

BACKGROUND OF THE INVENTION

This invention relates to improvements to electro-magnetic machines, that is machines with two portions moving with respect to each other and with a magnetic field between the two portions.

In the past, electro-magnetic machines would typically have a rotor and a stator as the two portions. However, the two portions could be non-rotating oscillating pieces as in the so-called linear apparatus.

Although the "rotor" is usually a rotary part and the "stator" is usually a stationary part, this does not have to be so. Throughout this disclosure and claims, it will be understood that either the rotor or the stator may rotate or move, and in fact both may rotate or move, provided there is relative movement between the two portions.

In the prior art, a magnetic flux B would be created and armature coils would pass through this magnetic flux to produce an induced voltage or current. The great disadvantage of many prior art D.C. generators or motors, however, was that

their geometry required the armature coils to pass through magnetic fluxes of opposite polarity in each rotation. This of course causes an induced current in one polarity for part of the rotation and an induced current of an opposite polarity for the other part of the armature coil's rotation.

As a result, in order to derive useful direct current through the entire 360° of rotation of the rotor, the prior art machines required commutating means in order to compensate for this reversal in polarity of induced electric potential. However, these various commutating means all shared the same drawbacks in that they complicated the practical implementation of the machine, they require brushes to operate, and they increased the expense of making and using the machine.

Accordingly, other prior art machines have been developed which are acyclic in that the armature coils pass through magnetic fluxes of only constant polarity. However, these machines still require brushes to either energize the magnetic flux generating means or remove useful electrical energy from the armature coils since the excitation coils or the armature coils had to rotate with respect to the energy source or the load, respectively.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to at least partially overcome the disadvantages of the prior art. Also, it is an object of this invention to provide an

alternative type of electro-magnetic machine with a geometry which does not require commutators and which is more efficient than known machines, including acyclic machines.

Accordingly, in one of its broad aspects, this invention resides in providing an electro-magnetic machine comprising a rotor means having at least one rotor pole face movable along a movement path, a stator means having at least one stator pole face extending substantially along the movement path, a gap between the at least one rotor pole face and the at least one stator pole face, a magnetic flux path passing unidirectionally through the gap either into or out of the at least one stator pole face through the stator means through a magnetic flux connecting means between the stator means and the rotor means, into the rotor means and through the rotor means to the gap, magnetic flux generating means for generating magnetic flux to pass through the magnetic flux path, and at least one armature conductor positioned in the gap such that when the at least one rotor pole face and the at least one stator pole face move relative to each other an electric current or potential is developed in the at least the one armature conductor.

Further aspects of the invention reside in providing an electro-magnetic machine which does not require commutators or brushes for the excitation coils or for the armature coils.

A further aspect of the present invention resides in providing an A.C. generator which generates an A.C. current with a square wave rather than a sinusoidal wave.

Further aspects of the invention will become apparent upon reading the following detailed description and the drawings which illustrate the invention and preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which illustrate embodiments of the invention:

Figure 1 is a top view of a preferred embodiment of the present invention;

Figure 2 is a top view of a further preferred embodiment of the present invention;

Figure 3 is a cross-sectional view of a preferred embodiment of the present invention taken along axis A-A of Figure 2;

Figure 4 is a cross-sectional view of a further preferred embodiment of the present invention;

Figures 5A, 5B and 5C show preferred embodiments of the armature conductor; and

Figure 6 is a schematic diagram of a preferred electrical connection of armature conductors.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

OF THE INVENTION

As shown in Figure 1, a preferred embodiment of the present invention is shown as an electro-magnetic machine 10 comprising a rotor means 12 and a stator means 14. The stator

means 14 has a stator pole face 15 extending substantially along a movement path 16 and the rotor means 12 has a rotor pole face 13 moveable along the movement path 16. As shown in Figure 3, there is also a gap 20 between the rotor pole face 13 and the stator pole face 15.

