United States Patent [19]

Koenig

[11] **Patent Number:** 4,584,438

[45] **Date of Patent:** Apr. 22, 1986

[54] **PERCUSSION AIR MOTOR**

[76] Inventor: Erl Koenig, Methodist Farm Rd., P.O. Box 559, Averill Park, N.Y. 12018

[21] Appl. No.: 524,195

[22] Filed: Aug. 18, 1983

Related U.S. Application Data

[63] Continuation of Ser. No. 165,962, Jul. 7, 1980, abandoned.

[51] Int. Cl.⁴ H04R 9/02; H04R 9/04

[52] U.S. Cl. .... 179/115.5 DV

[58] Field of Search .... 179/115.5 DV

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Primary Examiner—George G. Stellar

Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

An electromechanical transducer converts an electrical signal into distortion free sound. Two equal coils are mounted on a sleeve within separate magnetic circuits. The coils are wound in identical mirror image symmetry and the magnetic circuits are disposed symmetrically of the sleeve. The application of an electric signal at the terminals of the coils causes the sleeve and diaphragm to reciprocate linearly under balanced forces within the air gap defined by the magnetic circuits.

13 Claims, 4 Drawing Figures

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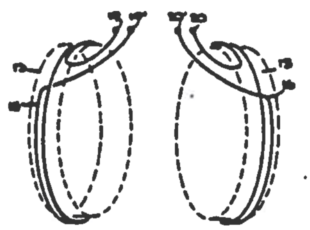
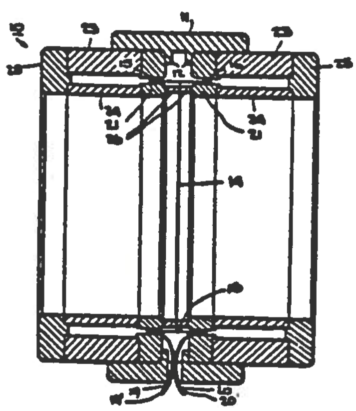




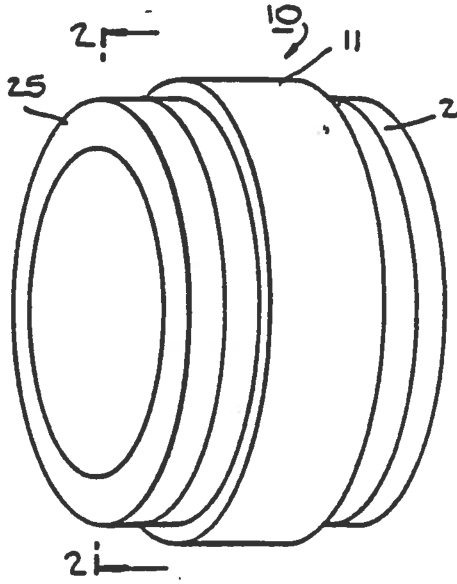
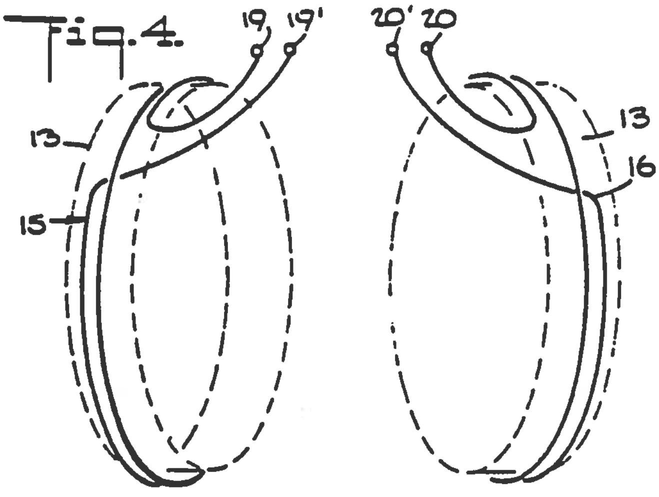


Fig.1.

Fig.4.



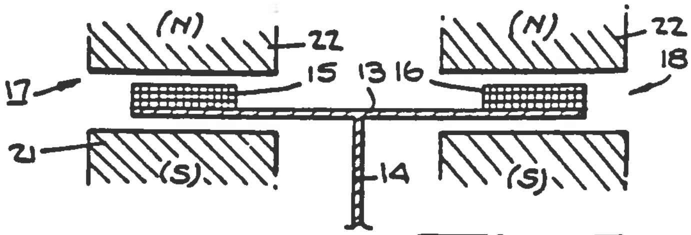


Fig.3.

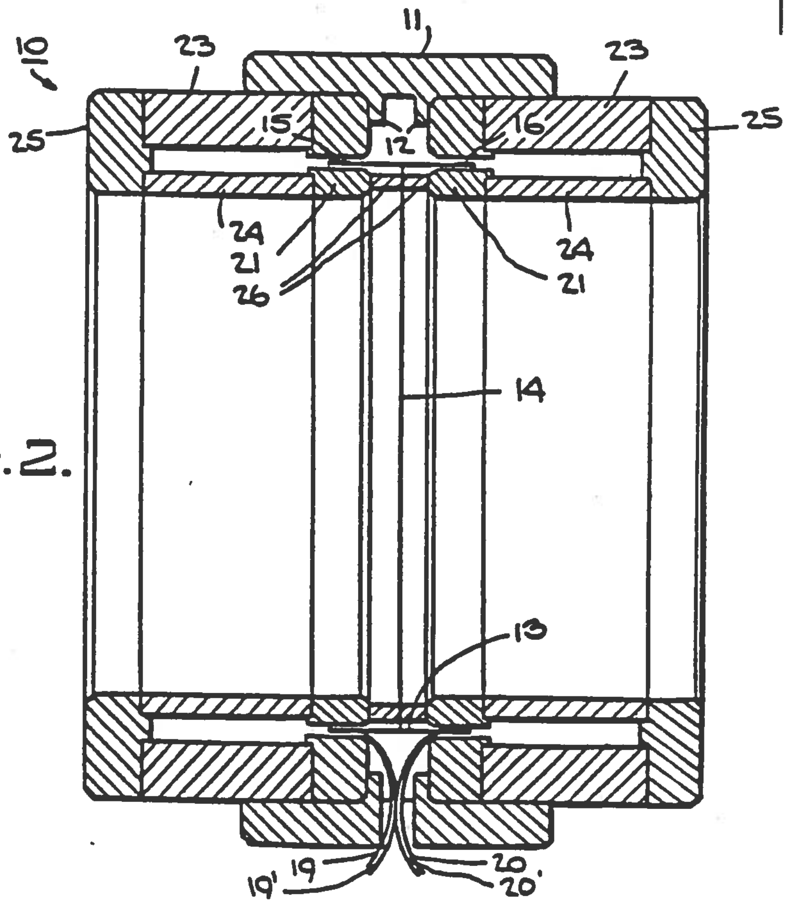


Fig.2.

PERCUSSION AIR MOTOR

This is a continuation of application Ser. No. 165,962 filed July 7, 1980 now abandoned.

This invention relates to a percussion air motor. More particularly, this invention relates to a percussion air motor, such as a loudspeaker, for converting electrical signals into corresponding percussive air movements.

It is well known that transducer systems, especially of the type which convert electrical energy into mechanical energy, are inefficient in operation. Generally, only a small fraction of the total electrical energy supplied to such transducer systems is actually converted and made available as mechanical energy.

It is also well known that when the electrical energy supplied to a transducer system is in the form of a desired signal, the resulting signal in the converted energy form, will not accurately correspond to the input signal. The difference in signal content between the input and output signals is a form of distortion which is a function of the construction of the transducer system. Further, as transducers are usually operated as components in larger systems, an inefficiency in converting from one form of energy to the other will increase the distortion of the larger system. For example, an inefficient audio speaker which converts electrical energy from an amplifier into mechanical energy for creating percussive air movements, i.e., sound pressure waves, requires such large amounts of electrical energy to be delivered from an amplifier in order to achieve acceptable sound pressure levels that the distortion introduced into the overall system by the amplifier will increase.

As is known, transducers which are used as loudspeakers generally have a driving assembly for receiving an electrical signal and a diaphragm which is connected to the driving assembly to vibrate in accordance with the received signal. The driving assembly, e.g. a voice coil, usually has a coil of wire and a magnet core mounted within the coil to move in response to the magnetic field caused by the coil upon energization. In these cases, the coil is secured to the diaphragm, e.g. at a central point, while the diaphragm is hinged or the like at the outer periphery. In other cases, it has been known to have the diaphragm driven by peripheral forces. One such system is described in U.S. Pat. No. 3,979,566.

However, in this system, the diaphragm is driven in an unbalanced manner such that distortion may well result. Other similar systems are described in U.S. Pat. Nos. 3,012,107; 2,535,757 and 2,520,646. It must be noted that any improvement in the mechanical advantage of a transducer system will affect only the particular form of the available mechanical energy. In other words, in a transducer system which produces reciprocating axial mechanical motion in response to an electrical input, a variation in the mechanical advantage will cause short and forceful strokes to be exchanged for longer, but weaker ones, or vice versa. The actual work available, defined by the product of the mechanical force and the distance over which the force operates, will remain the same, signifying that a fundamental improvement in the conversion efficiency has not been achieved.

