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(19) (CA) APPLICATION FOR CANADIAN PATENT (12)

(54) Asymmetrical Electro-Mechanical Device

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Notice: This application is as filed and may therefore contain an incomplete specification.

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ABSTRACT OF THE INVENTION

This invention relates to an asymmetrical, electro-mechanical device comprising a geometrically-magnetically-asymmetrical stator and a rotor which move with respect to each other. There is a stator air gap which makes the stator asymmetrical. The continuous magnetic flux path is still substantially planar. The magnetic flux passing from the rotor to the stator is interrupted when the rotor passes by the stator air gap. The stator has two faces with armature conductors on both faces and the rotor has two faces which successively interact with the two stator faces. In a further embodiment, the electro-mechanical device comprises a plurality of stators and rotor faces, each being substantially interchangeable. The invention is able to achieve improvements over the prior art electro-mechanical devices, particularly in respect of efficiency.

//jep/PAT/ASST

ASYMMETRICAL ELECTRO-MECHANICAL DEVICE
a.k.a. SST

BACKGROUND OF THE INVENTION

This invention relates to an asymmetrical, electro-mechanical device which may act as a motor or a generator. In particular, the invention relates to an improved and efficient generator/motor.

Of course, electro-mechanical devices which act as motors and generators are known. It is always important to improve upon the prior electro-mechanical devices and, in particular, to improve the efficiency of those devices.

In the past, the present invention has improved the efficiency of electro-mechanical devices, in particular as disclosed in published PCT application PCT/CA93/00088.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to at least partially improve upon the prior art devices, including the device disclosed in published PCT application PCT/CA93/00088, particularly by improving the efficiency of the prior art devices. Also, it is an object of this invention to provide an improved alternative type of electro-mechanical device, namely an asymmetrical electro-mechanical device.

Accordingly, in one of its broad aspects, this invention resides in providing an asymmetrical, electro-mechanical device comprising:

(a) a geometrically-magnetically-asymmetrical stator means comprising:

a non-continuous stator magnetic flux path extending from a first stator portion to a second stator portion;

a stator air gap extending from the second stator portion to the first stator portion; and

a stator face having a plurality of armature conductors extending substantially transversely across the stator face;

(b) a rotor means having a rotor face and moving along a rotor movement path;

(c) a rotor/stator air gap between the rotor face and the stator face when the rotor face and the stator face are adjacent each other;

(d) a continuous magnetic flux path extending along at least a portion of the stator magnetic flux path, through the stator face, through the rotor/stator air gap, into or out of the rotor face, through the rotor means, and through at least one magnetic flux connecting means which enables the magnetic flux path to be continuous;

(e) magnetic flux generating means for generating magnetic flux to pass through the continuous magnetic flux path;

(f) wherein the rotor means is capable of cyclically moving relative to the stator means in a direction along a rotor movement path which is outside of the stator magnetic flux path, wherein:

(i) a first part of the rotor movement path is adjacent to the stator magnetic path, and a second part of the rotor movement path is not adjacent to the stator magnetic path such that magnetic flux, except magnetic flux leakage, cannot pass through the rotor face to or from the stator magnetic flux path;

(ii) beginning at time zero until time critical, the rotor face moves away from both a first portion of the stator face and the stator magnetic flux path such that magnetic flux, except magnetic flux leakage, does not pass through the rotor face into or out of the stator magnetic flux path, then toward a second portion of the stator face, and then such that the rotor face is adjacent to and overlapping with the stator face such that operational magnetic flux passes through the rotor face into or out of the stator magnetic flux path;

(iii) at time critical, the rotor face moves into a position of maximal overlap with the stator face; and

(iv) from time critical until time end of cycle, the rotor face moves along at least a portion of the stator face and adjacent to the stator face in a direction of the stator magnetic path;

(g) wherein when the rotor face and the stator face move relative to and adjacent to each other an armature electric voltage and armature current having directions are developed in the plurality of armature conductors;

(h) wherein when the plurality of armature conductors is closed or under load, the direction of the armature current reverses at time critical when the rotor face moves into a position of maximal overlap with the stator face, without the magnetic flux reversing direction and without the rotor means reversing direction; and

(i) wherein the continuous magnetic flux path is substantially planar.

In a further aspect, the invention relates to a generator having a non-continuous stator magnetic flux path which is planar in that it is substantially confined to one plane. In a still further aspect, the present invention relates to an invention wherein a plurality of stator portions can be used with a single rotor having a plurality of rotor faces.

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 schematic view of one embodiment of a prior art device;

Figure 2(a) is a schematic, top view, of an improvement of the invention shown in Figure 1 at about time zero;

Figure 2(b) is a schematic, top view, of an improvement of the invention shown in Figure 1 at about time critical;

Figure 2(c) is a schematic, top view, of an improvement of the invention shown in Figure 1 at about time end of cycle;

Figure 3 is a schematic, top view, of a further embodiment of the invention shown in Figure 2(a) at time zero;

Figure 4 is a schematic, top view, of a further embodiment of the invention shown in Figure 3; and

Figure 5 is a schematic, top view, of a further embodiment of the invention shown in Figure 3.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

As shown in Figure 1, an asymmetrical, electro-mechanical device 10, as previously disclosed in PCT application PCT/CA93/00088, the invention includes a geometrically-magnetically-asymmetrical stator 12. Although the word "stator" is used to describe this feature and other similar features in this disclosure and the claims, the "stator" need not be "stationary".

The stator 12 has a non-continuous stator magnetic flux path 14 extending from a first stator portion 16 to a second stator portion 18.

There is also a stator air gap 20 which extends from the second stator portion 18 to the first stator portion 16. The stator air gap 20 may be an absolute air gap in the sense that the stator 12 is physically and completely discontinuous at the stator air gap 20. However, the stator air gap 20 may also be an effective air gap in the sense that the stator, for example only, as shown in Figure 1, could go into the plane of the paper beginning at the second stator portion 18 and extend sufficiently far from the remainder of the stator 12 and then return to the first stator portion 16. In this manner, there would be an effective air gap between the second stator portion 18 and the first stator portion 16 when a rotor 22 passed along the stator from the second stator portion 18 to the first stator portion 16. A stator air gap will be created, whether actual or effective, when magnetic flux, except leakage flux, will not pass from the rotor 22, specifically the rotor face 28, to the stator 12.

On at least some portion of the stator 12 there is a stator face 24. The stator face 24 has a plurality of armature conductors 26 extending substantially transversely across the stator face 24. The armature conductors 26 are substantially transverse to the direction of the stator magnetic flux path 14.

In Figure 1, the armature conductors 26 are coiled around a toroidally-shaped stator 12.

The rotor 22 has a rotor face 28. The rotor face 28 faces the stator face 24.

The rotor 22 moves along a rotor movement path 30. Preferably the rotor movement path 30 follows as closely as possible the stator magnetic flux path 14.

A rotor/stator air gap 32 exists between the rotor face 28 and the stator face 24 when the rotor face 28 and the stator face 24 are adjacent to each other.

The device 10 also has a continuous magnetic flux path 34 extending along at least a portion of the stator magnetic flux path 14. In the embodiment shown in Figure 1, the continuous magnetic flux path 34 extends along the entire portion of the stator flux path 14 from the first stator portion 16 to the second stator portion 18. The length of the continuous magnetic flux path 34 is variable in time as the rotor 22 moves along the rotor movement path 30. This will be explained below.

The continuous magnetic flux path 34 passes through the rotor/stator air gap 32, through the stator face 24 and through at least one magnetic flux connecting means 36 which enables the continuous magnetic flux path 34 to be continuous.

In Figure 1, in the position where the rotor 22 is shown in solid lines, the continuous magnetic flux path 34 is very short. The continuous magnetic flux path 34 extends from the rotor face 28 through an arm 40 which connects the rotor face 28 to an input/output shaft 42. In this embodiment, the input/output shaft 42 is magnetically connected to the connecting means 36 by any appropriate means such as a friction fit (not shown), brushes (not shown), or an air gap 44.

