacement. Since these undesirable forces are a function of the uniformity of the leakage fields, they can be further reduced by increasing the mechanical clearance around the secondary coil to be greater than the desired coil motion, as is explained below with reference to Figure 6.

The undesirable forces on the secondary coil 46 are due to the interaction of the primary and secondary flux leakage fields in the coil space. These undesirable forces can be further reduced by attention to the primary coil leakage field uniformity throughout the space to be occupied by the secondary coil 46. Figure 6 depicts the primary coil leakage flux in the transformer coil space in both direction and magnitude; also showing the envelope of the desired secondary coil motion. If the primary leakage field were perfectly uniform in magnitude and direction over the desired secondary coil motion, no forces would exist. However, it is seen from Figure 6 that the leakage field is strong at the primary coil and weak at the point farthest from the primary coil. One method to improve the leakage field uniformity in the range of motion of the secondary coil 46, and hence to reduce the forces, is to enlarge the mechanical clearances so as to be substantially greater than the desired motion of the secondary coil.

Figure 2 is a perspective view of a preferred embodiment of the invention with a section removed to depict the principal components and their relative positions within the apparatus. The configuration shown is exemplary and not to be construed as limiting. Thus, for example, the axial bore, the positioning of the supports, etc., plays no part in the efficacy of the present invention and may not be required with other mounting arrangements. Other coil dispositions, such as providing a fixed winding on the inner annular wall of a closed core 60, are also useful.

The closed core 60 comprises a magnetically permeable annular ring 62 having a cavity 64 and a cover plate 66. The core 60 is so constructed and arranged that no air gap is permitted at the interface with the cover plate 62. A first winding 68 which may comprise a primary winding for accepting electrical energy is fixedly disposed in the cavity 64 and in stationary contact with the core 62. Positioned within the cavity 64 and radially spaced from the primary winding 68 is a second electrical winding 70 which may comprise a secondary winding for delivering electrical power transferred by inductive coupling to a load, not shown. It may be seen that the core 60, the first winding 68, and the second winding 70 comprise a magnetic circuit and that the second winding is positioned for free movement with respect to the core and first winding, while maintaining substantially constant flux coupling independent of the positional relationship with respect to the first winding.

The closed core 60, which may be comprised of a ceramic based ferrite material, together with the primary coil 68, may be attached to a mounting base and power source, not shown. The secondary coil

70 maintains at least a predetermined clearance from the primary coil 68 and the walls of core 62 to minimise the reaction forces noted above, by assuring operation when the secondary 70 is confined with a region of substantially uniform flux linkages, and is attached by supports 72 to the payload or moving element. The secondary winding 70 is located within the annular cavity 64 bounded by the walls of magnetically permeable core 62 and the primary coil 68. The closed magnetic core 60 surrounds both the primary coil 68 and the secondary coil 70 with no air gap to provide a closed path magnetic circuit coupling the flux from the primary coil to the secondary coil. A cylindrical core with an axial through bore is shown, but this is exemplary, and other shapes, such as a solid cylindrical core or a rectangular core, may also be utilised.

A plurality of apertures 74 is provided for receiving the structural supports 72 with clearance to allow free motion of the secondary coil 70.

Referring now to Figure 3 as well as to Figure 4, in which like reference numerals indicate like components with respect to Figure 3, the magnetically permeable core 80 is made up of two or more components to allow the primary coil 82 and the secondary coil 84 to be assembled into the enclosed core. The core illustrated is comprised of a cup 86 having an essentially cylindrical body with an annular cavity 88 into which the primary coil 82 and the secondary coil 84 are placed. The primary coil 82 is affixed to the outer peripheral wall of the cup 86. An end plate 90 is placed in contact with the core 86 to provide an essentially gapless magnetic circuit. The core assembly 80 is comprised of a highly magnetic permeable material and must be machined to a close tolerance so that no air gap will be alowed in the magnetic circuit. The end plate 90 is provided with apertures 92 through which supports 94, which are fixed to the secondary coil 84, may extend. In order to assure no disturbance of the magnetic field, the supports 94 must be formed of a nonmagnetic material. The supports 94, in turn, will be coupled to a supporting structure, not shown, on which is mounted a payload for receiving the coupled power.

The primary coil 82 is comprised of a toroidal winding of magnetic wire 96 wound on an insulating bobbin 98. While the winding 96 of Figure 4 is a single toroidal coil, the winding may also be comprised of several individual coils connected in series and disposed within the cavity 88.

The secondary coil 84 is a further toroidal winding of magnetic wire 100 on a bobbin 102 which is also formed from an insulating material, such as phenolic plastic. Coil 84 is proportioned to provide a mechanical clearance 104 in the vertical direction and a clearance 106 in a horizontal direction to allow the desired freedom of motion in axial, radial, and angular directions. Preferably, the mechanical clearances will be substantially greater than the desired range of motion of the secondary coil 84 to minimise the effects of magnetic disturbance forces on the structure to which the coil 84 is coupled. Typically, the transformer will provide free movement of 0.05 to 0.50 inches (1.27 mm to 12.7 mm) over six degrees of freedom. It will be clear that while the supports 94 are shown extending through the end plate 90, apertures may alternatively be provided in the base of the core or the sidewalls with appropriate clearances for the primary coil 82.