In many cases, the construction of loudspeakers have generally focused upon the diaphragm, being the element which directly couples to the air medium, as the mass of primary interest. Although the development of an effective low mass diaphragm is a worthwile design goal, advances in materials sciences and manufacturing methods have enabled the production of diaphragms which are low in weight with respect to the driving assembly. Since it is known that efficiency is related to the ratio of voice coil weight to diaphragm weight, as diaphragm weight is reduced, so must the weight of the driving coil, if efficient operation is to be retained. This is especially significant in peripherally driven transducer systems wherein the driving coils are situated at the periphery of the diaphragm, thereby having decreased the mechanical advantage with respect to the coupling of low frequency signals which are center-loaded in the diaphragm.

It becomes apparent from this analysis, that although the mechanical advantage of an electromagnetic transducer system operating at high frequencies is improved by peripheral drive, the same advantage does not hold true for low frequencies which produce maximum air pressure at a region near the center of the diaphragm, which region is furthest from the peripheral drive means. Thus, the operating efficiency of electromagnetic acoustic transducer systems at high audio frequencies which radiate along the surface of the transducer diaphragm, can be improved by producing a low mass peripheral drive system. Moreover, such reduced driving means mass will also improve the efficiency of the transducer system at low frequencies because instantaneous low frequency sound pressure waves are produced essentially by causing the diaphragm to push the air axially with the entire width of the diaphragm face. Since the pressure is maximized at the center of the diaphragm, the drive coils appear to be at one end of a radial moment arm, while the air load is at the other end.

Accordingly, it is an object of this invention to provide an electromechanical transducer system with improved energy conversion efficiency.

It is another object of this invention to provide an electromechanical transducer system which retains a high correspondence between the signal content of the respective input and output signals.

It is a further object of this invention to provide a transducer system which is economical to manufacture and simple to assemble.

It is another object of the invention to eliminate distortion in a transducer.

It is another object of this invention to provide equal but separate electro-magnetic circuits for each direction of alternating current flow.

Briefly, the invention provides a transducer, such as a loudspeaker, which is formed, in part, of a sleeve, a diaphragm secured to and within the sleeve in a central plane and electromagnetic means disposed in symmetric relation to said sleeve for reciprocating the sleeve and diaphragm in a linear manner to produce a balanced distortion free sound.

The means for reciprocating the sleeve and diaphragm includes a pair of coils wound about the sleeve in symmetrical relation about the central plane and means defining a pair of stationary magnetic circuits disposed in symmetrical relation about the central plane. The coils are equally wound to effect equal and co-directional electromagnetic forces therein in response to an alternating current supplied to the coils while each magnetic circuit is disposed about a respective one of the coils.

The arrangement of the coils and magnetic circuits relative to the sleeve and diaphragm improves low and high frequency operation of acoustic transducers by providing a peripheral drive system which contains less mass and is more efficient in converting electrical to mechanical energy than prior art systems.

By winding the coils in symmetric relation, and particularly, as mirror images of each other, an isomagnetic equilibrium is obtained at the plane of the diaphragm. The magnetic circuits are each of the type which produces magnetic lines of flux radially across an air gap in which is disposed a portion of the sleeve which contains the respectively associated coil. Energization of the coils by application of an electrical signal at the coil ends or terminals results in corresponding mechanical motion of the sleeve in a direction parallel to the central axis of the magnetic circuits.

In this construction, the transducer, i.e., loudspeaker, is able to produce sound which is distortion free as the electromotive forces imposed on the sleeve are applied symmetrically, i.e., in a balanced manner. Thus, the diaphragm is able to reciprocate, i.e., vibrate, in a balanced manner to produce a true sound wave corresponding to the electrical signal received.

Further, in this construction, the combined mass of the mirror image coil is less than the mass of a single coil required in previously known transducer systems for producing the same energy conversion efficiency. Thus, conversion efficiency is improved over prior art single coil systems having equivalent mass.

Still further, the reduced effective equivalent mass of the peripheral drive system elevates the mehanical resonant frequency of the sleeve thereby improving the ability of the sleeve to cause high frequency signals to radiate across the surface of the diaphragm. Additionally, reduced sleeve mass, with respect to a given conversion efficiency, reduces the effective moment arm at low frequencies thereby further improving the mechanical advantage and efficiency of low frequency operations.

These and other objects and advantages of the invention will become more apparent from the following detailed description and accompanying drawings in which:

FIG. 1 is a perspective view of the transducer constructed in accordance with the invention;

FIG. 2 is a cross-sectional view of the transducer of FIG. 1;

FIG. 3 is an enlarged view of the sleeve, coils and associated parts of the magnetic circuits of the transducer of FIG. 1; and

FIG. 4 is an illustrative arrangement for winding the coils on the sleeve in accordance with the invention.

Referring to FIG. 1, the transducer 10 has a generally cylindrical configurtion with open ends.

As shown in FIG. 2, the transducer 10 includes a central mounting frame 11 by which the transducer 10 can be mounted in a suitable housing or on a suitable support. The frame 11 is of annular shape and has a pair of inwardly directed spaced apart flanges 12. In addition, a thin-walled flangeless sleeve 13 is housed within the frame 11 and a flat disc-shaped diaphragm 14 is secured to and within the sleeve 13 in a central plane of the sleeve 13. The sleeve 13 is made of any suitable material, such as brass, while the diaphragm 14 is likewise made of a suitable material, such as metal, i.g. brass.

As shown in FIGS. 2 and 3, an electromagnetic means is provided in the transducer 10 for reciprocating the sleeve 13 and diaphragm 14 in a linear manner in a direction transverse to the central plane of the sleeve 13 to produce a balanced sound. This means includes a pair of coils 15, 16 equally wound about and on the sleeve 13 in symmetrical relation to the diaphragm 14 and a pair of stationary magnetic circuits 17, 18 disposed in symmetrical relation about the diaphragm 14. The coils 15, 16 are equally wound on the sleeve 13 in fixed relation to effect equal and codirectional electromotive forces therein in response to an alternating current supplied to the coils 15, 16. As shown in FIG. 4, the equally wound coils 15, 16 are wound to achieve a mirror image symmetry with respect to one another. Only two windings are shown in each coil for purposes of clarifying the winding directions. Each coil 15, 16 has a pair of ends or leads 19, 19', 20, 20' which extend away from the sleeve 13 to a suitable common tap (not shown) in the frame 11. In addition, the current entering lead 19', 20' of each coil is located under the wound coil. The coils 15, 16 are energized in parallel by applying an electrical signal from a suitable common source (not shown) to the terminals 19, 19', 20, 20' at the tap (not shown). The symmetrical arrangement shown provides an equal distribution of incoming electrical current throughout each coil 15, 16.

In this embodiment, the current leads for the two coils are illustrated as being next to one another. Variations in the placement of leads 19, 19' with respect to leads 20, 20' will establish manufacturing methods and signal transformation requirements.

Referring to FIG. 2, the magnetic circuits 17, 18 are mounted in the frame 11 in spaced apart relation and are abutted against the flange 12. Each circuit 17, 18 includes a pair of concentric spaced apart pole rings 21, 22 disposed about a respective coil 15, 16. One pole ring 21 acts, e.g. as a South pole, while the other pole ring 22 acts as a North pole. In addition, each circuit 17, 18 has an annular magnet 23 secured to the outer pole ring 22, a transfer ring 24 secured to the inner pole ring 21 and an annular transfer plate 25 secured to the magnet 23 and transfer ring 24. As indicated, the transfer plate 25 forms a circular opening in communication with the diaphragm 14.

The pole rings 21, 22 define air gaps in which the sleeve 13 and respective coils 15, 16 are located and across which magnetic lines of flux flow. The magnetic flux thus flows via the magnet 23, transfer plate 25 and transfer ring 24 between the pole rings 21, 22. In this construction, the magnets 23, pole rings 21, 22 and flux transfer plates 25 are made of low loss magnetic material. The transfer rings 24 are made of cast iron.

A pair of resilient pads 26, for example of compressible fiber, are mounted between the pole rings 21 to center the diaphragm 14. These pads 26 are sufficiently resilient to avoid imparting a damping effect on the reciprocating motion of the diaphragm 14 during operation.

In operation, an electrical signal in the form of an alternating current is supplied to the terminals 19, 19', 20, 20' of the two coils 15, 16. The signal is then divided into two balanced currents which are passed through the two coils 15, 16. Magnetic flux lines are then developed in each coil 15, 16 and interact with the stationary lines of flux generated across the pole rings 21, 22. As a result, an electromotive force is created to move each coil 15, 16 and, thus, the sleeve 13. As these forces are co-directional, i.e. directed in the same direction, for example to the right as viewed in FIG. 2, the sleeve 13 and diaphragm 14 move to the right. As the current alternates, so does the direction of electromotive forces. Thus, the sleeve 13 and diaphragm 14 move to the left as viewed in FIG. 2. A linear reciprocating motion is thus effected in the diaphragm 14.

It is noted that the stationary magnetic field width and flux density is dependent on the size and width of each respective wound coil 15, 16.

In one embodiment, the inner pole ring 21 has an outside diameter of 3.593 inches while the outer pole ring 22 has an inner diameter of 3.625 inches to form an annular air gap of 0.032 inches. The sleeve 13 has an inner diameter of 3.607 inches while the coil 15, 16 has an outer diameter of 3.643 inches to give a clearance of 0.032 inches from the outer pole ring 22. The coils may be formed of wires of width of 0.003 inches and a height of 0.012 inches.