In any case, the continuous magnetic flux path 34 passes from the rotor 22 (specifically from the rotor arm 40 in this embodiment) to the connecting means 36. The continuous magnetic flux path 34 then continues through the connecting means 36 to that portion of the stator face 24 which is immediately adjacent to the rotor face 28. The continuous magnetic flux path 34 which has just been described in association with the rotor 22 when it is in the position shown by solid lines in Figure 1 is essentially the shortest continuous magnetic flux path 34 which can be obtained in the embodiment shown in Figure 1.

The longest continuous magnetic flux path 34 which can be obtained in the embodiment of Figure 1 is shown when the rotor 22 is in the region of the first stator position 16 which is shown generally by the rotor 22A shown in dashed lines in Figure 1. In that embodiment, the portion of the continuous magnetic flux path 34 which extends through the stator flux path 14 extends from the position of the rotor face 28A (as shown with dashed lines in Figure 1) clockwise all the way around the stator flux path 14 to the second stator portion 18.

As the rotor 22 moves clockwise around the circular rotor movement path 30, the length of the actual continuous magnetic flux path 34 decreases.

There is also a magnetic flux generating means 46 for generating magnetic flux F. This magnetic flux passes through the continuous magnetic flux path 34. In Figure 1, the magnetic flux generating means 46 is a coil 46 around the rotor arm 40. However, any other suitable magnetic flux generating means could be used anywhere in the magnetic flux path 34.

The rotor 22 is capable of cyclically moving relative to the stator 12. Once again, as discussed with respect to the stator, although the word "rotor" is used to describe this feature 22, the rotor need not rotate and it need not even move. The important point is that there is relative movement between the rotor 22 and the stator 12.

In the embodiment of Figure 1, the rotor 22 moves in a direction (as shown by the arrow on the dashed representation of the rotor 22A in Figure 1) along the rotor movement path 30. The rotor movement path 30 is outside of the stator magnetic flux path 14. In essence, the rotor movement path 30 does not cross through and is not positioned within the stator magnetic flux path 14.

A first part of the rotor movement path 30 is adjacent to the stator magnetic path 14, preferably adjacent the stator face 24. In that way, a rotor/stator air gap 32 can be created and the continuous magnetic flux path 34 can be created. In Figure 1, this first part of the rotor movement path corresponds to the movement of the rotor from a position adjacent to the first stator position 16 to a position adjacent to the second stator portion 18.

There is also a second part of the rotor movement path 30 which is not adjacent to the stator magnetic path 14 such that the magnetic flux F, except for magnetic flux leakage, does not pass through the rotor face 28 to or from the stator magnetic flux path 14. In other words, during the second part of the rotor movement path 30, the rotor face is in such a position such that there is no continuous magnetic flux path 34 or otherwise in that particular position. This is accomplished by having the second part of the rotor movement path 30 pass by or through the stator air gap 20.

The second part of the rotor movement path 34, in the embodiment shown in Figure 1, is part of the rotor movement path 30 from the second stator flux portion 18 to the first stator portion 16. In other words, the second part of the rotor movement path 30 is when the rotor face 28 passes through or over the stator air gap 20.

Beginning at a time zero until a time critical, the rotor face 28 moves away from both a first portion 48 of the stator face 24 and the stator magnetic path 14. In the embodiment shown in Figure 1, the first part 48 of the stator face 24 corresponds to the second stator portion 18. This is because the stator face 24 in Figure 1 includes substantially all of the stator 14. However, it would be possible to have the armature conductors 26 extend only around a portion of the toroidally-shaped stator 14. In that situation, the first part 48 of the stator face 24 (which is really an end of the stator face 24) would not correspond to the first and second stator portions 16, 18.

During at least part of this time zero to time critical, magnetic flux F, except magnetic flux leakage, does not pass through the rotor face 28 into or out of the stator magnetic flux path 14. Therefore, during at least part of this time zero to time critical, there is no flux F, except leakage flux, passing through the continuous magnetic flux path 34.

During this time zero to time critical, after the rotor face 28 moves away from the first portion 48 of the stator face 24, the rotor face 28 moves towards a second portion 50 of the stator face 24. Once again, in the embodiment shown in Figure 1, the second portion 50 of the stator face 24 corresponds to the first stator portion 16. This is because the armature conductors 26, as shown in Figure 1, are coiled substantially right to the end of the stator 14 where the stator air gap 20 begins. However, if the armature conductors 26 were not coiled right up to the end of the stator 14 at the stator air gap 20, the stator face 24 would have ended at a place different than the first stator means 16.

During this time zero to time critical, the rotor face 28 moves to a position adjacent to the second portion 50 of the stator face 24, and eventually overlaps with the second portion 50 of the stator face 24, such that operational magnetic flux F passes through the rotor face 28 into or out of the stator magnetic flux path 14. Thus, the continuous magnetic flux path 34 is brought into existence.

At time critical, the rotor face 28 moves into a position of maximum overlap with the stator face 24. In Figure 1, time critical occurs when the rotor 22A is in the position shown by dashed lines.

From time critical until time end of cycle, the rotor face 28 moves along at least a portion of the stator face 24 and adjacent to the stator face 24 in a direction of the stator magnetic flux path 14.

When the rotor face 28 and stator face 24 move relative to and adjacent to each other, an armature electric voltage Va and an armature current Ia having directions are developed in the plurality of armature conductors 26. In the embodiment shown in Figure 1, only the rotor 22 moves and the stator 14 remains stationary.

When the plurality of armature conductors 26 is closed or under load 52, the direction of the armature current Ia reverses at time critical when the rotor face 28 moves into a position of maximal overlap with the stator face 24, without the magnetic flux F reversing direction and without the rotor 28 reversing direction.

In the device as shown in Figure 1, the stator is a toroidally-shaped body. A first end of the toroidally-shaped body corresponds to the first stator portion 16 and a second end of the toroidally-shaped body corresponds to the second stator portion 18. The stator extends toroidally for less than 360° from the first end to the second end. The gap between the first and second ends of the toroidally-shaped body is the stator air gap 20.

As noted previously, in the embodiment shown in Figure 1, the conductors of the plurality of armature conductors 26 are coiled around the toroidally-shaped body. As shown, there is one continuous coil. However, it would be possible to have other arrangements of the armature conductor coils 26.

In the device as shown in Figure 1, the rotor 22 is connected by the rotor arm 40, which acts as a magnetic path connecting means, to complete the continuous magnetic flux path 34. The rotor 22 is connected to the input/output shaft 42 which is located concentrically within the toroidally-shaped stator 12.

In the device as shown in Figure 1, during the time from time zero to time critical, the rotor face 28 passes by the stator air gap 20 such that magnetic flux F, other than leakage flux, cannot pass through the rotor face 28 into or out of the stator magnetic flux path 14.

An improvement on the invention shown in Figure 1 is shown in Figures 2(a), 2(b) and 2(c). Respecting the embodiments of Figures 2(a), 2(b), 2(c), 3, 4 and 5 the numeric references will have three digits. The first digit will correspond to the particular figure number and the last two digits will correspond to the numeric reference of the corresponding like feature in the embodiment described with reference to Figure 1.

The embodiments shown in Figures 2 , 3 and 5 are exemplary and are used to explain the principles of the invention.

In the embodiment shown in Figures 2(a), 2(b) and 2(c), the rotor 222 is shown rotating in a clockwise direction. Figures 2(a), 2(b) and 2(c) show a partial view of the rotor in three consecutive positions corresponding to about time zero, time critical and time end of cycle. While Figures 2(a), 2(b) and 2(c) show the rotor 222 as moving relative to the stator 212 which is shown remaining stationary, it is understood that the rotor 222 need not rotate and it need not even move. The important part is that there is relative movement between the rotor 222 and the stator 212.

As shown in Figure 2(a), the plurality of armature conductors 226 extend substantially traversely across the stator face 224 from a first portion 248 of stator face 224 to a second portion 250 of stator face 224. In Figures 2(a), 2(b) and 2(c), the armature conductors are coiled around the stator 212. The magnetic flux generating means 246 is a coil 246 wound around the stator path member 264. The stator path member 264 magnetically connects the stator face 224 with the second stator face 224'.