In a preferred embodiment, wherein the exciting current was applied at an audio frequency of about 10 kHz, the inductive coupler comprised a transformer, wherein the primary coil was wound of seven turns of 525 parallel strands of number 33 AWG insulated copper wire, of the type known as Litz wire to reduce skin effect, and the secondary was wound of two turns of a total of 1750 strands of number 33 AWG Litz wire. The core was fabricated of manganese-zinc ferrite material using flat upper and lower plates and inner and outer rings to form the core. The coil bobbins were machined from cloth-reinforced phenolic plastic with a wall thickness of 0.075 to 0.125 inches (1.905mm to 3.175mm). The transformer leads were terminated at six inches (15 cm) from the transformer body with brass lugs to serve as electrical interfaces to the input and output circuits.

The coupler described above, designed for a 2500 watt power transformer, exhibited a power output substantially independent of the platform displacement with a power transfer efficiency of 99.3%. Secondary coil disturbance forces were about 0.0006 lb-ft (0.008135J) axial and less than 0.003 lb-ft (0.004063J) radial. Motion capability was provided of ± 0.20 inches (5.08mm) radial, ± 0.75° tilt, and ± 2° rotation.

Figure 5 shows a magnetically suspended movable platform 110 for a precision pointing mount, including an inductive coupler 112 of the present invention of which toroidal core 114 has an annular chamber with a primary winding 116 fixedly mounted therein and energised by a power source, not shown, coupled to a mount 115. A movable secondary winding 117 is enclosed within the core 114 and affixed to the platform 110 via non-magnetic supports 118. The secondary winding 117 is coupled to energise a payload (not shown), such as optical instruments or an antenna which is mounted on the platform 110, thereby avoiding the use of slip rings or flexible cables. Payload data signals are transmitted through the transformer axial bore via an optical coupler (not shown), housed within an axial enclosure 122 in the mount. The transformer through-hole allows integration with the optical coupler since it requires operation on the centre line of rotation. The enclosed core 114 allows the transformer to be positioned in close proximity to the magnetic bearing assemblies 124 and 126 without imposing undesirable distrubances therebetween due to the flux leakage.

The platform 110 is magnetically supported and oriented to provide six degrees of freedom by magnetic bearing assemblies 124 and 126 cooperating with armatures 128 and 130, respectively, which support the platform. Since the required range of movement is limited, the clearances between the secondary coil 117 and the core primary windings 116 are made sufficiently large that the force versus displacement characteristics, which are a function of the displacement, provide substantially reduced mechanical forces imposed on the movable platform as a result of energising the primary winding and withdrawing energy from the secondary winding.

Referring again to Figure 4, in operation the primary winding 82 is energised by an AC current supply to set up an alternately reversing flux as shown by the flux path 108. Since the flux path 108 is substantially contained within the core 80 and completely surrounds the secondary winding 84, an induced voltage is provided in the secondary winding 84 which is independent of its physical displacement with respect to the primary winding 82. Since all of the core material remains fixed during the motion of the secondary coil 84, there is no magnetic force interaction between permeable magnetic surfaces. Thus, there is provided an essentially forceless restraint of the movement of the secondary winding 84. The secondary coil 84 is free to move throughout the mechanical clearances 104, 106 without significant change in the efficiency of energy transformation. In contrast with the prior art apparatus which utilises a magnetic circuit which provided an airgap for free rotation of one of the magnetic elements, the present invention employs a magnetic circuit with no air gaps, which results in limited leakage flux and thus minimises electromagnetic disturbances. Furthermore, since the movable portion of the transformer contains no permeable materials it is substantially independent of disturbances forces.

Claims

1. An inductive coupler comprising an enclosed core (36; 62; 86; 112) of magnetically permeable material and substantially without air gaps and defines a cavity (64; 68), a first winding (44; 68; 82; 116) and a second winding (46; 70; 84; 117), the first and second winding being capable of relative motion, characterised in that the first electrical winding is disposed within the cavity in stationary contact with the magnetic core, in that the second electrical winding is disposed radially with respect to the first winding and positioned for movement within the core cavity, the first electrical winding, the second electrical winding and the core being disposed to provide predetermined spacial clearances (104, 106) for motion of the second winding with respect to the first winding and the core, and the first winding, the second winding, and the core being so constructed and arranged as to provide a zone of substantially constant flux density within said clearances, and in that the coupler further comprises means for limiting said motion to predetermined axial, radial, and angular displacements substantially less than said predetermined spacial clearances, and for confining the motion to the zone of substantially constant flux density, so that electrical energisation of the first winding permits transfer of energy to the second winding over the displacement while minimising reaction forces between the first and second windings.

2. An inductive coupler according to claim 1, characterised in that the second winding (46; 70; 84) further comprises at least one non-magnetically permeable support member (48; 52; 72; 94) affixed thereto and the magnetic core (36; 62: 86) includes at least one corresponding aperture (52; 74; 92) for receiving the support member to permit limited displacement between the first (44; 68; 82) and second (46; 70; 84) windings.

3. An inductive coupler according to claim 1 or 2, characterised in that the magnetic core (36; 62; 86; 112) is comprised of a body having a generally circular cross section.