The use of two coils 15, 16 and two magnetic circuits 17, 18 for driving the diaphragm 14 results in a balanced movement. If a single magnetic circuit were used with the two coils 15, 16 or if two magnetic circuits 17, 18 were used with one symmetrically placed coil, there would be an imbalance of forces. This imbalance of forces, in turn, restricts the electrical current from generating motion to maximum potential. Further, the length of two equal and parallel coils 15, 16 compared to a single series conductor of equal total length reduces the time required for a current to travel their lengths. That is, the time is reduced by one-half. Thus, a transducer employing this parallel arrangement generates an increased efficiency relative to time.

The invention thus provides a transducer which, when used as a loudspeaker, can reciprocate a diaphragm in a balanced manner and, as such, can produce sound waves without distortion. As a result, less power is required to produce sound of a given intensity.

The transducer 10 may be provided with suitable gridlike diffuser covers at the open ends for diffusion of the produced sound waves. These covers can be secured in place in any known manner.

What is claimed is:

1. a transducer comprising
a sleeve;
a diaphragm secured to and within said sleeve in a central plane thereof; and
electromagnetic means disposed in mirror image symmetric relation to said sleeve for reciprocating said sleeve and diaphragm in a linear manner to produce a balanced distortion free sound.

2. A transducer as set forth in claim 1 wherein said means includes a pair of coils wound about said sleeve in mirror image symmetrical relation about said central plane, said coils being equally wound to effect equal and co-directional electromotive forces therein in response to an alternating current supplied to said coils, and means defining a pair of stationary magnetic circuits disposed in symmetrical relation about said central plane, each said magnetic circuit being disposed about a respective one of said coils.

3. A transducer as set forth in claim 1 wherein said diaphragm is a flat disc.

4. A transducer as set forth in claim 3 wherein said disc is made of metal.

5. A transducer as set forth in claim 2 which further comprises a frame having said magnetic circuit defining means mounted therein in stationary relation.

6. A transducer as set forth in claim 5 wherein each magnetic circuit includes a pair of concentric spaced apart pole rings having one end of said sleeve disposed concentrically therebetween.

7. A transducer as set forth in claim 6, wherein each magnetic circuit includes an annular magnet secured to one of said pole rings, a transfer ring secured to the other of said pole rings and an annular transfer plate secured to said magnet and said transfer ring, said transfer plate defining an opening in communication with said diaphragm.

8. A transducer as set forth in claim 6 which further comprises at least one resilient pad for centering said diaphragm relataive to said pole rings.

9. A transducer as set forth in claim 1 wherein said electromagnetic means is disposed to reciprocate said sleeve in a direction transverse to said plane.

10. A transducer as set forth in claim 9 wherein said electromagnetic means includes a pair of coils equally wound about and on said sleeve in mirror image symmetrical relation about said central plane for conducting an alternating current therethrough in parallel from a common source.

11. A transducer as set forth in claim 10 wherein said sleeve is flangeless.

12. A transducer comprising
a sleeve;
a diaphragm secured to and within said sleeve at a central plane thereof;
a first coil of wire wound about said sleeve on one side of said plane, said coil having a pair of ends extending away from said sleeve to conduct an alternating current through said coil to effect an electromotive force therein;
first means on said one side of said plane defining a magnetic circuit about said first coil;
a second coil of wire wound about said sleeve on an opposite side of said plane in mirror image symmetry to said first coil, said second coil having a pair of ends extending away from said sleeve to conduct an alternating current through said second coil to effect an electromotive force therein equal to and directed in the same direction as said electromotive force in said first coil;
second menas on said opposite side of said plane defining a second magnetic circuit about said second coil; and
a common source of alternating current connected to said first coil and said second coil.

13. An electroacoustic transducer apparatus for converting electrical energy to mechanical energy, said apparatus comprising
first and second magnetic circuits, each circuit having a permanent magnet and at least one magnetic flux translative element for producing an elongated annular air gap for conducting magnetic flux;
tubular sleeve means disposed in said gap between said magnet and said element of each magnetic circuit;
first and second coils mounted on respective ends of said tubular sleeve and wound in identical mirror image relation to one another for conducting an alternating current therethrough in parallel from a common source;
a diaphragm disposed within said tubular sleeve and midway between said first and second coils; and
a frame holding said first and second magnetic circuits in mirror image relationship with one another.

* * * * *

United States Patent [19]

Koenig

[11] Patent Number: 4,806,834

[45] Date of Patent: Feb. 21, 1989

[54] ELECTRICAL CIRCUIT FOR INDUCTANCE CONDUCTORS, TRANSFORMERS AND MOTORS

[75] Inventor: Earl Koenig, Averill Park, N.Y.

[73] Assignee: Donald Goodman, Fort Lee, N.J.; a part interest

[21] Appl. No.: 39,081

[22] Filed: Apr. 16, 1987

[51] Int. Cl.[4] H02P 8/00

[52] U.S. Cl. 318/523; 318/138; 318/696; 336/182; 336/75; 336/145; 310/156; 310/162

[58] Field of Search .... 318/138, 685, 687, 696, 318/254, 257, 439, 38, 523; 310/156, 162, 163, 49 R, 49, 184, 198, 166; 307/105, 104; 339/180, 182, 145, 146, 147; 381/117, 195, 203

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Primary Examiner—William M. Shoop, Jr.
Assistant Examiner—Paul Ip
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] ABSTRACT

An electrical circuit for inductance conductors, transformers and motors is provided wherein two coils of electrically conductive wire are coiled about a bar of magnetizable material such that they are disposed in mirror image symmetrical relation with each other. A tap is connected to one end of each coil to conduct an electrical current thereto to magnetize the bar. A second tap is connected to the other ends of each coil to conduct an electrical current therefrom.

16 Claims, 1 Drawing Sheet

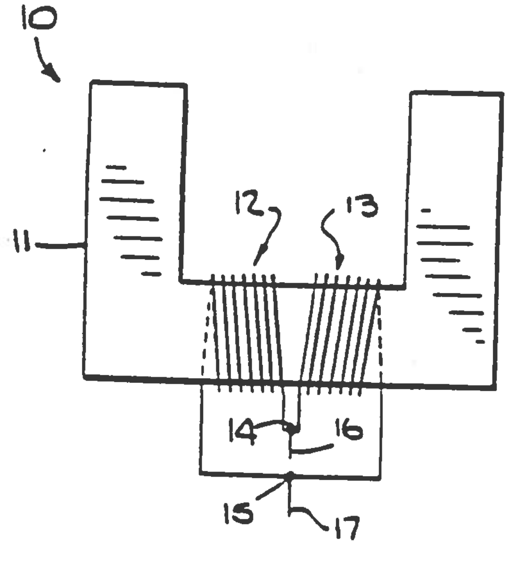


FIG. 1.

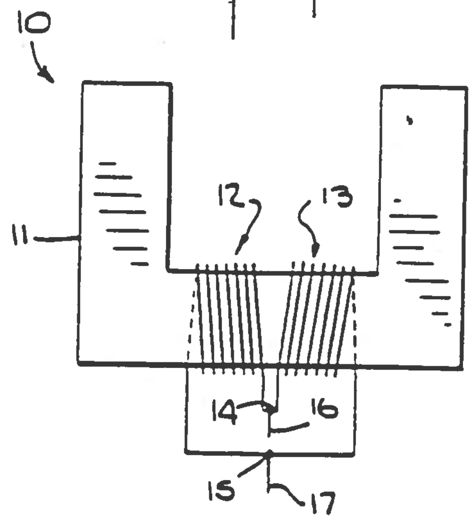


FIG. 2.

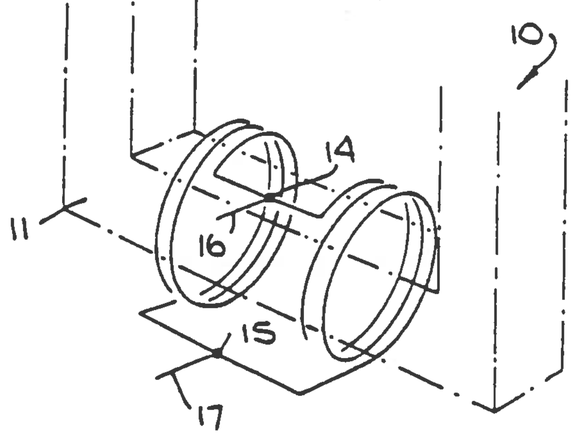


FIG. 3.

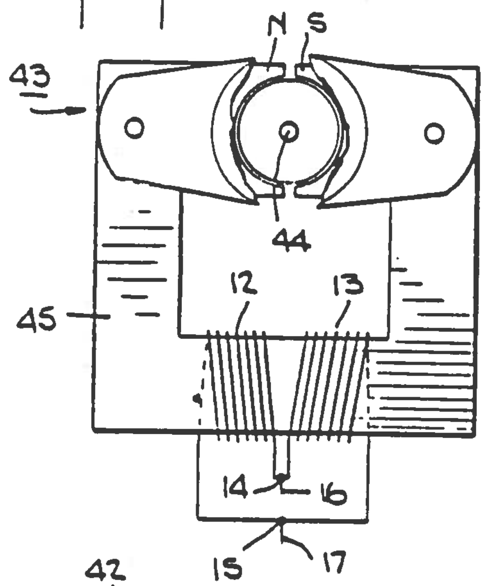


FIG. 4.
PRIOR ART

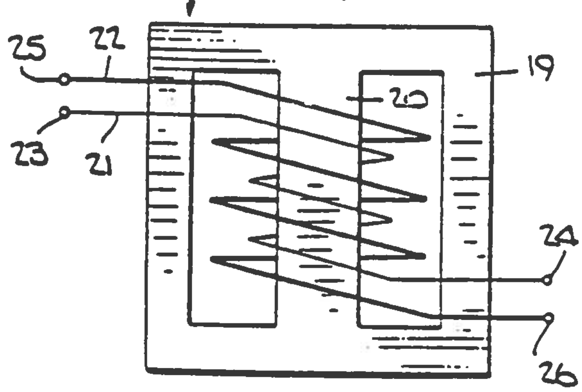


FIG. 6.