As stated above, Figure 2(a) shows the asymmetrical electro-mechanical device 210 at time zero where the rotor face 228 is moving away from both the first portion 248 of the stator face 224 and the stator magnetic flux path 214 (shown as a dot-dash line). At time zero, no magnetic flux, except magnetic flux leakage, flows through the stator.

Figures 2(b) and 2(c) show the electro-mechanical device 210 at about time critical and time end of cycle, respectively, during which the continuous magnetic flux path 234 is complete and magnetic flux F is flowing therethrough. The continuous magnetic flux path 234 is shown as a dashed line in Figures 2(b) and 2(c).

As shown in Figure 2(b), at about time critical the rotor face 228 is adjacent the stator face 224 and thereby forming the rotor/stator air gap 232. As also shown, the stator 212 comprises a second stator face 224' and the rotor 222 comprises a second rotor face 228'. For at least some time period during which the rotor face 228 is adjacent the stator face 224, and at least between time critical and time end of cycle, the second rotor face 228' is adjacent the second stator face 224' thereby forming a second rotor/stator air gap 232' between the second rotor face 228′ and the second stator face 224′. This completes the continuous magnetic flux path 234 and magnetic flux F can pass through the rotor face 228 into the stator face 224 and through the second stator face 224′ into the second rotor face 228′.

As can be seen from Figures 2(b) and 2(c), the continuous magnetic flux path 234′ extends along at least a portion of the stator magnetic flux path 214, through the stator face 224 through the rotor/stator air gap 232 into or out of the rotor face 228, through the rotor means 222, into or out of the second rotor face 228′, through the second rotor stator air gap 232′, through the second stator face 224′ and through the stator path member 280 which extends to the first stator portion 216 thereby making the continuous magnetic flux path 234 continuous. In this embodiment, the at least one magnetic flux connecting means 236 comprises the second rotor face 228′, the second rotor/stator air gap 232′ and the second stator face 224′.

As seen from Figures 2(b) and 2(c), the continuous magnetic flux path 234 is substantially planar in that the individual line paths of flux are confined to a single plane. In other words, the continuous magnetic flux path 234 may be completely represented on a two dimensional drawing, such as Figures 2(b) and 2(c). In contrast, the magnetic flux path 14 as shown in Figure 1 comes out of and goes into the plane of the paper as shown, for example, as "B" on rotor 22.

There are several practical advantages to having the continuous magnetic flux path 234 substantially planar. One of these is that the cost of manufacturing the device 210 is less in that the stator is more simply designed than the stator, for example, as shown in Figure 1.

Further, having a substantially planar magnetic flux path 234 permits the stator 212 to be linear, meaning that the stator 212 can be represented by a continuous line on a single line. This allows the stator 212 to be formed of thin steel wires (not shown) having teflon or plastic coating and being compressed together to decrease internal eddy currents in the stator 212.

It is apparent that when the rotor face 228 is adjacent to the stator face 224 and the second rotor face 228′ is adjacent to the second stator face 224′, the continuous magnetic flux path 234 is closed and magnetic flux F can pass through the continuous magnetic flux path 234. In order to break or open the continuous magnetic flux path either the rotor face 228 must not be adjacent to the stator face 224 or the second rotor face 228′ must not be adjacent to the second stator face 224′, or both the rotor face 228 and the second rotor face 228′ must not be adjacent the stator face 224 and second stator face 224′, respectively.

In a preferred embodiment, when the rotor face 228 is not adjacent to the stator face 224, the second rotor face 228′ is not adjacent to the second stator face 224′ during which magnetic flux F, except magnetic flux leakage, cannot pass through the rotor face 228 to or from the stator magnetic flux path 214. More preferably, when the rotor face 228 is adjacent to the stator face 224, the second rotor face 228′ is adjacent to the second stator face 224′ for the same period such that magnetic flux can pass through the rotor face 228, through the stator face 224 and through the second stator face 224′ into the second rotor face 228′. In this way, each time the rotor face 228 is adjacent the stator face 224, the second rotor face 228′ is adjacent the second stator face 224′ thereby making the device 210 more efficient. The preferred way to accomplish this is by having the stator face 224 substantially the same as the second stator face 224′ and the rotor face 228 substantially the same as the second rotor face 228′ as shown in Figures 2(a), 2(b) and 2(c).

In a further preferred embodiment, as shown in Figure 3, the second stator face 324′ also comprises a second plurality of armature conductors 326′ extending substantially traversely across the second stator face 324′. The second armature conductors 326′ are wound around stator 312. This embodiment is shown in Figure 3 where the rotor means 322 is shown at time zero. It is apparent that for time critical and time end of cycle the embodiment shown in Figure 3 will be similar to those shown in Figures 2(b) and 2(c) except that the second stator face 324′ would have armature conductors 326′ and the stator 312 comprises a second non-continuous stator magnetic flux path 314′.

As shown in Figure 3, the second non-continuous stator magnetic flux path 314′ extends from the second portion 350′ of the second stator face 324′ to the first portion 348′ of the second stator face 324′ and is shown as a dash-dot line. The second stator magnetic flux 314′ is outside the rotor movement path 330 and the stator magnetic flux path 314 and the continuous magnetic flux path 324 extends along at least a portion of the second stator magnetic flux path 314′. As with the stator magnetic flux path 314, the second magnetic flux path 314′ has a second stator air gap 320′ extending from the first portion 348′ of the second stator face 324′ to the second portion 350′ of the second stator face 324′.

As with the stator magnetic flux path 314, the first part of the rotor movement path 330 is adjacent to the second stator magnetic flux path 314′. Likewise, the second part of the rotor movement path 330 is not adjacent to either the stator magnetic flux path 314 or the second stator magnetic flux path 314′ such that magnetic flux, except for magnetic flux leakage, cannot pass through the rotor face 328 to and from the stator magnetic flux path 314 or through the second stator face 324′ to or from the second stator magnetic flux path 314′.

Beginning at time zero until time critical, the second rotor face 328′ moves away from both the first portion 348′ of the second stator face 324′ and the second stator magnetic flux path 314′ such that magnetic flux, except for magnetic flux leakage, does not pass through the second rotor face 328′ into or out of the second stator magnetic flux path 314′. Then, the second rotor face 328′ moves toward a second portion 350′ of the second stator face 324′ and then moves such that the second rotor face 328′ is adjacent to and overlapping with the second face 324′ when the rotor face 328 is adjacent to and overlapping with the stator face 324. In this way, the continuous magnetic flux path 334 is formed and operational magnetic flux F passes through the second rotor face 328′ into or out of the second stator magnetic flux path 314′.

At time critical the second rotor face 328′ moves into a position of maximum overlap with the second stator face 324′ while the rotor face 328 is overlapping the stator face 324′. From time critical until time end of cycle, the second rotor face 328′ moves along at least a portion of the second stator face 324′ and adjacent to the second stator face 324′ in a direction of the second stator magnetic flux path 314′ while the rotor face 328 is overlapping with the stator face 324.

Preferably, time zero, time critical and time end of cycle for the second rotor face 328′ should occur substantially simultaneously as time zero, time critical and time end of cycle for the rotor face 328. In this way, the plurality of armature conductors 326 and the second plurality of armature conductors 326′ will operate substantially in unison. In one preferred embodiment, this is accomplished by the rotor face 328 being substantially the same as the second rotor face 328′.

It is apparent that the embodiment shown in Figure 3, because it has two armature conductors 326 and 326′, will have an increased power production over the embodiment shown in Figures 2(a), 2(b) and 2(c), as well as over Figure 1, and therefore is much more efficient.

When the second rotor face 328′ and the second stator face 324′ move relative to and adjacent to each other, a second armature electric voltage Va′ and second armature current Ia′ having directions are developed in the second armature conductors 326′. As with the armature conductors 326, when the second armature conductors 326′ is closed or under load, the direction of the second armature current Ia′ reverses at time critical when the second rotor face 328′ moves into a position of maximum overlap with the second stator face 324′ without the magnetic flux F reversing direction and without the rotor means 322 reversing direction.

Figure 4 shows a further preferred embodiment of the present invention. Figure 4 shows the rotor means 422 having a plurality of rotor faces (shown generally as 429) each of which is substantially identical and substantially interchangeable with the rotor face 428 and the second rotor face 428′. In this way, each of the plurality of rotor faces 429 are interchangeable. Accordingly, the rotor faces 429 move with respect to the stator 412 and successively interact with the stator face 424 and the second stator face 424′.