4. An inductive coupler according to claim 2, characterised in that the magnetic core (62; 86) is comprised of ferrite material and the cavity (64; 88) defines an annular cup for receiving the first and second windings (68; 82; 70; 84), the core including a mating cover plate (60; 90), substantially free of an air gap at the interface, and the or each aperture (74; 92) is disposed in the cover plate and aligned with the associated support member (72; 94).

5. An inductive coupler according to any of the preceding claims, characterised in that the first winding (44; 68; 82; 116) is adapted for connection to a source of electrical energy, and the second winding (46; 70; 84; 117) is adapted to provide at least a portion of the energy to a load.

6. An inductive coupler according to any of the preceding claims, characterised in that the first and second windings (44; 68; 82; 116: 46; 70; 84; 117) are comprised of a conductor having a plurality of conductive strands (96, 100) of predetermined diameters so symmetrically disposed that each strand assumes, substantially to the same extent, a plurality of different possible positions in the cross-section of the conductor, for providing a substantially uniform distribution of current over the cross-section when operative at audio frequencies.

7. An inductive coupler according to any of the preceding claims, characterised in that first and second windings (82: 84) are respectively wound on non-conductive, non-metallic, non-magnetic bobbins (98: 102), and the second winding is concentrically disposed within the first winding.

8. An inductive coupler according to claim 2 and any of the preceding claims appended thereto, characterised in that the magnetic core (36; 62; 86; 112) is affixed to a support base, and the support members (48; 52; 72; 94) of the second winding (46; 70; 84; 117) are coupled to structure for supporting a movable member.

9. An inductive coupler according to claim 8, characterised in that the supporting structure comprises a magnetically operative suspension having a plurality of stops for limiting motion of the suspension.

10. An inductive coupler according to claim 2, and any of the preceding claims appended thereto, characterised in that the linear movement is limited to a predetermined linear displacement.

11. An inductive coupler according to claim 10, characterised in that the second winding (46; 70; 84; 117) is provided with a predetermined clearance with respect to the first winding (44; 68; 82; 116) which exceeds the predetermined linear displacement, and in that the displacement is situated within a region of substantially uniform flux linkages.

12. An inductive coupler according to claim 2, and any of the preceding claims appended thereto, char-

acterised in that the angular movement is limited to a predetermined angular displacement.

13. An inductive coupler according to claim 2, and any of the preceding claims appended thereto, characterised in that the second winding (46; 70; 84; 117) is provided with a further predetermined clearance with respect to the first winding (44; 68; 82; 116) which exceeds the predetermined angular displacement, and in that the angular displacement is situated within a region of substantially uniform flux linkages.

Patentansprüche

1. Induktiver Koppler mit einem umschlossenen Kern (36; 62; 86; 112) aus magnetisch permeablem Material und im wesentlichen ohne Luftspalte, der einen Hohlraum (64; 68) umgrenzt, mit einer ersten Wicklung (44; 68; 82; 116) und einer zweiten Wicklung (46; 70; 84; 117), wobei die ersten und zweiten Wicklungen eine Relativbewegung zueinander ausführen können, dadurch gekennzeichnet, daß die erste elektrische Wicklung innerhalb des Hohlraumes in stationärem Kontakt mit dem magnetischen Kern steht, daß die zweite elektrische Wicklung in Radialrichtung bezüglich der ersten Wicklung vorgesehen und für eine Bewegung innerhalb des Kernhohlraumes angeordnet ist, daß die erste elektrische Wicklung, die zweite elektrische Wicklung und der Kern so angeordnet sind, daß sich ein vorgegebenes Abstandsspiel (104, 106) für eine Bewegung der zweiten Wicklung bezüglich der ersten Wicklung und des Kerns ergeben, daß die erste Wicklung, die zweite Wicklung und der Kern so aufgebaut und angeordnet sind, daß ein Bereich von im wesentlichen konstanter Flußdichte innerhalb der Abstände geschaffen wird, und daß der Koppler weiterhin Einrichtungen zur Begrenzung der Bewegung auf vorgegebene axiale, radiale und Winkelbewegungen, die wesentlich kleiner als die vorgegebenen räumlichen Abstände sind, und zur Beschränkung der Bewegung auf den Bereich von im wesentlichen konstanter Flußdichte aufweist, so daß die elektrische Ansteuerung der ersten Wicklung die Überführung der Energie auf die zweite Wicklung über die Bewegung ermöglicht, während gleichzeitig Reaktionskräfte zwischen den ersten und zweiten Wicklungen zu einem Minimum gemacht werden.

2. Induktiver Koppler nach Anspruch 1, dadurch gekennzeichnet, daß die zweite Wicklung (46; 70; 84) zumindestens ein daran befestigtes nicht magnetisch permeables Tragteil (48; 52; 72; 94) umfaßt, und daß der magnetische Kern (36; 62; 86) zumindestens eine entsprechende Öffnung (52; 74; 92) zur Aufnahme des Tragteils derart einschließt, daß eine begrenzte Bewegung zwischen den ersten (44; 68; 82) und den zweiten (46; 70; 84) Wicklungen ermöglicht wird.

3. Induktiver Koppler nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der magnetische Kern (36; 62; 86; 112) aus einem Körper mit einem allgemein kreisförmigen Querschnitt besteht.