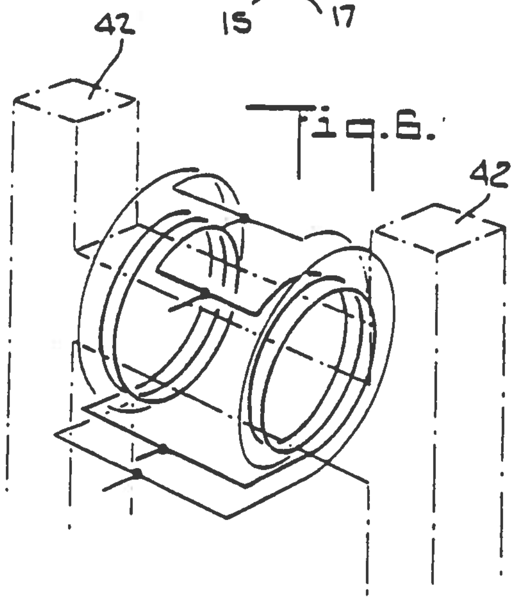
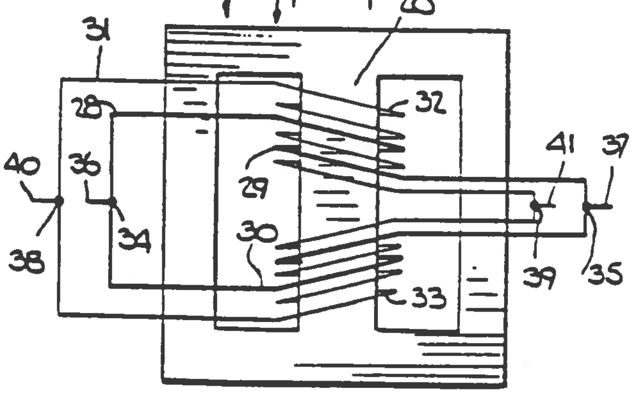


FIG. 5.



ELECTRICAL CIRCUIT FOR INDUCTANCE CONDUCTORS, TRANSFORMERS AND MOTORS

This invention relates to an inductance conductor. More particularly, this invention relates to an electrical circuit for an inductance conductor, a transformer, a generator and a motor.

As described in U.S. Pat. No. 4,584,438, an electrical circuit can be constructed with a pair of coils wound in mirror image symmetrical relation about a central plane so as to drive a diaphragm located in the central plane to provide a balanced and distortion free sound wave corresponding to an electrical signal delivered to the circuit.

It is also known that electromagnetism results from the passage of an electrical current through a wire which is wrapped around a core of magnetizable material. Generally, in the known electromagnetic structures, the curent enters the wire at one end, travels along the entire length of the wire, and exits at the other end of the wire with a magnetic force being produced as the current passes through the coil of wire. The magnetic force produced is usually associated with a proportional amount of work.

It is also known that an increase in magentic force and a corresponding increase in work output can be accomplished by increasing the flow rate of the current through the coil of wire.

Rotary motion motors or generators employ such coiled inductance conductors. These coiled induction structures are designed using a single wire wound and layered around a laminated core to reflect a desired resistance and inductive reactance.

As is known, a core transformer is based on the principle that energy will be transferred by induction from one conductor to another by means of a varying magnetic flux, provided that both conductors are on a common magnetic circuit. In the conventional transformer, a primary winding of wire is wound about a core with a secondary winding of wire wound about the primary winding. In addition, an electrical current under a high voltage is usually passed through the primary winding to induce a current of lower voltage in the secondary winding. During this time, an electric current travels through the length of each wire coil from one end to the other producing the effects described above.

In the past, transformers of relatively large size, for example, of 20 KVA which are used in power transmission generate a hum or buzz during operation which is usually objectionable to personnel working in the surrounding environment or to people living in the surrounding environment. In addition, heat is generated in the windings and where excessive must be dissipated to avoid a melt-down.

In the past, attempts to obtain more efficient electrical transformers, electrical generators and the like have usually concentrated on the constructional aspects of these devices rather than on the electrical circuitry for these devices. As a result, efficiencies which can be obtained have been relatively limited.

Accordingly, it is an object of the invention to provide an electrical circuit which permits an increase in efficiency to be obtained in electrical apparatus such as transformers, generators, induction motors, and the like.

It is another object of the invention to increase the efficiency of a transformer in a relatively simple manner.

It is another object of the invention to provide a relatively simple electrical circuit to permit a reduction in size of a transformer, generator, or motor of a given output.

It is another object of the invention to provide an electrical circuit which permits a decrease in the amount of current required for the circuit to perform a given amount of work.

Briefly, the invention provides an electrical circuit wherein a pair of coils of electrically conductive wire are coiled about a common axis in mirror image symmetrical relation to each other and connected in parallel electrically. To this end, a common tap is connected to one end of each coil in order to conduct an electrical current thereto while a second common tap is connected to a second end of each of the coils to conduct the electrical current therefrom.

The mirror image symmetry of the coils is believed to have the effect of increasing the flow rate of current through the circuit by decreasing the inductive time constant. This constant (T) is the ratio of the inductance (L) measured in Henries to the resistance (R) measured in Ohms. In this respect, the inductive time constant is reduced because the current travels a shorter distance from tap to tap as compared with a single coil between the two taps or a pair of coils in series between the taps. Further, there is an increase in the magnetic lines of flux which are generated as compared with a single coil of the same coil length.

In one embodiment, the electrical circuit can be incorporated into an inductance conductor, for example by winding the two coils about a bar of magnetizable material. When the coils are energized, the bar becomes magnetized and can be used in a conventional manner.

In another embodiment, the electrical circuit can be incorporated into a transformer. In this case, a primary winding formed of a pair of mirror image wound coils is wound about a core while a secondary winding also composed of a pair of mirror image wound coils is disposed concentrically about the primary winding and the core. The transformer also has a common tap connected to one end of each coil of the primary winding and a common tap connected to the remaining ends of each coil of the primary winding. In like manner, a pair of taps are connected to the secondary winding.

It is believed that the mirror image winding of both the primary winding coils and the secondary winding coils provides an increase in the magnetic lines of flux so that there is an increased efficiency in the use of such a transformer. For example, when comparing a conventionally wound transformer with primary and secondary windings and a rated resistance of 125 Ohms for stepping down a voltage of 110 V to 3 V, a transformer wound in accordance with the invention with the same resistance provides a step-down voltage of 5.8 V for an input voltage of 110 V. Thus, an efficiency of almost 100% can be achieved. Further, this efficiency can be achieved with a reduction in the size of the wire used for winding the transformer. Also, it has been found that for the same output, a transformer can be constructed with mirror image wound coils so as to operate at a lower amperage than the conventionally wound transformer.

The electrical circuit can also be incorporated into an electrical generator. In this respect, the generator would be wound in similar fashion to a transformer as described above.

In another embodiment, the electrical circuit can be incorporated into a motor. In this respect, the motor is constructed with a rototable shaft and an electromagnetic drive for rotating the shaft. The drive, in turn, includes a magnetizable bar having a North pole and a South pole in spaced facing relation and a pair of coils of electrically conductive wire coiled in mirror image symmetrical relation about the bar and connected in parallel to conduct an electrical current therethrough in order to magnetize the bar for driving the shaft.

These and other objects and advantages of the invention will become more apparent from the following detailed description and accompanying drawings in which:

FIG. 1 is a perspective view of a coiled inductance conductor constructed in accordance with the invention;

FIG. 2 is a side view of the conductor shown in FIG. 1;

FIG. 3 is an illustrative example of the motor which utilizes the invention;

FIG. 4 depicts a conventional transformer of the prior art;

FIG. 5 is a transformer constructed in accordance with this invention; and

FIG. 6 is a side view of the transformer shown in FIG. 5.

Referring to FIGS. 1 and 2, the inductance conductor 10 includes a U-shaped bar 11 of magnetizable material and a pair of coils 12, 13 of electrically conductive wire, each of which is coiled about a base of the bar 11 and thus about a common axis. Further, the coils 12, 13 are wound in mirror image symmetry to each other and with an equal number of turns.

In addition, a common tap 14 or like means is connected to one end of each coil 12, 13 in order to conduct an electrical current into the coils 12, 13 in order to magnetize the bar 11 while a second tap 15 is connected in common to the remaining ends of each coil 12, 13 in order to conduct the electrical current therefrom. In this regard, the coils 12, 13 are connected in parallel between the taps 14, 15. Suitable leads 16, 17 are also connected to the respective taps 14, 15 to conduct an electrical current.