It is apparent that as the plurality of rotor faces 429 move with respect to the stator 412 each of the plurality of rotor faces 429 shall appear identical with respect to the plurality of armature conductors 426 and the second plurality of armature conductors 426′. This means that there is relative motion between the rotor 442 and the stator 412. Also, as the rotor face 428 moves away from both a first portion 448 of the stator face 424 and the stator magnetic flux path 414, the rotor face 428 shall approach the second stator face 424′. In this way, because the rotor face 428 and second rotor face 428′ are interchangeable, the next incremental rotation of the rotor 422 shall cause the rotor face 428 to interact with the second stator face 424′ in the same manner as the second rotor face 428′ did. A third rotor face 428" shall then move into the position of the rotor face 428, as shown in Figure 4, and interact with the stator face 426 in the same manner as the rotor face 428. In this way, there will be successive interaction between the rotor faces 429 and the stator face 424 and second stator face 424′ throughout the rotation of the rotor 422.

An interesting aspect of the embodiment shown Figure 4 is that because the plurality of rotor faces 429 interact with two stator faces, namely the stator face 424 and second stator face 424′, the device 410 has an increased frequency over the device as shown, for example, in Figure 1.

Each of the plurality of rotor faces 429 is positioned at substantially the same distance from the input/output shaft 442. The input/output shaft, in this embodiment, is located concentrically within the rotor 422 and the rotor 422 moves relative to the stator 412 around the input output shaft 442 in a circular path 430. As stated above, it is apparent that rather than the rotor 422 rotating, the stator 412 could rotate with respect to the rotor 422 which would remain stationary or also rotate. The length of each of the plurality of rotor faces 429 is less than 180 degrees in the direction of the circular path 430.

Figure 4 further shows a plurality of stators, generally shown as 413, each of which is substantially interchangeable with the stator 412. These plurality of stators 413 are oriented around the rotor 422 so that the plurality of rotor faces 429 can successfully interact with the stator face 424, and second stator face 424′ of each of the plurality of stators 413. In addition, each stator 412 of the plurality of stators 413 has one of a plurality of stator air gaps 480, 480′, 480", etc., extending from the second stator face 424′ of each stator 412 to the stator face 424 of the adjacent stator 412′. In this way, the stator magnetic flux path 414 and second stator magnetic flux path 414′ remain discontinuous.

Figure 5 is an exemplary drawing of a further embodiment of the invention wherein the stator 512 has a different shape over that shown in Figure 3, but nevertheless, the magnetic flux path 534 is planar and the stator 512 is substantially linear. As shown in Figure 3, the stator path member 364 extends from the second portion 350 of the stator face 324 to the second portion 350′ of the second stator face 324′. By contrast, the stator 512 shown in Figure 5 has stator path member 564 extending from the first portion 548 of the stator face 524 to the second portion 550′ of the second stator face 524′. In this way, the stator 512 requires less material to manufacture, but, the magnetic flux path 534 remains substantially the same length as the rotor 522 moves along the first part of the rotor movement path 530. It is apparent that this type of stator 512 may be used in the embodiments shown in Figures 2(a), 2(b) 2(c), 3 and 4.

In a preferred embodiment of the invention, the Lorentz force equal to B.l.i does not create any more than a negligible negative torque on the input/output shaft connected to either of the moving rotor 322 or to the moving stator 312, if the stator moves. A negative torque is one which opposes the desired movement of the rotor 322 and is shown as Tn in the Figures (for convenience, the reference numerals will refer to the reference numerals of Figure 3, but the following applies to each of the embodiments shown in Figures 2(a), 2(b), 2(c), 4 and 5).

In regard to this invention, "B" of the Lorentz force is a magnetic flux F through the rotor/stator air gap 332 and the second rotor/stator air gap 332'. Also, "l" is the length of that portion of the armature conductor 326 and second armature conductors 326' passing across the stator face 324 and second stator face 324' and through the rotor/stator air gap 332 and second rotor/stator air gap 332', respectively. The length "l" is shown as reference 54 in Figure 1 and corresponds to the thickness of the rotor face 328 perpendicular to the rotor movement path 330 in Figure 3.

Also, "i" is the armature current Ia shown in Figure 1 and corresponding the current passing through the armature conductors 326 and second armature conductors 326'.

In a further preferred embodiment of the invention, the device 310 is operable such that between time zero and time critical, the armature current Ia creates a magnetic flux F in the stator magnetic flux path 314 and second stator magnetic flux path 314' which contributes to a positive torque Tp on the input/output shaft 342. A similar positive torque Tp is created by the second armature current Ia' passing through the second armature conductors 326' shown in Figures 3.

In a further preferred embodiment of the invention, the positive torque Tp described above, between time zero and time critical, is created when the following features of the device 310 are properly adjusted:

resistance R of the load connected to the armature conductors 326;
capacitance C of the load;
length L1 from the first portion 348 of the stator face 324 to the second portion 350 of the stator face 324 during which the magnetic flux F, except magnetic flux leakage, does not pass through the rotor face 328 into or out of the stator magnetic flux path 314;
shape S of the rotor face 328; and

length L2 of the rotor face 328.

This positive torque Tp can be created for both the armature conductors 326 and the second armature conductors 326'.

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 described and illustrated herein.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An asymmetrical, electro-mechanical device comprising:

(a) geometrically-magnetically-asymmetrical stator means comprising:

a non-continuous stator magnetic flux path extending from a first stator portion to a second stator portion;

a stator air gap extending from the second stator portion to the first stator portion; and

a stator face having a plurality of armature conductors extending substantially transversely across the stator face;

(b) a rotor means having a rotor face and moving along a rotor movement path;

(c) a rotor/stator air gap between the rotor face and the stator face when the rotor face and the stator face are adjacent each other;

(d) a continuous magnetic flux path extending along at least a portion of the stator magnetic flux path, through the stator face, through the rotor/stator air gap, into or out of the rotor face, through the rotor means, and through at least one magnetic flux connecting means which enables the magnetic flux path to be continuous;

(e) magnetic flux generating means for generating magnetic flux to pass through the continuous magnetic flux path;

(f) wherein the rotor means is capable of cyclically moving relative to the stator means in a direction along a rotor movement path which is outside of the stator magnetic flux path, wherein:

(i) a first part of the rotor movement path is adjacent to the stator magnetic path, and a second part of the rotor movement path is not adjacent to the stator magnetic path such that magnetic flux, except magnetic flux leakage, cannot pass through the rotor face to or from the stator magnetic flux path;

(ii) beginning at time zero until time critical, the rotor face moves away from both a first portion of the stator face and the stator magnetic flux path such that magnetic flux, except magnetic flux leakage, does not pass through the rotor face into or out of the stator magnetic flux path, then toward a second portion of the stator face, and then such that the rotor face is adjacent to and overlapping with the stator face such that operational magnetic flux passes through the rotor face into or out of the stator magnetic flux path;

(iii) at time critical, the rotor face moves into a position of maximal overlap with the stator face; and

(iv) from time critical until time end of cycle, the rotor face moves along at least a portion of the stator face and adjacent to the stator face in a direction of the stator magnetic path;

(g) wherein when the rotor face and the stator face move relative to and adjacent to each other an armature electric voltage and armature current having directions are developed in the plurality of armature conductors;

(h) wherein when the plurality of armature conductors is closed or under load, the direction of the armature current reverses at time critical when the rotor face moves into a position of maximal overlap with the stator face, without the magnetic flux reversing direction and without the rotor means reversing direction; and

(i) wherein the continuous magnetic flux path is substantially planar.

2. An electro-magnetic device as defined in claim 1 wherein the at least one magnetic flux connecting means comprises a second rotor face of the rotor means, a second stator face of the stator means and a second stator/rotor air gap when the second rotor face is adjacent to the second stator face such that at least at time critical to time end of cycle magnetic flux can pass through the rotor face into the stator face and through the second stator face into the second rotor face; and

wherein the continuous magnetic flux path extends along at least a portion of the stator magnetic flux path, through the stator face, through the rotor/stator air gap, into or out of the rotor face, through the rotor means, into or out of the second rotor face, through the second rotor/stator air gap, into the second stator face and through a stator path member in a manner so as not to impede the relative movement between the rotor means and the stator means.