4. Induktiver Koppler nach Anspruch 2, dadurch gekennzeichnet, daß der magnetische Kern (62; 86) aus Ferritmaterial besteht, daß der Hohlraum (64; 88) eine kreisringförmige Schale zur Aufnahme der ersten und zweiten Wicklungen (68; 82; 70; 84) umgrenzt, daß der Kern eine passende Abdeckplatte (60; 90) einschließt, die im wesentlichen an der Grenzfläche frei von Luftspalten ist, und daß die oder jede Öffnung (74; 92) in der Deckplatte angeordnet und mit dem zugehörigen Tragteil (72; 94) ausgerichtet ist.

5. Induktiver Koppler nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die erste Wicklung (44; 68; 82; 116) für eine Verbindung mit einer elektrischen Energiequelle ausgebildet ist, und daß die zweite Wicklung (46; 70; 84; 117) zur Lieferung zumindestens eines Teils der Energie an eine Last ausgebildet ist.

6. Induktiver Koppler nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die ersten und zweiten Wicklungen (44; 68; 82; 116/46; 70; 84; 117) aus einem Leiter mit einer Mehrzahl von leitenden Strängen (96, 100) mit vorgegebenen Durchmessern gebildet sind, die derart symmetrisch angeordnet sind, daß jeder Strang im wesentlichen im gleichen Ausmaß eine Mehrzahl von unterschiedlichen möglichen Positionen im Querschnitt des Leiters einnimmt, um eine im wesentlichen gleichförmige Verteilung des Stromes über den Querschnitt zu erzielen, wenn der Koppler bei Niederfrequenzen betrieben wird.

7. Induktiver Koppler nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die ersten und zweiten Wicklungen (82; 84) jeweils auf einem nicht leitenden, nicht metallischen, nicht magnetischen Spulenkörper (98; 102) gewickelt sind und daß die zweite Wicklung konzentrisch innerhalb der ersten Wicklung angeordnet ist.

8. Induktiver Koppler nach Anspruch 2 und einem der hierauf zurückbezogenen vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der magnetische Kern (36; 62; 86; 112) an einem Halterungs-Basisteil befestigt ist und daß die Tragteile (48; 52; 72; 94) der zweiten Wicklung (46; 70; 84; 117) mit einer Struktur zur Halterung des beweglichen Teils gekoppelt sind.

9. Induktiver Koppler nach Anspruch 8, dadurch gekennzeichnet, daß die Tragstruktur eine magnetisch wirksame Lagerung mit einer Vielzahl von Anschlägen zur Begrenzung der Bewegung der Lagerung umfaßt.

10. Induktiver Koppler nach Anspruch 2 und einem der darauf zurückbezogenen vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Linearbewegung auf eine vorgegebene Linearverschiebung begrenzt ist.

11. Induktiver Koppler nach Anspruch 10, dadurch gekennzeichnet, daß die zweite Wicklung (46; 70; 84; 117) mit einem vorgegebenen Abstand bezüglich der ersten Wicklung (44; 68; 82; 116) angeordnet ist, die die vorgegebene Linearbewegung übersteigt, und daß die Verschiebung innerhalb eines Bereiches von im wesentlichen gleichförmigen Flußverkettungen liegt.

12. Induktiver Koppler nach Anspruch 2 und einem der darauf zurückbezogenen vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Win-

kelbewegung auf eine vorgegebene Winkelverstellung begrenzt ist.

13. Induktiver Koppler nach Anspruch 2 und einem der darauf zurückbezogenen vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die zweite Wicklung (46; 70; 84; 117) mit einem weiteren vorgegebenen Abstand bezüglich der ersten Wicklung (44; 68; 82; 116) angeordnet ist, die den vorgegebenen Winkelverstellbereich überschreitet, und daß die Winkelverstellung innerhalb eines Bereiches von im wesentlichen gleichförmigen Flußverkettungen liegt.

Revendications

1. Coupleur inductif comprenant un noyau fermé (36; 62; 86; 112) d'un matériau magnétiquement perméable et pratiquement sans entrefer, délimitant une cavité (64; 68), un premier enroulement (44; 68; 82; 116) et un second enroulement (46; 70; 84; 117), le premier et le second enroulement pouvant présenter un déplacement relatif, caractérisé en ce que le premier enroulement électrique est disposé dans la cavité en contact fixe avec le noyau magnétique, en ce que le second enroulement électrique est disposé radialement par rapport au premier enroulement et est disposé afin qu'il se déplace dans la cavité du noyau, le premier enroulement électrique, le second enroulement électrique et le noyau étant disposés afin qu'ils délimitent des espaces prédéterminés (104, 106) permettant le déplacement du second enroulement par rapport au premier et au noyau, et le premier enroulement, le second enroulement et le noyau ont une construction et une disposition telles qu'ils forment une zone à densité de flux sensiblement constante dans lesdits espaces, et en ce que le coupleur comporte en outre un dispositif destiné à limiter le mouvement à des déplacements axiaux, radiaux, et angulaires prédéterminés nettement inférieurs aux espaces prédéterminés, et à limiter le mouvement à la zone ayant une densité de flux pratiquement constante, si bien que l'excitation électrique du premier enroulement permet le transfert d'énergie au second enroulement pendant le déplacement, alors que les forces de réaction appliquées entre le premier et le second enroulement sont minimales.