In order to wind the coils 12, 13 about the bar 11, the bar 11 is mounted in a suitable rotatable jig or the like and a pair of wires of equal size and material are thereafter wound simultaneously about the bar 11 from the center of the bar 11 outwardly. The two ends of the wires leading to the bar 11 can then be connected to the common tap 14 while the two trailing ends of the wires can be connected to the common tap 15. The taps can be subsequently connected to the leads 16, 17 or vice versa.

The inductance conductor 10 can be used for any suitable purpose for which previously known inductance conductors have been constructed. For example, the inductance conductor may be incorporated in a choke or ballast for a fluorescent-type light bulb in order to smooth a DC current.

Referring to FIG. 4, as is known, a conventional transformer 18 is usually constructed of a bobbin 19 having a magnetizable core 20 around which a primary winding 21 and a secondary winding 22 are wound. For example, the primary winding 21 is usually coiled about the core 20 in one or more laminations or layers while the secondary winding 22 is wound about the primary winding in another series of laminations or layers. These laminations are shown schematically in FIG. 4.

In addition, the primary winding is usually connected between suitable taps 23, 24 for the flow of current while the secondary winding 22 is connected between a separate pair of taps 26 for the flow of current. Usually, the windings 21, 22 are wound of wires of a dissimilar number of turns so that an input voltage can be stepped-down to a lower voltage.

Referring to FIGS. 5 and 6, wherein like reference characters indicate like parts as above, a transformer 27 employing an electrical circuit in accordance with the invention has a primary winding 28 formed of a pair of coils 29, 30 of electrically conductive wire wound in mirror image symmetry about the core 20. In addition, a secondary winding 31 includes a pair of coils 32, 33 which are wound in mirror image symmetry about the core 20. In this respect, the secondary winding 31 is disposed concentrically about the primary winding 28 and an insulating sheath (not shown) is concentrically disposed between the windings 28, 31.

As indicated in FIG. 5, the wire used for the coils 29, 30 of the primary winding 28 are thinner than the wires used for the coils 32, 33 of the secondary winding 31.

The coils 29, 30 of the primary winding 28 are also connected in parallel between and to a pair of common taps 34, 35 with suitable electrical leads 36, 37 being connected to the respective taps 34, 35 to conduct a flow of current through the primary winding 28. Likewise, the coils 32, 33 of the secondary winding 31 are connected in parallel between and to a pair of taps 38, 39 each of which is connected to a suitable lead 40, 41 in order to conduct a current therethrough.

By way of example, a step-down transformer was constructed in accordance with the circuit indicated in FIG. 5 and compared with a conventionally wound transformer having a circuit as indicated in FIG. 4.

The conventional step-down transformer had a primary winding 21 formed of No. 32 wire while the secondary winding 22 was formed of a coil of No. 18 wire and was wound to provide a primary resistance of 125 Ohms and a secondary resistance of 0.20 Ohms so as to step down a voltage of 117 volts to 3.09 volts.

The step-down transformer constructed in accordance with FIG. 5 used thinner wire than that of the conventional transformer in order to obtain a rated resistance of 250 Ohms for each coil. To this end, the primary coils 29, 30 were wound of No. 40 wire while the coils 32, 33 of the secondary winding 31 were wound with No. 22 wire. In addition, each coil 29, 30 of the primary winding 28 had 1000 turns in 10 layers or 100 turns per layer to give a resistance of 125 Ohms. The coils 32, 33 of the secondary winding 31 had 65 turns in 5 layers or 13 turns per layer to give a resistance of 0.4 Ohmsfor each coil. A non-ferrous metal sheath, for example, of copper, was located concentrically between the windings 28, 31 in order to insulate the windings from each other.

When the conventional step-down transformer was subjected to an input voltage of 117 volts, the output voltage was 3.09 volts; however, when the transformer wound in accordance with FIG. 5 was subjected to the same input voltage, the transformer provided an output of 5.77 volts or nearly double the output of the conventionally wound transformer.

A transformer can also be wound in the manner indicated in FIG. 5 so as to provide the same output as a conventional transformer, for example 3 volts in the above example, in which case, less current would be used, for example to illuminate a light bulb. Testing has indicated that there is a reduction of about 25% to 33% less current used.

Referring to FIG. 6, a transformer may be constructed with a core 20, connected to a pair of flanges 42 so that the core and flanges define a bobbin. Such a bobbin can be incorporated into other structures in order to complete a transformer.

Referring to FIG. 3, wherein like reference characters indicate like parts as above, the electrical circuit, for example as shown in FIG. 1 can also be incorporated into a motor 43. As indicated, the motor 43 is constructed as a conventional shaded pole motor and need not be further described. As indicated, the motor 43 includes a rotatable shaft 44, for example for driving a fan (not shown). In addition, the motor 43 has an electromagnetic drive for rotating the shaft 44. This drive includes a magnetizable bar 45 having a North pole and a South pole in spaced facing relation and a pair of coils 12, 13 of electrically conductive wire coiled in mirror image symmetrical relation about the bar 45 and connected in parallel to conduct an electrical current therethrough to magnetize the bar 45 for driving the shaft 44.

Again, in comparing a motor 43 wound in the manner indicated in FIG. 3 for driving a fan with a motor wound in conventional fashion, i.e. with a single coil of wire about a bar 45, the motor constructed in accordance with FIG. 3 provided faster acceleration than the conventional motor as well as a greater velocity to the fan. Further, after current was shut off from each motor, it was found that the fans decelerated to a stop in substantially the same time. In essence, the motor constructed in accordance with FIG. 3 provided a greater output than the conventional motor. Also, for the same output, a motor wound in accordance with FIG. 3 requires about 25% less amperage.

The invention thus provides an electrical circuit which is capable of increasing the efficiency of existing electrical motors, transformers, generators and like electrical apparatus.

Further, the invention provides an electrical circuit which is capable of reducing the size and weight of electrical apparatus such as motors, transformers and generators for a given output. Still further, the use of the electrical circuit, for example, in a transformer can reduce the amount of heat generated during transformation of a voltage while also eliminating or substantially reducing the hum normally associated with large tranformers.

What is claimed is:

1. An inductance conductor comprising
a bar of magnetizable material;
a first coil of electrically conductive wire coiled about said bar;
a second coil of electrically conductive wire of equal resistance to said first coil coiled about said bar in mirror image symmetrical relation to said first coil;
a first common tap means connected to one end of said coils to conduct an electrical current sumultaneously thereto to magnetize said bar; and
a second common tap means connected to a second end of each of said coils to conduct an electrical current sumultaneously therefrom.

2. An inductance conductor as set forth in claim 1 wherein said bar is U-shaped with said coils wound about a base of said bar.

3. An inductance conductor as set forth in claim 1 wherein said bar is made of metallic material.

4. An inductance conductor as set forth in claim 1 wherein said first coil has a resistance of 250 ohms and said second coil has a resistance of 250 ohms.

5. A transformer comprising
a core;
a primary winding on said core including a pair of coils of electrically conductive wire wound in mirror image symmetry about said core; and
a secondary winding on said core including a pair of coils of electrically conductive wire wound in mirror image symmetry about said core.

6. A transformer as set forth in claim 5 wherein said secondary winding is disposed concentrically about said primary winding.

7. A transformer as set forth in claim 6 wherein said coils of said primary winding are of thinner diameter that said coils of said secondary winding.

8. A transformer as set forth in claim 5 wherein said primary winding has a resistance of 250 Ohms and said secondary winding has a resistance of 0.4 Ohms.

9. A transformer as set forth in claim 5 which further comprises a first common tap connected to one end of each coil of said primary winding to conduct an electrical current thereto, a second common tap connected to a second end of each coil of said primary winding to conduct an electrical current therefrom, a third common tap connected to one end of each coil of said secondary winding to conduct an electrical current thereto and a fourth common tap connected to a second end of each coil of said secondary winding to conduct an electrical current therefrom.

10. A transformer as set forth in claim 5 which further comprises a pair of flanges secured to opposite ends of said core to define a bobbin.

11. A transformer as set forth in claim 5 wherein said primary and said secondary windings have a respective resistance to step down a delivered voltage from 110 volts to 5.8 volts.

12. A transformer as set forth in claim 11 wherein said primary winding has a resistance of 250 Ohms.

13. A transformer as set forth in claim 5 wherein said wire of said primary winding is a No. 40 wire and said wire of said secondary winding is No. 22 wire and wherein each coil of said primary winding has 1000 turns in 10 laminations and each coil of said secondary winding has 13 turns in 5 laminations.

14. A transformer as set forth in claim 5 which further comprises an insulating sheath concentrically between said windings.

15. A motor comprising
a rotatable shaft; and
an electromagnetic drive for rotating said shaft, said drive including a magnetizable bar having a North pole and a South pole in spaced facing relation and a pair of coils of electrically conductive wire of equal resistance coiled in mirror image symmetrical relation about said bar and connected in parallel to conduct an electrical current simultaneously therethrough to magnetize said bar for driving said shaft.

16. An electrical circuit comprising
a pair of coils of electrically conductive wire equal resistance coiled about a common axis in mirror image symmetrical relation to each other;
a common tap connected to one end of each of said coils to conduct an electrical current simultaneously thereto; and
a common tap connected to a second end of each of said coils to conduct an electrical current simultaneously therefrom.

* * * * *

OPEN CROSS-SECTIONAL WIRE   U.S. Patent No. 5,985,448

AN OPENING IN MAGNET WIRE MATERIAL IS MORE RESPONSIVE TO INDUCED FIELDS THAN WITH NO OPENING.