3. An electro-magnetic device as defined in claim 2 wherein when the rotor face is not adjacent to the stator face, the second rotor face is not adjacent to the second stator face.

4. An electro-magnetic device as defined in claim 3 wherein when the rotor face is adjacent to the stator face, the second rotor face is adjacent to the second stator face.

5. An electro-magnetic device as defined in claim 2 wherein

(a) the geometrically-magnetically-asymmetrical stator means comprises a second non-continuous stator magnetic flux path having a second stator air gap extending from the first portion of the second stator face to the second portion of the second stator face such that the second stator magnetic flux path is outside the rotor movement path and the stator magnetic flux path and the continuous magnetic flux path extends along at least a portion of the stator magnetic flux path;

(b) the second stator face has a second plurality of armature conductors extending substantially transversely across the second stator face;

(i) the first part of the rotor movement path is adjacent to the stator magnetic flux path and the second stator magnetic flux path, and the second part of the rotor movement path is not adjacent to either the stator magnetic flux path or the second stator magnetic flux path such that magnetic flux, except magnetic flux leakage, cannot pass through the rotor face to or from the stator magnetic flux path or through the second rotor face to or from the second stator magnetic flux path;

(ii) beginning at time zero until time critical, the second rotor face moves away from both the first portion of the second stator face and the second stator magnetic flux path such that magnetic flux, except magnetic flux leakage, does not pass through the second rotor face into or out of the second stator magnetic flux path, then toward a second portion of the second stator face, and then such that the second rotor face is adjacent to and overlapping with the second stator face when the rotor face is adjacent to and overlapping with the stator face such that operational magnetic flux passes through the second rotor face into or out of the second stator magnetic flux path;

(iii) at time critical, the second rotor face moves into a position of maximal overlap with the second stator face while the rotor face is overlapping the stator face; and

(iv) from time critical until time end of cycle, the second rotor face moves along at least a portion of the second stator face and adjacent to the second stator face in a direction of the second stator magnetic flux path while the rotor face is overlapping the stator face;

(c) wherein when the second rotor face and the second stator face move relative to and adjacent to each other a second armature electric voltage and second armature current having directions are developed in the second armature conductors; and

(d) wherein when the second armature conductors is closed or under load, the direction of the second armature current reverses at time critical when the second rotor face moves into a position of maximal overlap with the second stator face, without the magnetic flux reversing direction and without the rotor means reversing direction.

6. An electro-magnetic device as defined in claim 5 wherein when the rotor face is not adjacent to the stator face, the second rotor face is not adjacent to the second stator face such that magnetic flux, except magnetic flux leakage, cannot pass through the rotor face to or from the stator magnetic flux path.

7. An electro-magnetic device as defined in claim 6

wherein when the rotor face is adjacent to the stator face, the second rotor face is adjacent to the second stator face such that magnetic flux can pass through the rotor face into the stator face and through the second stator face into the second rotor face.

8. An electro-magnetic device as defined in claim 7 wherein time zero, time critical and time end of cycle for the second rotor face occur substantially simultaneously as time zero, time critical and time end of cycle for the rotor face.

9. An electro-magnetic device as defined in claim 8 wherein the rotor face and the second rotor face are substantially interchangeable.

10. An electro-magnetic device as defined in claim 9 wherein the rotor means comprises a plurality of rotor faces, each of which is substantially interchangeable with the rotor face and second rotor face such that each of the plurality of rotor faces successively interact with the stator face and second stator face.

11. An electro-magnetic device as defined in claim 10 further comprising a plurality of geometrically-magnetically-asymetrical stator means, each of which is substantially interchangeable with the geometrically-magnetically-asymetrical stator means;

a plurality of stator air gaps extending from the second stator face of each stator means to the stator face of an adjacent stator means; and

wherein the plurality of stator means are oriented around the rotor means so that the plurality of rotor faces can successively interact with the stator face and second stator face of each stator means.

12. An electro-magnetic device as defined in claim 9 further comprising a plurality of geometrically-magnetically-asymetrical stator means, each of which is substantially interchangeable with the geometrically-magnetically-asymetrical stator means;

a plurality of stator air gaps extending from the second stator face of each stator means to the stator face of an adjacent stator means; and

wherein the plurality of stator means are oriented around the rotor means so that the rotor face and second rotor face can successively interact with the stator face and second stator face of each stator means.

13. An electro-magnetic device as defined in claim 2 wherein the stator means is linear.

14. An electro-magnetic device as defined in claim 11 wherein the stator means is linear.

15. An electro-magnetic device as defined in claim 13 wherein the stator path member extends from the second portion of the stator face to the second portion of the second stator face.

16. An electro-magnetic device as defined in claim 14 wherein the stator path member extends from the first portion of the stator face to the second portion of the second stator face.

17. An electro-magnetic device as defined in claim 15 wherein the rotor means is connected to an input/output shaft located concentrically within the rotor means and the rotor means moves relative to the stator means around the input/output shaft in a circular path; each of the plurality of rotor faces is positioned at substantially the same distance from the input/output shaft; and the length of each

rotor face in the direction of the circular path is less than 180°.

18. An electro-magnetic device as defined in claim 17 wherein a Lorentz force equal to B.l.i does not create any more than a negligible negative torque on an input/output shaft connected to either the moving rotor means or the moving stator means,

where: "B" is magnetic flux through each rotor/stator air gap;
"l" is a length of that portion of the armature conductor passing across each stator face and through the rotor/stator air gap; and
"i" is the armature electric current in each of the plurality of armature conductors.

19. An electro-magnetic device as defined in claim 18 wherein the device is operable such that between time zero and time critical the armature electric current in each plurality of armature conductors creates a magnetic flux in each stator magnetic flux path contributing to a positive torque on the input/output shaft when the following features of the device are properly adjusted:

resistance of a load connected to each armature conductors;
capacitance of the load;
length from the first portion of each stator face to the second portion of each stator face during which the magnetic flux, except magnetic flux leakage, does not pass through the rotor faces into or out of each stator magnetic flux paths;
shape of the rotor face; and
length of the rotor face.

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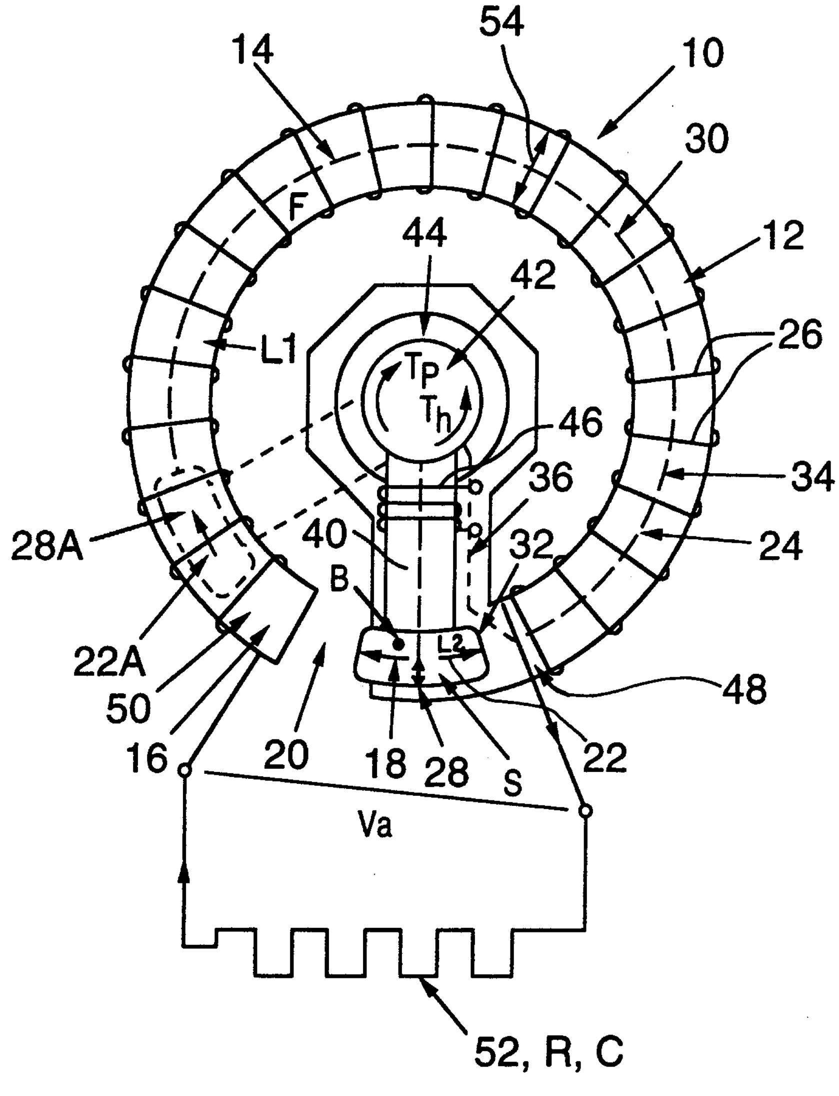

FIG.1. (PRIOR ART).