2. Coupleur inductif selon la revendication 1, caractérisé en ce que le second enroulement (46; 70; 84) comporte en outre au moins un organe de support (48; 52; 72; 94) qui n'est pas magnétiquement perméable et qui lui est fixé, et le noyau magnétique (36; 52; 86) comporte au moins une ouverture correspondante (52; 74; 92) destinée à loger l'organe de support et à permettre ainsi un déplacement limité entre le premier enroulement (44; 68; 82) et le second (46; 70; 84).

3. Coupleur inductif selon la revendication 1 ou 2, caractérisé en ce que le noyau magnétique (36; 62; 86; 112) est constitué d'un corps ayant une section générale circulaire.

4. Coupleur inductif selon la revendication 2, caractérisé en ce que le noyau magnétique (62; 86) est formé d'un matériau à base de ferrite, et la cavité (64; 88) délimite une cuvette annulaire destinée à loger le premier et le second enroulement (68; 82: 70; 84), le noyau comprenant une plaque complémentaire formant couvercle (60; 90) ne présentant pratiquement pas d'entrefer à l'interface, et l'ouverture ou chaque ouverture (74; 92) est disposée dans la plaque formant couvercle et est alignée sur l'organe associé de support (72; 94).

5. Coupleur inductif selon l'une quelconque des revendications précédentes, caractérisé en ce que le premier enroulement (44; 68; 82; 116) est destiné à être connecté à une source d'énergie électrique, et le second enroulement (46; 70; 84; 117) est destiné à transmettre au moins une partie de l'énergie à une charge.

6. Coupleur inductif selon l'une quelconque des revendications précédentes, caractérisé en ce que le premier et le second enroulement (44; 68; 82; 116: 46; 70; 84; 117) sont formés d'un conducteur ayant plusieurs brins conducteurs (93, 100) de diamètre prédéterminé, disposés symétriquement de manière que chaque brin prenne, pratiquement au même degré, plusieurs positions différentes possibles dans la section du conducteur afin que la répartition du courant soit sensiblement uniforme dans toute la section lors du travail à des audiofréquences.

7. Coupleur inductif selon l'une quelconque des revendications précédentes, caractérisé en ce que le premier et le second enroulement (82: 84) sont enroulés respectivement sur des bobines non conductrices, non métalliques, et non magnétiques (98: 102), et le second enroulement est disposé concentriquement dans le premier enroulement.

8. Coupleur inductif selon la revendication 2 et l'une quelconque des revendications précédentes qui en dépendent, caractérisé en ce que le noyau magnétique (36; 62; 86; 112) est fixé à une base de support, et les organes de support (48; 52; 72; 94) du second enroulement (46; 70; 84; 117) sont couplés à la structure de support d'un organe mobile.

9. Coupleur inductif selon la revendication 8, caractérisé en ce que la structure de support comporte une suspension fonctionnant magnétiquement et ayant plusieurs butées destinées à limiter son déplacement.

10. Coupleur inductif selon la revendication 2 et l'une quelconque des revendications précédentes qui en dépendent, caractérisé en ce que le mouvement linéaire est limité à un déplacement linéaire prédéterminé.

11. Coupleur inductif selon la revendication 10, caractérisé en ce que le second enroulement (46; 70; 84; 117) présente un espace prédéterminé par rapport au premier enroulement (44; 68; 82; 116), dépassant le déplacement linéaire prédéterminé, et en ce que le déplacement se trouve dans une région à flux de fuite sensiblement uniforme.

12. Coupleur inductif selon la revendication 2 et l'une quelconque des revendications précédentes qui en dépendent, caractérisé en ce que le mouvement angulaire est limité à un déplacement angulaire prédéterminé.

13. Coupleur inductif selon la revendication 2 et l'une quelconque des revendications précédentes, qui en dépendent, caractérisé en ce que le second enroulement (46; 70; 84; 117) a un espace prédéter-

miné supplémentaire par rapport au premier enroulement (44; 68; 82; 116) qui est supérieur au déplacement angulaire prédéterminé, et en ce que le déplacement angulaire se trouve dans une région de flux de fuite sensiblement uniformes.

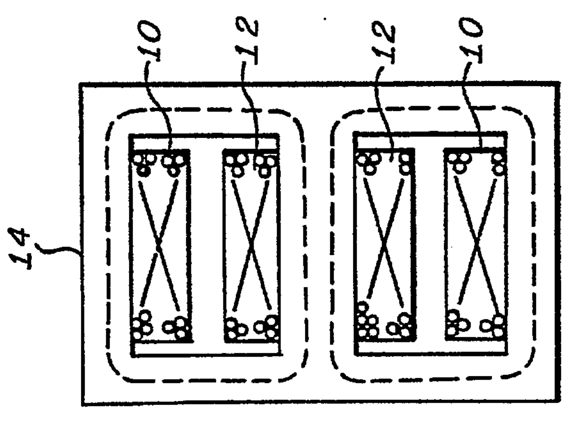

FIG.1a.