DISPLACING MATERIAL DURING WIRE MANUFACTURING CREATES OPENING

MATERIAL DATA:

A). WIDTH = .012"

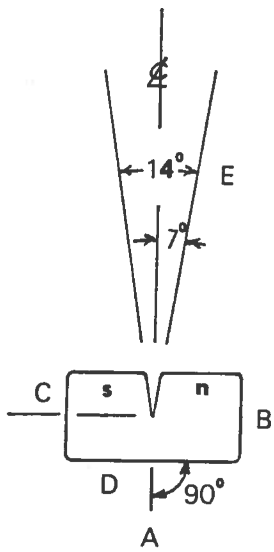
B). THICKNESS = .006"

C). OPENING DEPTH = .003"

D). OPENING LOCATION =
(midway width)

E). OPENING ANGLE =
(14 degree wedge)

F). MAGNET POLE LOCATIONS =
(N north, S south)



OPENING DETAILS:

* THE OPEN CROSS SECTION CREATES A "U" SHAPE MAGNET WITH A NORTH POLE FACE AND A SOUTH PLOE FACE.
* OPENING DEPTH IS 50% AT RIGHT ANGLES FROM THE OUTSIDE SURFACE.
* LESS THAN 50% DEPTH PRODUCES LESS MAGNET POLE FORCE.
* MORE THAN 50% DEPTH PRODUCES MORE MAGNET POLE FORCE UNTIL MATERIAL YIELD STRENGTH BECOMES UNACCEPTABLE.

OPENING BENEFITS:

* OPENING LOWERS MANUFACTURING COST AND INCREASES LIFE SPAN.
* OPENING INCREASES SKIN SURFACE AREA WHICH INCREASES ELECTRIC CAPACITY.
* OPENING DIMENSION AND INSIDE TO OUTSIDE GEOMETRY INFLUENCES AMOUNT OF CAPACITY.
* OPENING INCREASES MATERIAL NOBILITY BECAUSE THE SAME MATERIAL MASS HAS LESS ELECTRIFIED HEAT RISE COMPARED TO NO OPENING.
* NATURAL CIRCULATING MAGNETIC FIELDS RESPOND TO THE SINGLE OPENING AND ALTER THE WIRE MOTION FROM "ROTATION TORQUE" TO "CHANGE IN OPENING SIZE". THIS ALTERED CONDITION REDUCES WIRE MATERIAL VIBRATION AND WEAR.
* OPENING REDUCES CHARACTERISTIC IMPEDANCE AND EDDY DECAY TIME.

QUESTIONS ABOUT VOICE COIL WINDINGS

WHAT IS:

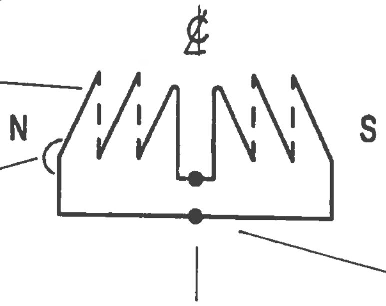
PITCH LEAD DIRECTION?
ANGLE OF INCLINATION?
EQUAL MAGNET POLE FORCE?
MIRROR IMAGE SYMMETRY RELATIONSHIP?

LEFT DIRECTED HALF
OF A WHOLE CIRCUIT

RIGHT DIRECTED HALF
OF A WHOLE CIRCUIT

PITCH LEAD
DIRECTION

ANGLE OF
INCLINATION



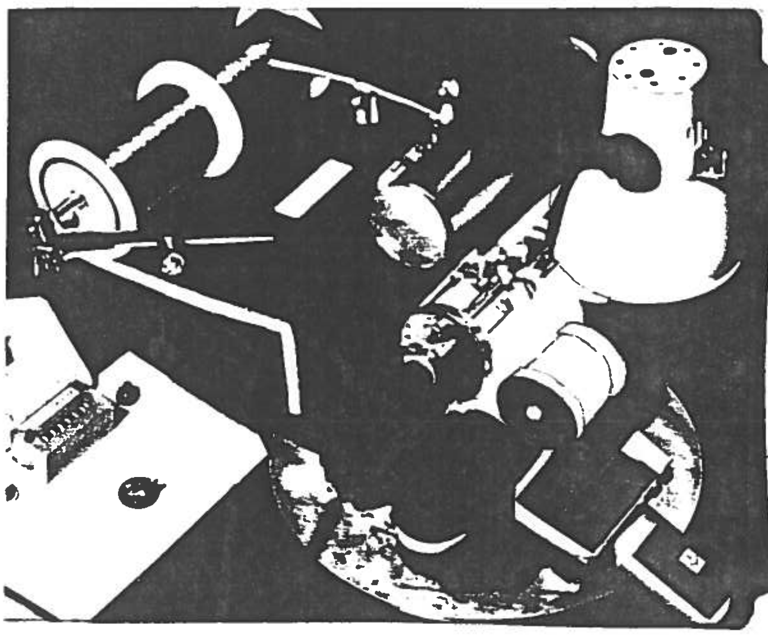
CIRCUIT MIRRORING PRODUCES
EQUAL MAGNET POLE FORCE
AND ELIMINATES TWIST WASTE

ELECTRICALLY PARALLEL
CONNECTION

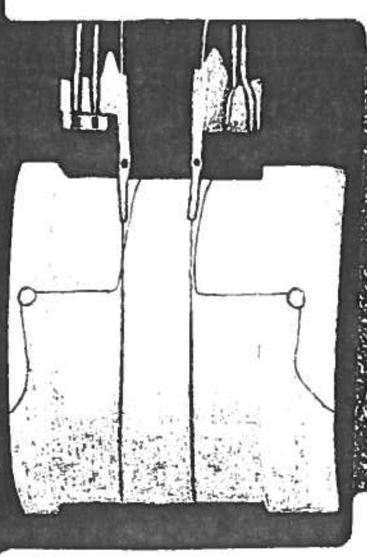
TRADITIONAL PRACTICE WINDS HALF OF A WHOLE CIRCUIT WHICH PRODUCES TWIST WASTE AND UNEQUAL MAGNET POLE FORCE. A HALF CIRCUIT IS INCOMPLETE WHEN COMPARED TO A WHOLE CIRCUIT.

LEFT DIRECTED HALF AND RIGHT DIRECTED HALF WOUND IN MIRROR IMAGE SYMMETRY RELATIONSHIP AND ELECTRICALLY CONNECTED IN PARALLEL, IS A WHOLE CIRCUIT.

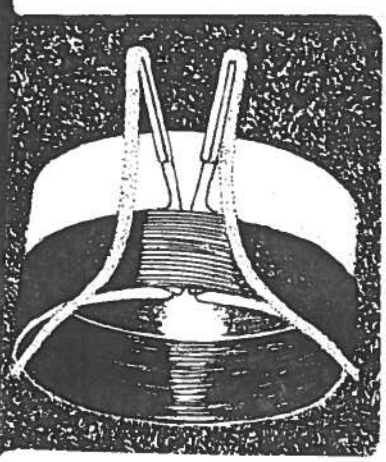
MIRROR IMAGING WINDING MACHINE



COIL WOUND ON SLOTTED BOBBIN



2" COIL DIAMETER, FLEX LEADS WITH TRANSIENT SNUBBERS



VOLUME 12, ISSUE 3 JANUARY 1999

VOICE COIL

THE PERIODICAL FOR THE LOUDSPEAKER INDUSTRY

Voice Coil (ISSN 1521-091X), the Periodical of the Loudspeaker Industry, is published on the 25th of each month by Audio Amateur Corporation, PO Box 876, Peterborough, NH 03458-0876 USA, (603) 924-9464, FAX (603) 924-9467.

Publisher - Edward T. Dell, Jr.
Editor - Vance Dickason
Contributing Editor - Richard Honeycutt

Voice-Coil Winding

Mirror Image Magnetics Company is offering a radical, if not simple, voice-coil technology for license. Percussion Air Motor (#4,584,438) is for an electromagnetic conductor circuit that is wound in a Mirror Image symmetrical relationship. Electric Circuit for Inductance Conductors, Transformers, and Motors (#4,806,834) expands the Mirror Image symmetry circuit to transformers and motors. At first glance this appears rather unusual, but is (according to MIM) actually a relatively simple method for winding voice coils in such a way as to cancel out some of the inductive characteristics of the voice coil. The methodology shows the mirror coil winding to be a single piece of wire that is wound in opposite directions with a different angular pitch (*Fig. 1*). While this certainly appears to be a difficult winding to accomplish in a production situation, the company claims that the coil can actually be wound faster than standard single-direction coils.

Claims and benefits made for this winding technique include superior clarity, lower distortion, reduced eddy current decay time, lower impedance and losses, increased motional linearity (by decreasing the twisting and torque), and lower heat coefficient for higher power handling for a given winding size. For more information on the parallel-mirrored image voice-coil circuit, contact Mirror Image Magnetics, PO Box 81, Averill Park, NY 12018-0081, Voice/FAX (518) 674-2233.

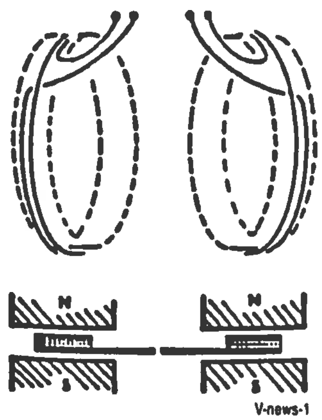


FIGURE 1: Mirror Image's simple technique of winding voice coils.