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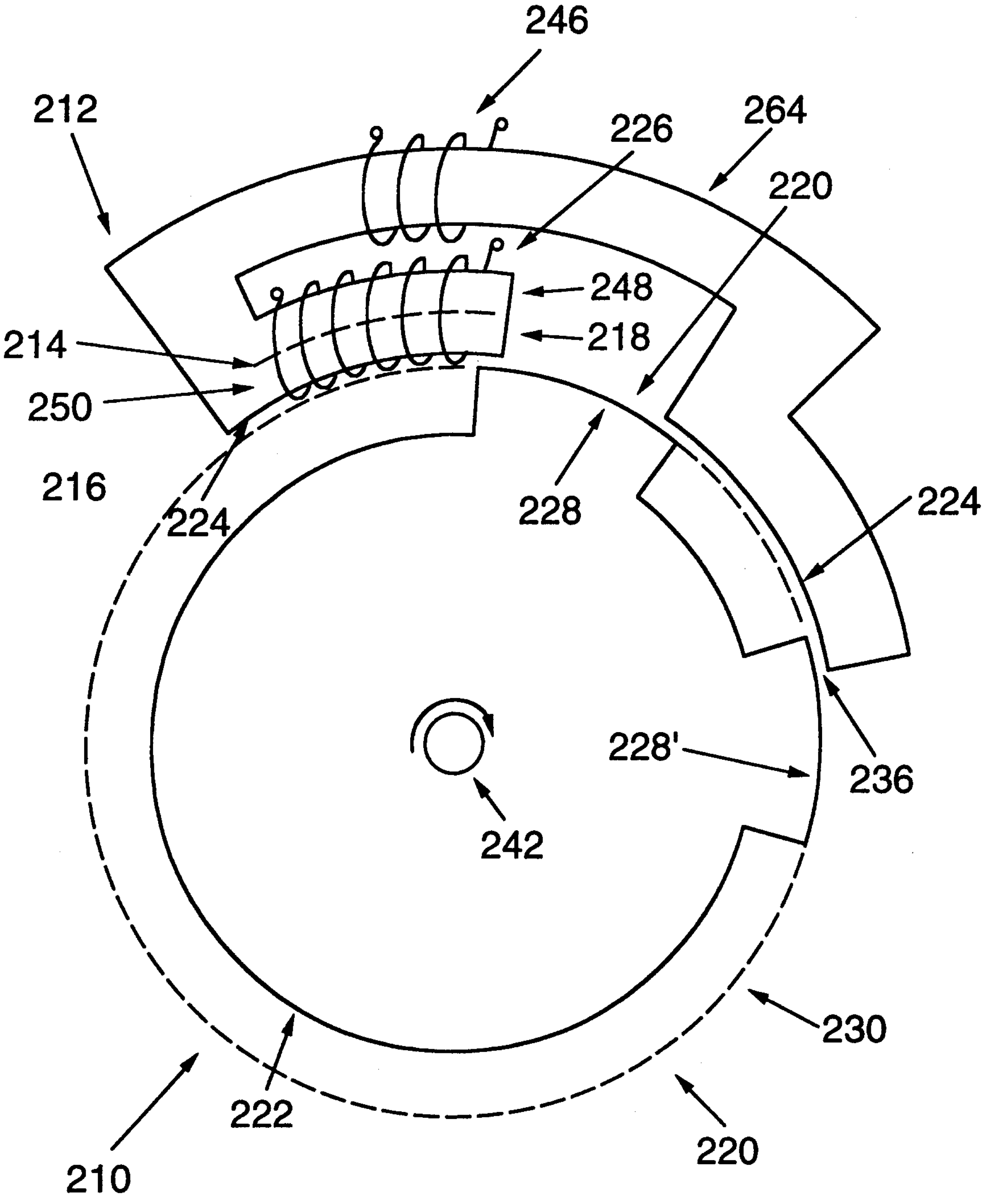

FIG.2a.

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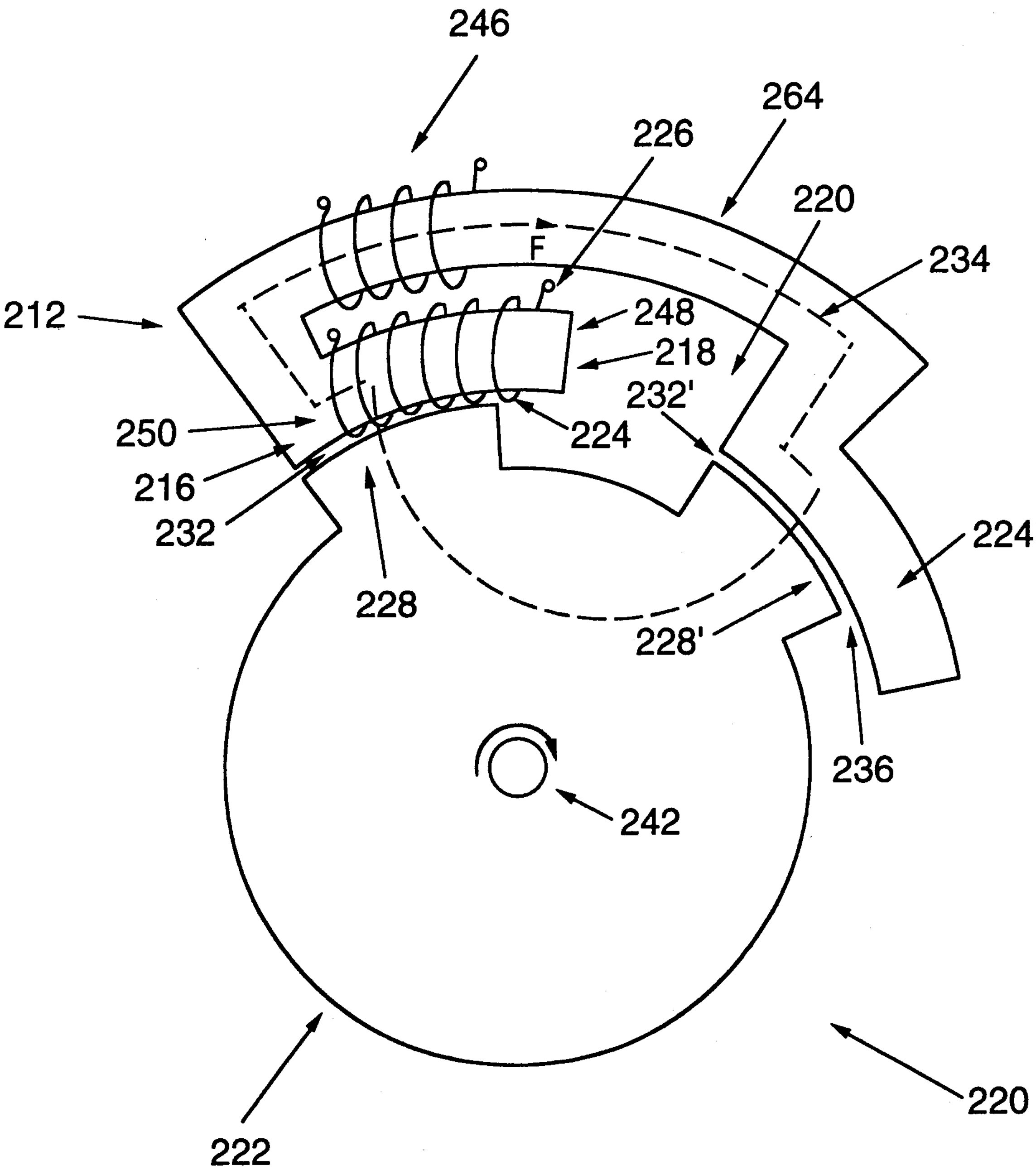