It is understood that the movement path 16 may have any shape, such as curved or straight. However, in a preferred embodiment, the movement path 16 is substantially circular as shown in Figure 1. Accordingly, in order to obtain this type of path, it is preferable that the stator means 14 is substantially toroidally shaped. Also, it is preferable that if a toroidally shaped stator means 14 is used that the toroid has a discontinuity gap or split 66 across the movement path 16 as shown in Figure 1 and 2. In this way, the toroid will not tend to become magnetically saturated.

The machine 10 further comprises a magnetic flux path 24 which passes uni-directionally through the gap 20 either into or out of the stator pole face 15, through the stator means 14, through a magnetic flux connecting means 22 between the stator means 14 and the rotor means 12, into and through the rotor means 12 through rotor pole face 13 and back through the gap 20.

The magnetic flux path connecting means 22 comprises any method or device which provides a preferred path for the magnetic flux F to flow from the stator means 14 to the rotor means 12. The magnetic flux connecting means 22 as shown in Figures 1, 2, 3 and 4 comprises a radial member 34 which

preferably has a low magnetic reluctance. In this way, the majority of the magnetic flux F will pass through the magnetic flux connecting means 22. In addition, it is preferable if the magnetic flux connecting means 22 comprises an arc member 36 near the rotor means 12 to increase the surface area directly exposed to the rotor means 12. This arc member 36 may also be a complete circle to form a sleeve around the rotor means 12.

There is also a magnetic flux generating means 26 for generating magnetic flux F passing along the magnetic flux path 24. The magnetic flux generating means 26 is shown in Figure 1 as excitation coil 30 wound around the rotor means 12 and in Figures 2 and 3 as excitation coils 30 along the radial member 34. However, it is understood that the magnetic flux generating means 26 may consist of any method or apparatus for generating a magnetic flux F such as excitation coils (not shown) wound around any part of the magnetic flux path 24 or permanent magnets (not shown) including magnets formed from super conductive materials.

The machine 10 further comprises at least one armature conductor 32 positioned in the gap 20 and physically attached to or associated with either the rotor pole face 13 or the stator pole face 15 such that when the rotor pole face 13 and the stator pole face 15 move relative to each other, an electric current or potential is developed in the armature conductor 32.

In the preferred embodiment shown in Figure 1, the magnetic flux connecting means 22 extends radially inwardly

from the stator means 14. And, in this embodiment, the gap 20 is positioned radially distant from the magnetic flux connecting means 22. However, in other embodiments, the magnetic flux connecting means 22 could extend longitudinally from the stator means 14, or partially longitudinally and partially radially. And also, in other embodiments, the gap 20 could be positioned longitudinally distant from the stator means 14.

In the preferred embodiment of Figure 1, the gap 20 extends radially and the stator pole face 15 and the rotor pole face 13 are separated longitudinally. However, in other embodiments, the rotor pole face 13 and the stator pole face 15 could be separated radially, or partially radially and partially longitudinally. In this embodiment, the rotor means 12 could extend and curve around the top of the stator means 14.

It is also preferable that the machine 10 does not use brushes to transfer current to or from the machine 10. Omitting the brushes will decrease the manufacturing and maintenance costs of the machine 10. Accordingly, avoiding use of brushes may be accomplished in several ways such as by using permanent magnets. However, in a further preferred embodiment, the magnetic flux generating means 26 consists of excitation coils 30 wound around the magnetic flux connecting means 22 when the magnetic flux connecting means 22 is physically connected to the stator means 14. In this way, when the stator means 14 is stationary, the excitation coils 30 will not rotate

with respect to a power source (not shown) driving the excitation coils 30. Similarly, if the armature conductor 32 is associated with the stationary stator pole face 15, the armature coil will not rotate with respect to a load (not shown) which is connected to the armature conductor 32. Accordingly, because there is no rotation of the excitation coils 30 or the armature conductor 32, no brushes are required.

Similarly, in a preferred embodiment, no commutators are required or used.