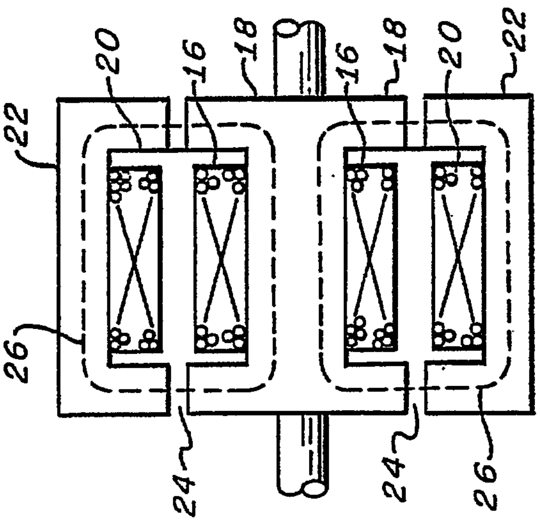

FIG.1b.

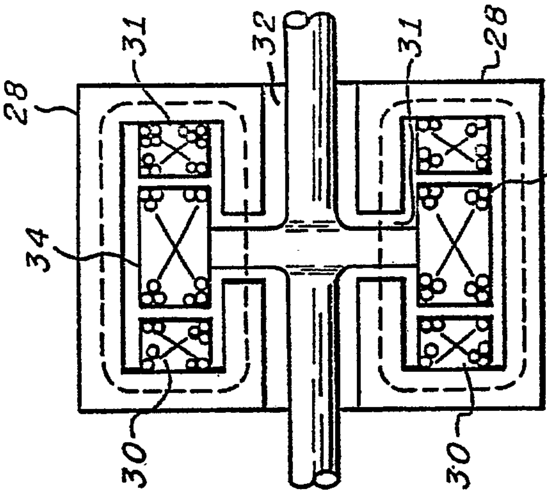

FIG.1c.

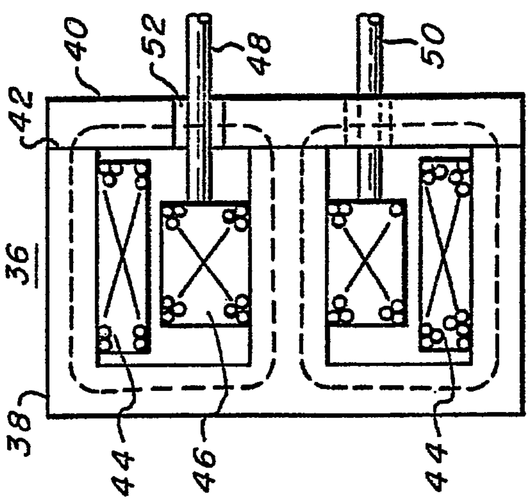

FIG.1d.

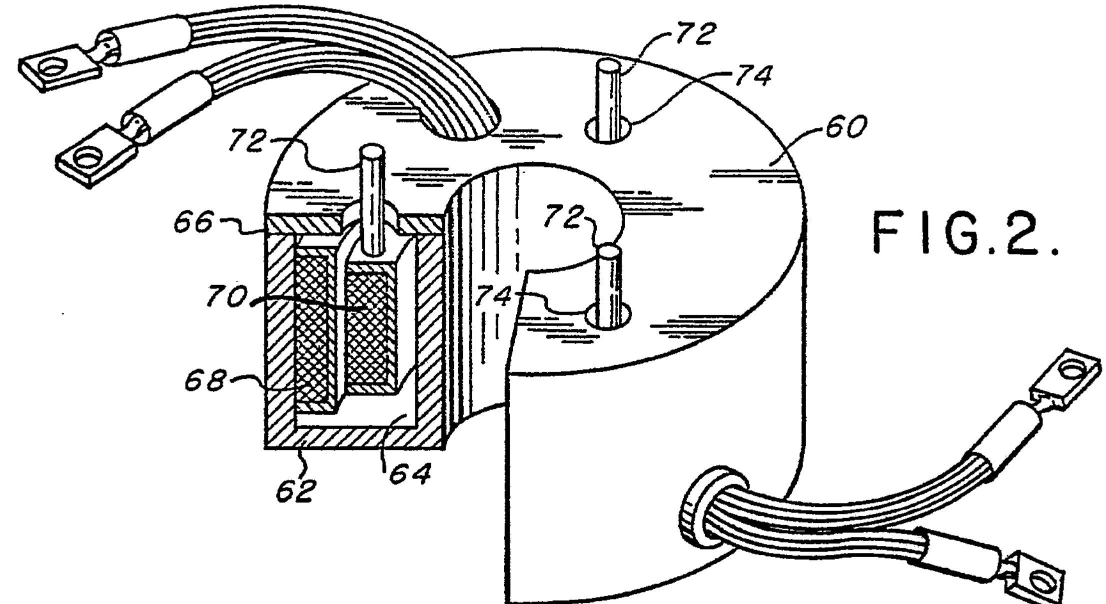

FIG.2.