FIG.2b

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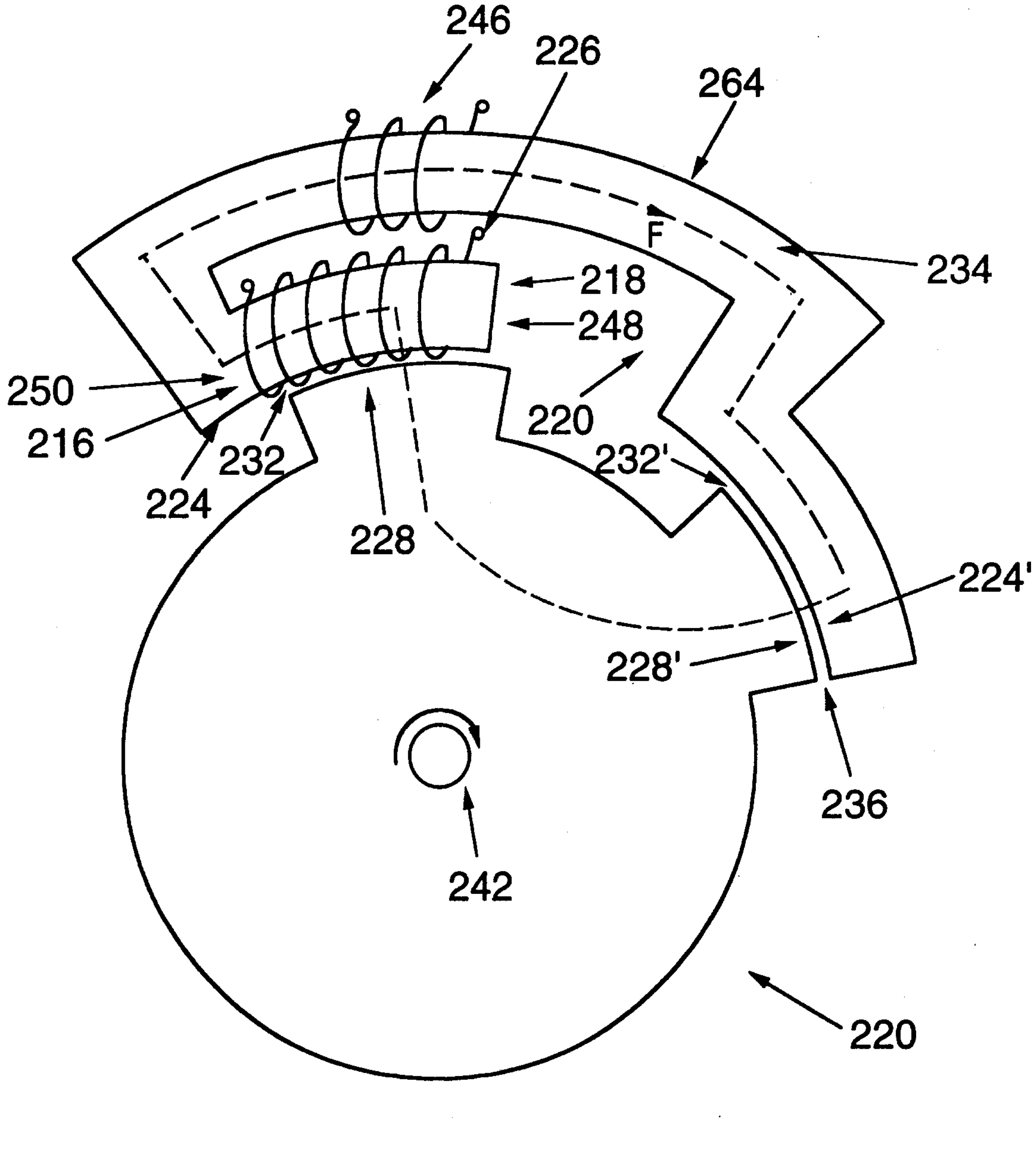

FIG.2c

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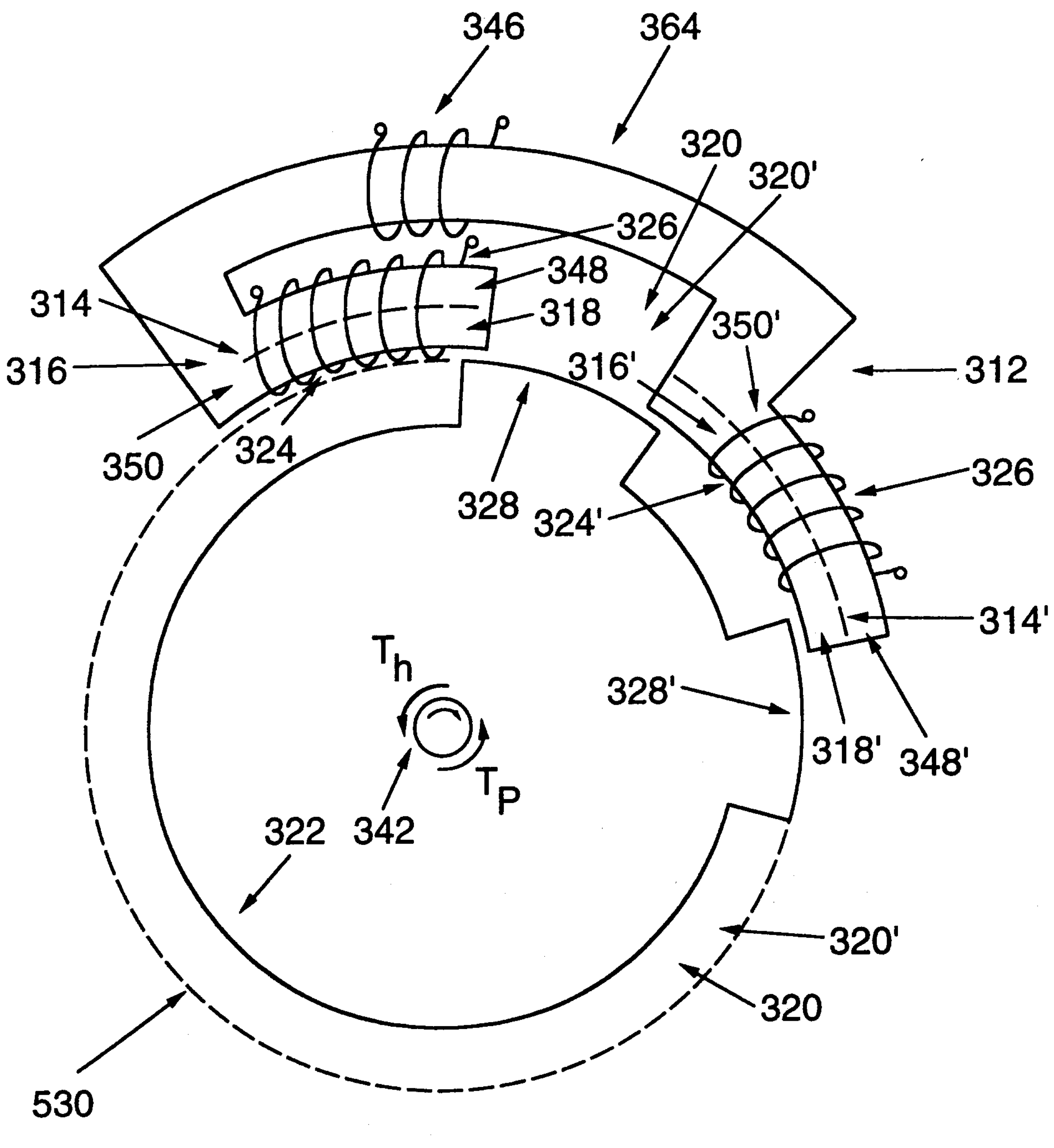