It is also preferable if the rotor means 12 is balanced in terms of mass and weight. Accordingly, in a preferred embodiment of the present invention, shown in Figure 2, there is another rotor pole face 40 diametrically opposite rotor pole face 13. In this way, the output of the machine 10 will increase at least because of the second rotor pole face 40 and also because the machine 10 will operate more smoothly as the rotor means 12 will be symmetrical about the axis of rotation. Similarly, any practical number of rotor pole faces could be used such as, for example, four, five, six, eight or twelve.

In still a further preferred embodiment, as shown in Figure 3, a machine 10' is substantially as shown in Figure 1 except that the rotor means 12 has third and fourth rotor faces 42, 44 movable along a second movement path 46 substantially parallel to the first movement path 16. The stator means 14 has a second stator pole face 48 substantially longitudinally opposite the first stator pole face 15 and extending

substantially along the second movement path 46.

In other words, there is a "second set" of rotor faces 42, 44 positioned on the other side of the stator means 14 and facing the "first set" of rotor faces 13, 40. There is also a second stator pole face 48 facing substantially in the opposite direction to the first stator pole face 15. Therefore, as seen from Figure 3, in one embodiment, the machine 10' is symmetrical about an axis Y-Y down the center of the stator means 14.

Accordingly, in machine 10' there is also a second gap 50 between the third and fourth rotor pole faces 42, 44 and the second stator pole face 48. There is also a second magnetic flux path 52 which passes uni-directionally through the second gap 50 and with the same direction as the first magnetic flux path 24 into or out of the second stator pole face 47. In other words, if the first magnetic flux path 24 passes into the first stator pole face 15, then the second magnetic flux path 52 passes into the second stator pole face 48, and vice versa. In either event, the second magnetic flux path 48 passes through the stator means 14, through the magnetic flux connecting means 22 (or a separate magnetic flux connecting means not shown), into the rotor means 12 and through the rotor means 12 and through the rotor pole faces 42, 44 to the second gap 50.

The magnetic flux F' that travels on the second magnetic flux path 50 is generated by the magnetic flux generating means 26. As above, the magnetic flux generating

means 26 may consist of any method or device that can produce magnetic flux F' . However, it is preferable to use excitation coils 30 as shown in Figure 3.

This preferred embodiment further comprises a second armature conductor 54 positioned in the second gap 50 such that when the third and fourth rotor pole faces 42, 44 move relative to the second stator pole face 48, an electric current or potential is developed in the second armature conductor 54.

In a preferred embodiment, as shown in Figure 2, the first and second armature conductors 32, 54 are a single conducting coil 101 which is wound around the first and second stator pole faces 15, 48. Similarly, in this preferred embodiment, the magnetic flux connecting means associated with the second flux path 50 is the same magnetic flux path connecting means 26 associated with the first magnetic flux path 24. However, the magnetic flux connecting means associated with the second flux path 50 could be separate and distinct from the first magnetic flux path connecting means 26.

The machine 10 in Figure 3 will produce an alternating current (A.C.) output if the first and second rotor pole faces 13, 40 move exactly opposite as shown the third and fourth pole faces. Also, surprisingly, this A.C. output is substantially square in shape rather than sinusoidal without the need of correcting electronics. This is also true of the embodiments in Figures 1 and 2.

Also surprisingly, a relatively small torque or force on the rotor means 12 is required to move the rotor face means

13, 40, 42, 44 to achieve this A.C. output. This is also true of the embodiments shown in Figure 1 and 2 as well as the embodiment (not shown) where the movement path is linear rather than circular. Therefore, the machine 10, 10' is very efficient.

In still a further preferred embodiment, it is desirable that the magnetic flux F in the first gap 20 be increasing in a unit of time while the magnetic flux F' in the second gap 50 is decreasing in same unit of time. This has been found to produce a bumpy D.C. output or D.C. and A.C. output instead of an A.C. output only. There are several possible orientations of the above-described elements which will accomplish this.

For instance, the first magnetic flux path 24 and the second magnetic flux path 52 may be magnetically separated. One way of doing this is by placing a magnetic insulating material 64 in the stator means 14 in between the two stator pole faces as seen in Figure 4. This necessitates having a first magnetic flux connecting means 22 and a second magnetic flux connecting means 62 to conduct magnetic flux F , F' from both sides of the now magnetically separated stator means 14.