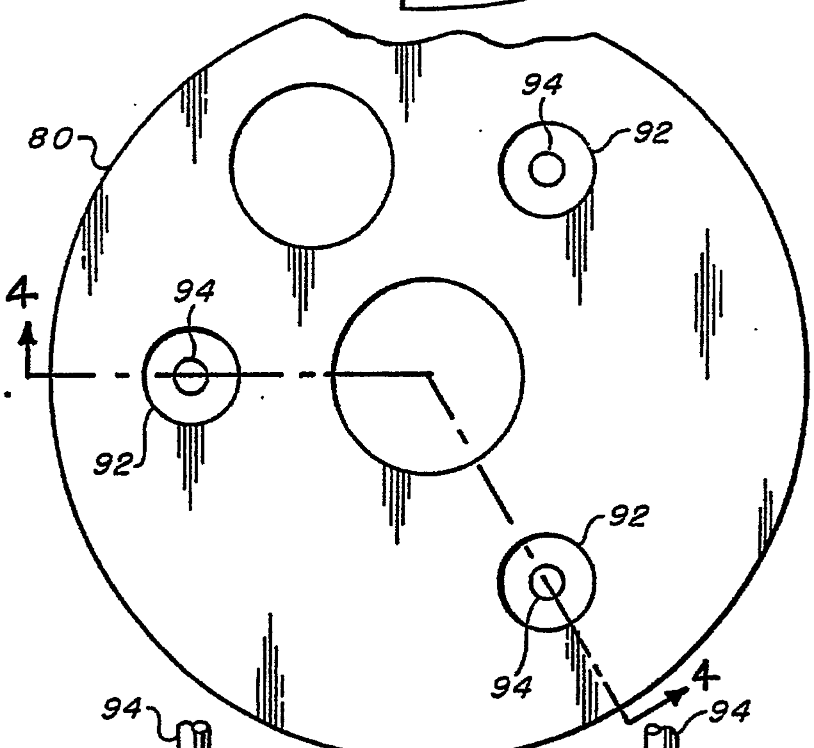

FIG.3.

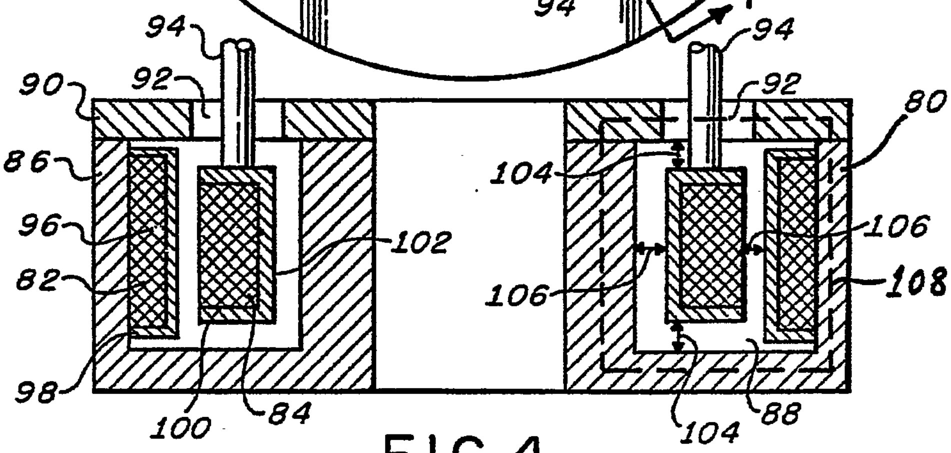

FIG.4.