FIG.3

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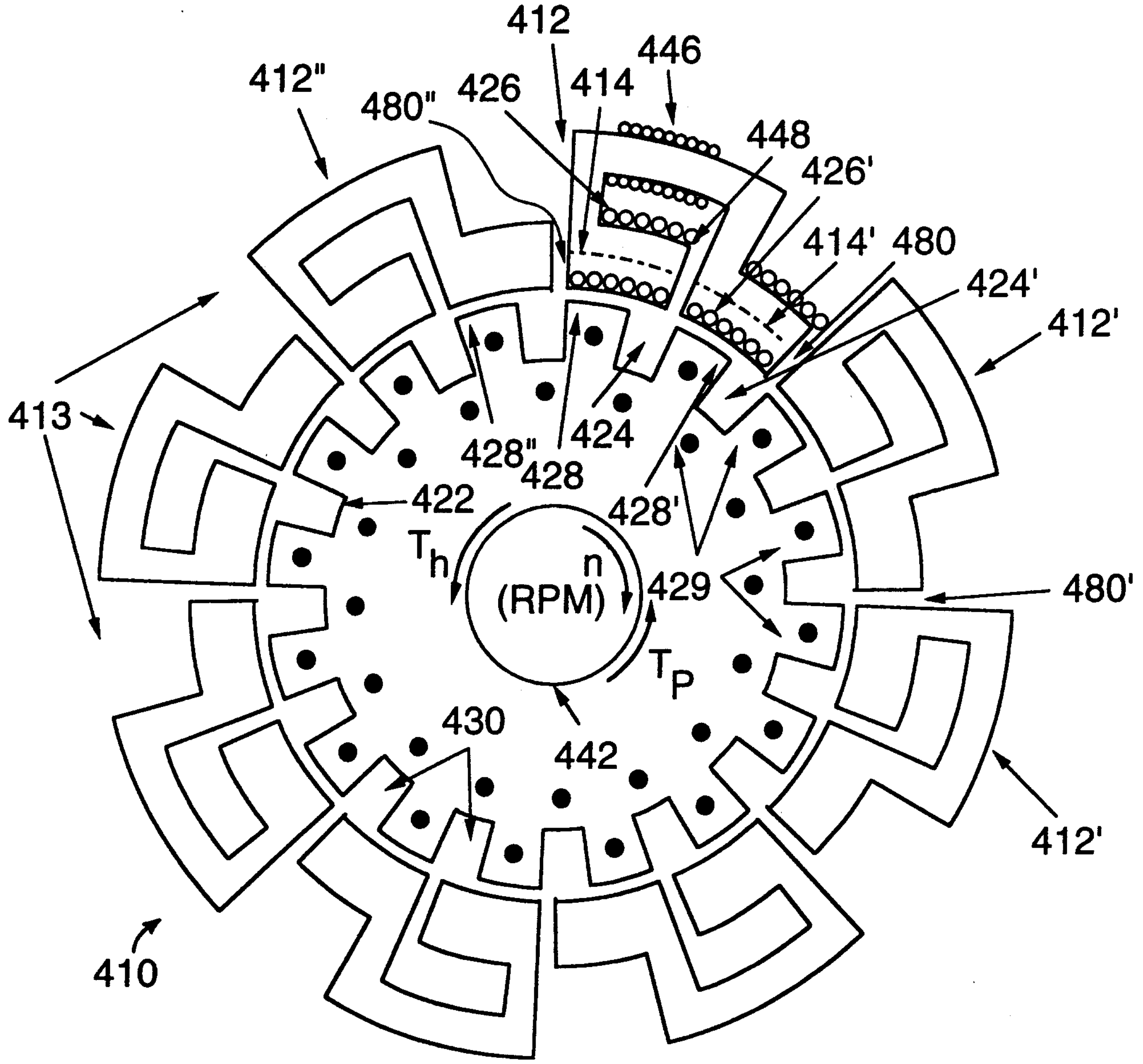

FIG.4

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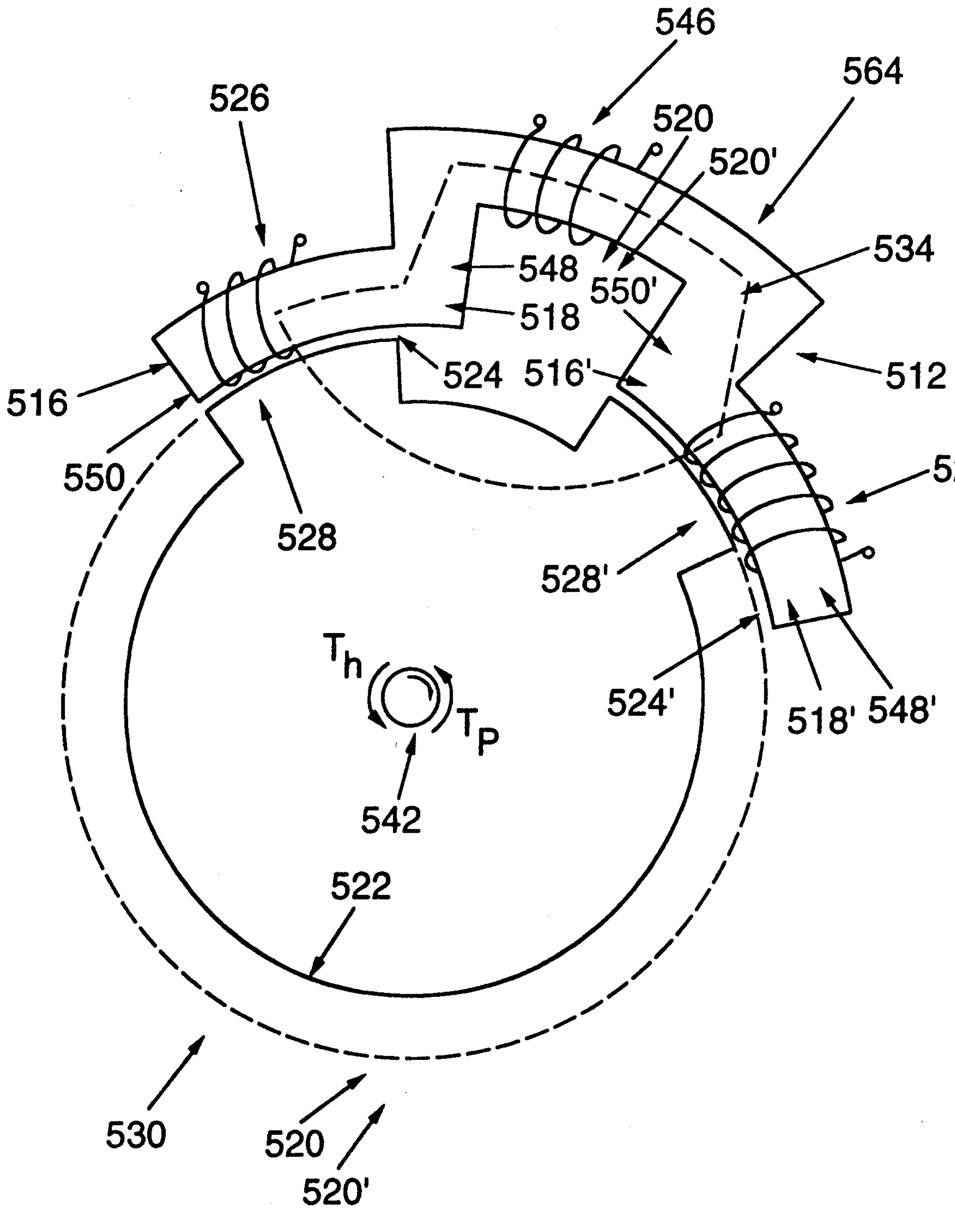

FIG.5