Having magnetically separated the stator means 14, it is possible to angularly displace the first magnetic path connecting means 22 from the second magnetic path connecting means 62 or to angularly displace the first and second rotor pole faces 13, 40 from the third and fourth rotor pole faces 42, 44 or a combination of the two. In this way the rotor pole

faces 13, 40 and 42, 44 on either side of the stator means 14 do not step onto the armature coils 32 at the same time. Accordingly, the magnetic flux F in the first gap 20 and the magnetic flux F' in the second gap 50 will be decreasing or increasing at the same time during at least a portion of the rotation of the rotor means 12.

In a further preferred embodiment, the stator means 14 has a discontinuity, gap or split 66 across the movement path 16, as shown in Figures 1 and 2, such that when the rotor pole face 13 passes over the discontinuity 66 there will be a break in the magnetic flux path 24 such that little or no flux F will flow in the magnetic flux path 24. In this embodiment, the first magnetic flux path connecting means 22 is preferably positioned at one end 68 of the discontinuity 66 and extends radially inwardly and, if there is a second magnetic flux path connecting means 62, the second magnetic flux path connecting means 62 is preferably positioned on the other end 70 of the discontinuity 66 and extends radially inwardly. However, the magnetic flux path connecting means 22, 62 could be positioned elsewhere on the stator means 14.

It should also be noted that whatever means is used to increase the magnetic flux F in gap 20 while the magnetic flux F' is decreasing in gap 50, it is preferable that the electricity production on either side of the stator means 14 is about 180 degrees out of phase so that the majority of the electricity generated is used to generate the bumpy D.C. output.

It has also surprisingly been found that when a split toroid is used to create a circular movement path, the force or torque required to maintain the motion of the rotor means and the moving poles is less than when a linear path apparatus is used.

It has also surprisingly been found that the torque or force required is further decreased if the length of each moving rotor face 13, 40, 42, 44 is about half the length of the stator pole face 15. It has further surprisingly been found that the presence of a diode to restrict each of the currents in armature conductors 32, 54 on either side of the stator means 14 to a single direction further decreases the force or torque required to maintain the rotor means 12 in relative motion to the stator means 14. Accordingly, in a further preferred embodiment, a diode D1 as shown in Figure 6 is connected in series to armature coil 32 and diode D2 is connected in series to armature coil 54, and armature coils 32 and 54 are connected in series. Also, the machine 10 has rotor faces 13, 40, facing the first stator pole face 15 and rotor faces 42, 44 facing the second stator pole face 48 such that the resultant electrical outputs from the armature conductors 32, 54 are about 180 degrees out of phase. Also, the armature conductors 32, 54 may be connected in series. In this way a D.C. current may be achieved with very little force or torque requirement thereby making the machine 10 very efficient.

The armature conductor 32 may be any material that

conducts electricity. Accordingly, the armature conductor 32 may consist of a wire 101 wound around the stator 14 as shown in Figures 1, 2, 3 or 4. Or, the armature conductor 32 may comprise several discrete wires 102 connected in parallel and arranged substantially transverse to the movement path 16. Also, the conductor 32 may comprise a series of electrically conductive strips 103 arranged substantially transversely to the movement path 16 or in an arc shaped member 104 several degrees wide. These last three embodiments are shown generally in Figures 5a, 5b or 5c, respectively.

It is understood that while the above discussion described primarily the operation of the present invention as a generator, it is also capable of acting as a motor. Accordingly, the expression "machine" is intended to include generators and/or motors, as the context requires.

It will be understood that, although various features of the invention have been described with respect to one or another of the embodiments of the invention, the various features and embodiments of the invention may be combined or used in conjunction with other features and embodiments of the invention as described and illustrated herein.

Although this disclosure has described and illustrated certain preferred embodiments of the invention, it is to be understood that the invention is not restricted to these particular embodiments. Rather, the invention includes all embodiments which are functional or mechanical equivalents of the specific embodiments and features that have been

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described and illustrated herein.