VALUES OF BENEFIT FOR THE MIRRORED ELECTROMAGNET CIRCUIT COMPARED TO TRADITIONAL NON MIRRORED CIRCUITS OF EQUAL MASS AND DC RESISTANCE.

1. MULTIPLE TRANSDUCERS SYNCHRONIZE TO REDUCE COUNTER E M F.
2. 100% INCREASE IN MOTION ACCELERATION·DECELERATION AND REVERSAL (INCREASES SIGNAL TO MOTION CORRESPONDENCE).
3. 300% DECREASE IN ENERGY CONTAINMENT (USE OF SMALLER AMPLIFIER).
4. INCREASED BAND WIDTH, INCREASED SPL, LONGER LASTING.
5. 50% INCREASE IN SKIN SURFACE AREA (INCREASES FORCE).
6. DOUBLE THE NUMBER OF TURNS (INCREASES FORCE).
7. CIRCUIT NORTH POLE STRENGTH IS CONCURRENT AND EQUAL TO SOUTH POLE STRENGTH (SYNCHRONIZES MAGNET POLARITY FOR BALANCE).
8. MIRRORED MAGNET WIRE FORMED CIRCUIT REFLECTS AN ELECTROMAGNET UNITY SIGNATURE.

Mirror Immage Magnetics

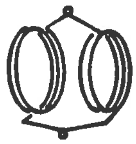
Mirrored Magnet Wire Formed Circuits Reflect An Electromagnet Unity Signature.
Electromagnet unity is a mirrored projection of halves that reflect a coherent whole and a state of oneness.

<u>What Are Mirrored Circuits?</u> They electrify magnet pole face locations at the <u>same time</u>.
<u>What Are Non Mirrored Circuits?</u> They electrify magnet pole face locations at <u>different times</u>.

Percussion Air Motor MOVING COIL LOUDSPEAKER AND MICROPHONE

The *Percussion Air Motor* contains a MIRROR IMAGE COIL ⊞ circuit which is formed by coiling a first magnet wire that is directed to the left and at the same time, coiling a second magnet wire that is directed to the right. These two coiled magnet wires are electrically connected in parallel.

MIRROR IMAGE COIL ⊞
PARALLEL CIRCUIT



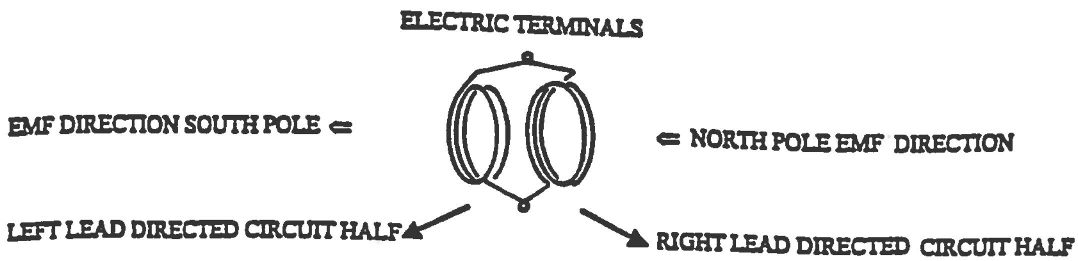
MIRROR IMAGE COIL ⊞
SCHEMATIC SYMBOL

The MIRROR IMAGE COIL ⊞ circuit inside a *Percussion Air Motor* , has two characteristics that differ from other coiled electromagnet circuits.

1. When electrified, the coils north magnetic pole force is concurrent and equal to the coils south magnetic pole force. Why, because the signal energy divides so that a first half goes to the north pole face location at the same time a second half goes to the south pole face location.

2. The pitch angle of inclination for a left directed coil is canceled by the opposite pitch angle of inclination for a right directed coil. This condition eliminates twist and torque coil motion distortion that is present in other coiled circuits.

MIRRORED CIRCUIT PERFORMANCE IS SUPERIOR TO NON MIRRORED CIRCUITS WHEN COMPARING EFFICIENCY, CLARITY, MULTIPLE APPARATUS SYNCHRONIZATION, COST, AND LIFE SPAN.



Averill Park, NY 12018-0081 (518) 674-2233

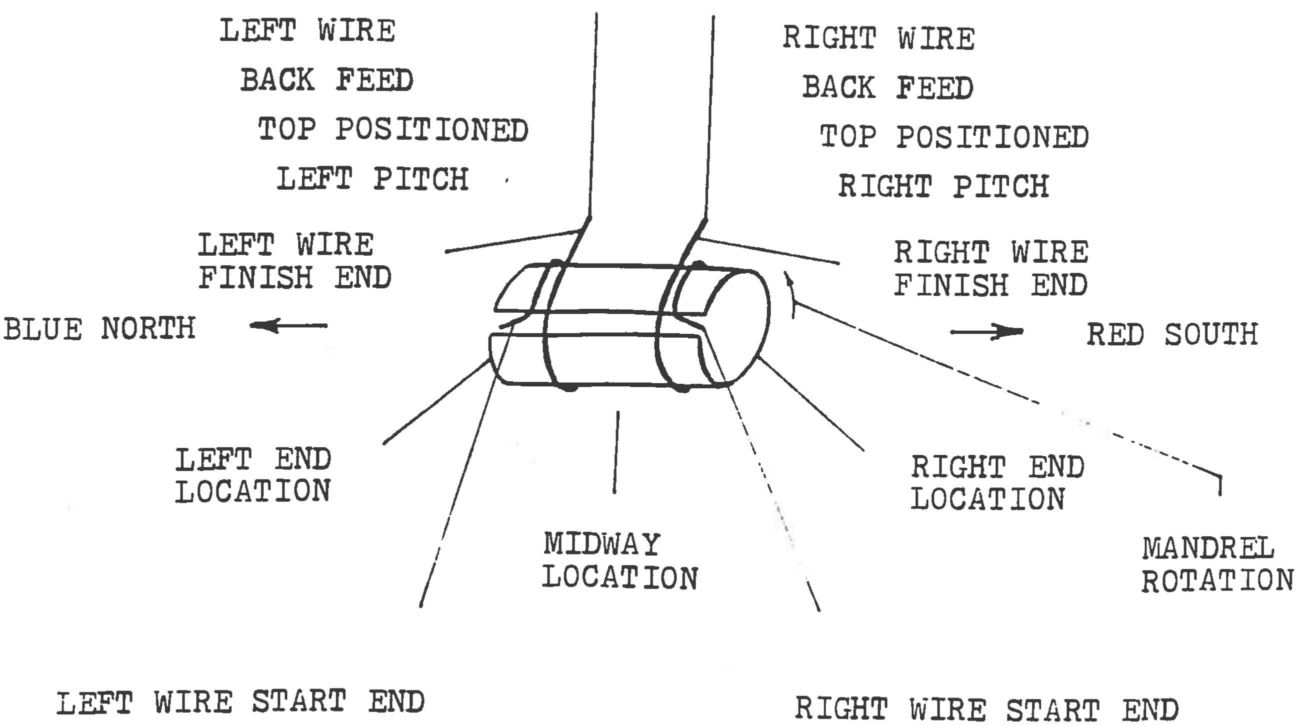
CONCURRENT COILING IS THE MANUFACTURING METHOD FOR MIRRORED COILS

WINDING THE LEFT DIRECTED CIRCUIT HALF, OF A MIRRORED COIL, CONCURRENTLY WITH WINDING THE RIGHT DIRECTED CIRCUIT HALF WILL PRODUCE MAXIMUM ELECTROMAGNETIC FORCE WHEN ELECTRICALLY CONNECTED TOGETHER IN PARALLEL. WHY, BECAUSE THE TWO CIRCUIT HALVES WILL NOT ELECTROMAGNETICALLY SYCHRONIZE IF THE TWO HALVES ARE WOUND SEQUENTIALLY, THAT IS TO SAY, WINDING THE LEFT HALF FIRST AND THEN WINDING THE RIGHT HALF NEXT DOES NOT PROVIDE NECESSARY SUPPORT FOR EACH COIL TO ELECTROMAGNETICALLY SYNCHRONIZE WITH EACH OTHER.

WHEN TWO MIRRORED COILS ARE WOUND SEQUENTIALLY, THE MAGNETIC FLUX FORCE FROM A FIRST WOUND LEFT DIRECTED COIL HAS NO EQUAL AND OPPOSITE MAGNETIC FLUX FORCE TO SYCHRONIZE WITH WHEN BEING WOUND. THEREFORE, THIS SEQUENTIAL COILING AND WINDING PROCESS IS NOT AS STRONG AS THE CONCURRENT COILING AND WINDING METHOD.

SEQUENTIAL COILING PRODUCES UNEQUAL ELECTRIC IMPEDANCES FOR MIRRORED CIRCUIT HALVES WHEN LEVEL WOUND NEXT TO ONE ANOTHER. INDUCTION IS INFLUENCED BY A COILED MAGNET WIRES SURROUNDINGS. A FIRST COILED CIRCUITS ELECTRIC IMPEDANCE IS DIFFERENT THAN A SECOND COILED CIRCUITS ELECTRIC IMPEDANCE BECAUSE A FIRST CIRCUITS SURROUNDING IS AIR, WHILE THE SECOND CIRCUITS SURROUNDING IS THE FIRST CIRCUIT. THIS CONDITION PRODUCES UNEQUAL IMPEDANCES AND UNBALANCES ELECTROMAGNET FORCE CHARACTERISTICS FOR THE TWO HALVES WHEN ELECTRICALLY CONNECTED IN PARALLEL.