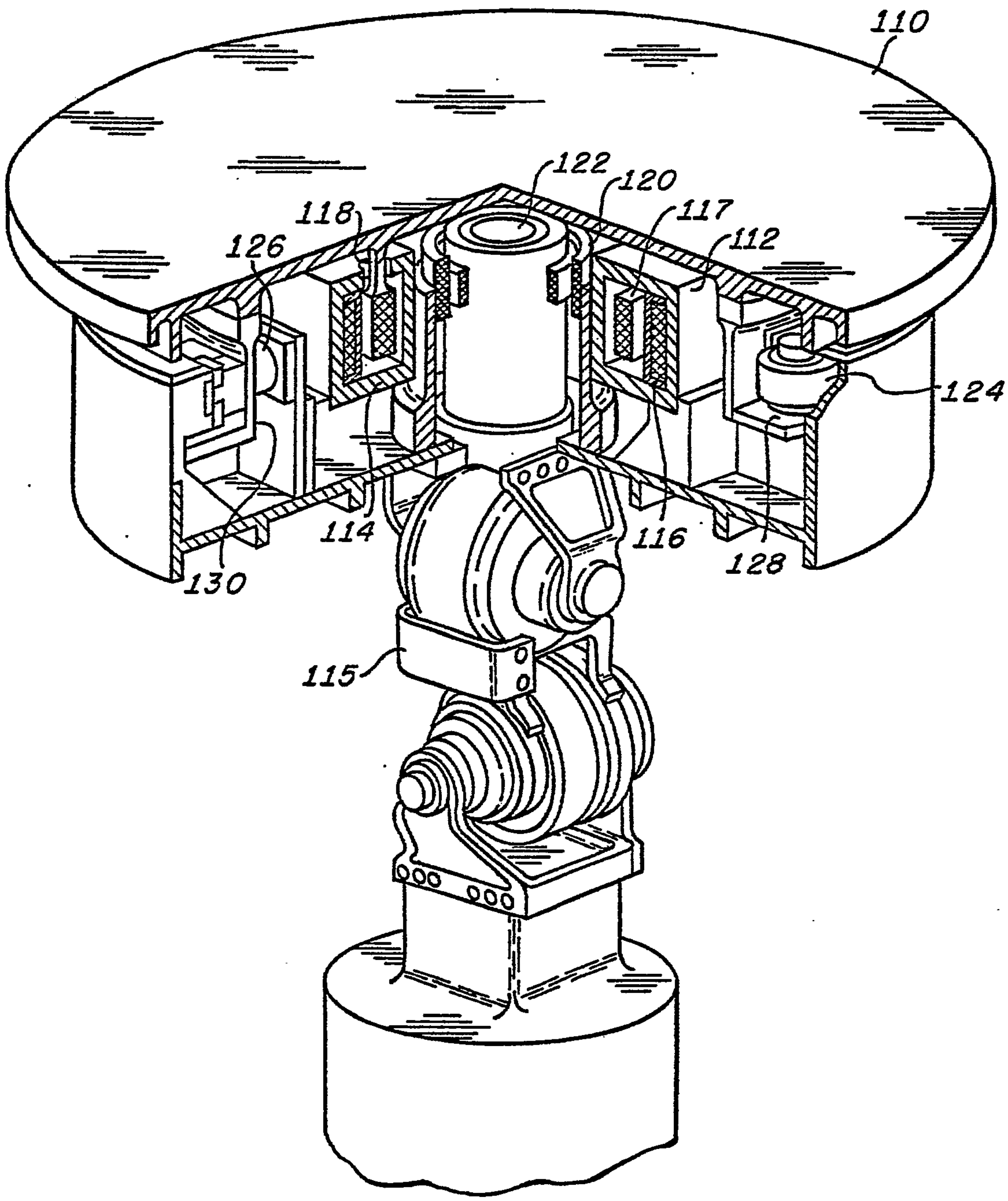

FIG.5.

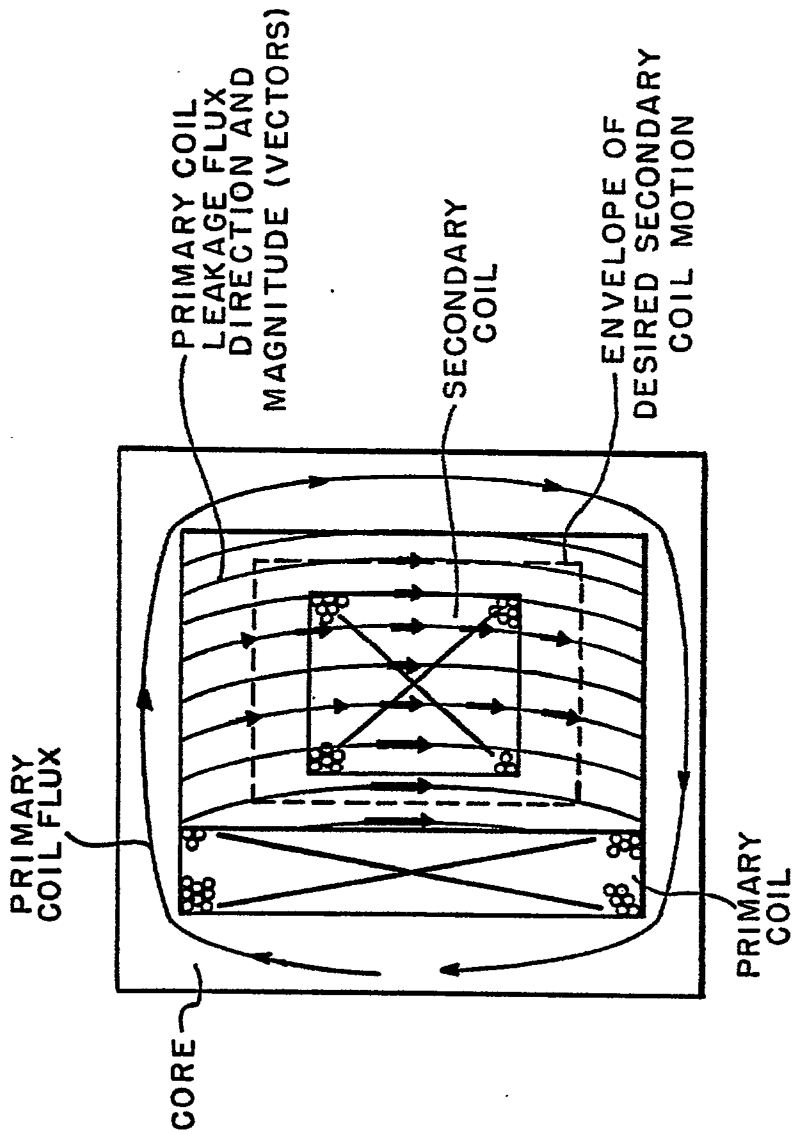
PRIMARY COIL LEAKAGE FLUX DIRECTION AND MAGNITUDE (VECTORS)
SECONDARY COIL
ENVELOPE OF DESIRED SECONDARY COIL MOTION
PRIMARY COIL FLUX
CORE
PRIMARY COIL

FIG.6.