CONCURRENT MIRRORED COILS STANDARDS NOMENCLATURE



AUDIO LOUDSPEAKER VOICE COIL COMPARISON TEST

PARALLEL MIRRORED MAGNET WIRE VOICE COIL CIRCUIT

COMPARED TO

NON MIRRORED SINGLE MAGNET WIRE VOICE COIL CIRCUIT

So that no question exists as to which circuit is superior, the magnet wire material and weight must be the same for the mirrored circuit as it is for the non mirrored circuit. Why? Because of the "Conversation of Mass" law which is a principle of classical physics that states the total mass of any material system is neither increased nor diminished by reactions between the parts – called also "Conservation of Matter" law.

Measured values of benefit show the mirrored electromagnet circuit possessing superior clarity, lower distortion, reduced eddy current decay time, lower circuit characteristic impedance, lower losses, increased motion linearity, and the circuit has lower heat rise so it lasts longer when compared to the non mirrored electromagnet circuits.

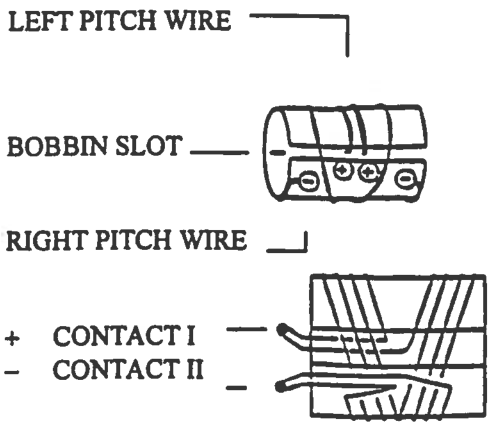
Constructing the non mirrored circuit, for example, uses a single wire and is of (64) circular mil cross section area, formed from end to end; reflecting a specific DC resistance, for a specific number of turns and layers, for a specific length and weight of wire.

Constructing an equal weight parallel mirrored circuit; it possesses two wires, each wire is of (32) circular mil gross section area. The two electrically parallel connected mirrored wires are (64) circular mil cross section area and are the same length and weight that the non mirrored (64) circular mil cross section area wire is.

The parallel mirrored circuit differs because the two opposite wire directed circuit halves balance magnet polarity so that magnet North Pole force at the same time is equal to the magnet South Pole force.

The parallel mirrored wire circuit halves, when compared to the single wire circuit, will possess 50% more wire skin surface area and will possess double the number of winding turns for the same wire weight.

PARALLEL MIRRORED MAGNET WIRE LOUDSPEAKER/MICROPHONE VOICE COIL CIRCUIT



Two identical circular mil cross section area magnet wires starting ends begin together midway between coils at bobbin slot and are lead inside bobbin slot to diaphragm where they connect together making terminal contact I.

Finished ends of magnet wires join together midway between coils and are lead to diaphragm where they connect together making terminal contact II.

Circuit shows wires starting ends under coil and wires finishing ends above coils.

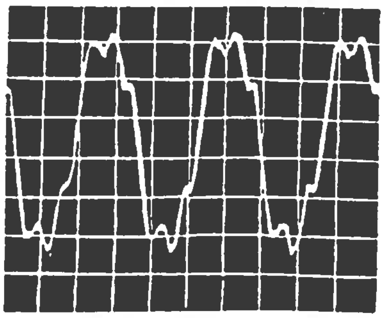
THIS MUTUAL INDUCTION ACCELEROMETER TEST WAS DESIGNED TO MEASURE THE ACCELERATION AND DECELERATION VALUES FOR AN ASSEMBLY APPARATUS THAT MUTUALLY CONNECTED TWO DYNAMIC MOVING PARALLEL ELECTRIC COILS WHEN ELECTRIFIED BY AN ALTERNATING CURRENT.

THESE GRAPHS SHOW VOICE COILS ACCELERATION VALUE FOR A SPEAKER ASSEMBLY WITH MIRRORED COILS AND A SPEAKER ASSEMBLY WITH NON MIRRORED COILS.

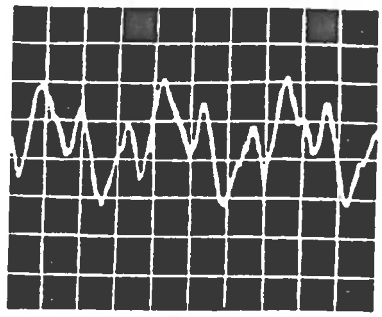
MIRRORED VOICE COIL SPEAKER ASSEMBLY = A LEFT PITCH DIRECTED VOICE COIL PARALLEL TO A RIGHT PITCH DIRECTED VOICE COIL.

NON MIRRORED VOICE COIL ASSEMBLY = A LEFT PITCH DIRECTED VOICE COIL PARALLEL TO A LEFT PITCH DIRECTED VOICE COIL.

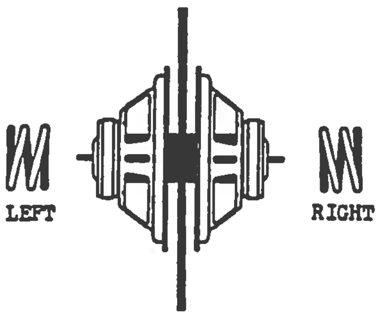
<u>MIRRORED COILS</u>

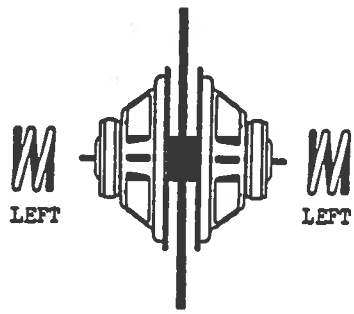


<u>NON MIRRORED COILS</u>



ACCELERATION GRAPH





SPEAKER ASSEMBLY

60 Hz. <u>IN</u> , 60 Hz. <u>OUT</u>
(100% AMPLITUDE)

60 Hz. <u>IN</u> , 120 Hz. <u>OUT</u>
(50% AMPLITUDE)

THE TEST SPEAKER ASSEMBLIES HAD 3"Dia. VOICE COILS - 2 LAYERS - 8 Ohms D C RESISTANCE, AND WERE ELECTRIFIED BY A 3 VOLT, 60 Hz. A C SIGNAL.

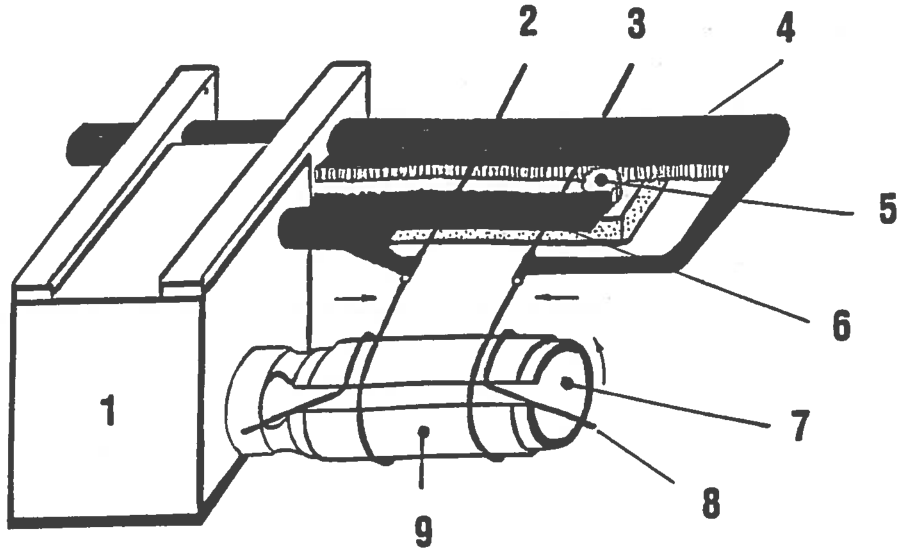
THE TEST SPEAKER ASSEMBLIES HAD AN ALUMINUM TIE ROD TO CONNECT TWO SPEAKERS, WITHOUT CONES, JUST SPIDERS, AND A LONG COIL FORM BOBBIN WITH COILS AT EACH END OF THE COIL FORM BOBBIN.

MIDWAY BETWEEN THE COILS WAS A THIN 18" SQUARE ALUMINUM HONEY-COMB PANEL FASTENED TO THE COIL FORM BOBBIN.

THE TEST SPEAKER ASSEMBLY WAS MOUNTED IN A FRAME.

AN ACCELEROMETER WAS LOCATED ON THE ALUMINUM PANEL.

MIRRORED COIL WINDING MACHINE



1. Mirrored Coil Winding Machine. *
2. Left Coil Wire.
3. Right Coil Wire.
4. Right Traverse With Rack And Wire Guide Motion Direction.
5. Pinion.
6. Left Traverse With Rack And Wire Guide Motion Direction.
7. Collapsible Mandrel And Rotation Direction.
8. Wire Start End.
9. Slotted Bobbin.

* Remote Controled Digital Signal From Telephone Modem Programs Machine To Wind Precise Number of Mirrored Coils.

Traverse Laterial Motion Reverses Direction Within One Spindle Revolution.