

A Practical Guide to 'Free Energy' Devices

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Please note that this is a re-worded excerpt from this patent. It describes a motor which has an output power greater than its input power.

United States Patent 5,436,518

25th July 1995

Inventor: Teruo Kawai

MOTIVE POWER-GENERATING DEVICE

SUMMARY OF THE INVENTION

It is an object of the invention to provide a motive power generation device in which the occurrence of a force acting in a direction opposite to the direction of movement of a rotor and/or a stator is prevented, so as to permit efficient use of electric energy to be applied to electromagnets, as well as magnetic energy generated by a permanent magnet.

In order to achieve the above object, the first invention comprises a permanent magnet disposed around a rotational output shaft which is mounted on a bearing, a magnetic body positioned concentrically with the permanent magnet for rotation with the output shaft, the magnetic body being subjected to the magnetic flux of the permanent magnet, a plurality of electromagnets permanently mounted on the support member so that they are spaced a predetermined distance around the periphery of the magnetic material, each magnetic circuit of the electromagnets being independent of one another and the excitation change-over mechanism of the electromagnets which can sequentially magnetise one of the electromagnets which is positioned forward, with regard to a rotational direction, of the output shaft, so as to impart to the electromagnet a magnetic polarity magnetically opposite to that of the magnetic pole of the permanent magnet, whereby a magnetic flux passing through the magnetic body converges in one direction thereby applying a rotational torque to the output shaft.

According to the first invention, when one of the electromagnets which is positioned ahead in the rotational direction of the rotational output shaft, a magnetic field created by the excited electromagnet and a magnetic field created by the permanent magnet interact with each other. Thus, the magnetic flux passing through the magnetic body converges toward the excited electromagnet, so as to rotate the rotational output shaft by a predetermined angle toward the excited electromagnet. When the rotational output shaft has been rotated by the predetermined angle, the above excited electromagnet is demagnetised, and another electromagnet currently positioned ahead with respect to the rotational direction of the rotor output shaft is excited or magnetised. Sequential excitation of the electromagnets in the above manner permits rotation of the output shaft in a predetermined direction. In this regard, it should be noted that the electromagnets are excited so as to have a magnetic polarity opposite to that of the magnetic pole of the permanent magnet and that the magnetic circuit of the excited electromagnets is independent from those of adjacent electromagnets. Thus, the magnetic flux generated by the excited electromagnet is prevented from passing through magnetic circuits of adjacent electromagnets, which, if it occurs, might cause the electromagnets to be magnetised to have the same polarity as that of the magnetic pole of the permanent magnet. Accordingly, no objectionable force will be generated which might interfere with rotation of the output shaft.

In order to achieve the above object, the second invention comprises a permanent magnet mounted on a movable body arranged movably along a linear track, a magnetic body mounted on the permanent magnet, the magnetic body being subjected to a magnetic flux of the permanent magnet, a plurality of electromagnets spaced an appropriate distance along the linear track, the electromagnets having magnetic circuits which are independent of one another and the excitation mechanism arranged to magnetise each of the electromagnets sequentially when each is positioned forward of the movable body, (with respect to the direction of movement) so as to impart to the excited electromagnet a magnetic polarity opposite to that of the magnetic pole of the permanent magnet, whereby a magnetic flux passing

through the magnetic body converges in a predetermined direction so as to cause linear movement of the movable body.

According to the second invention, when the electromagnet positioned ahead of the forward end of the movable body with regard to the direction of the movement of the movable body is excited, a magnetic field generated by the excited electromagnet and magnetic field generated by the permanent magnet interact with each other. Thus, a magnetic flux passing through the magnetic body converges toward the excited electromagnet, so as to displace the movable body a predetermined distance toward the excited electromagnet. When the movable body has been moved the predetermined distance, the movable body is positioned below the above excited electromagnet, and another electromagnet is positioned ahead of the forward end of the movable body. When this occurs, excitation of the electromagnet positioned above the movable body is interrupted, and excitation of the electromagnet now positioned ahead of the forward end of the movable body is initiated. Sequential excitation of the electromagnets in the above manner permits movement of the movable body in a predetermined direction. It should be noted that no objectionable force which would interfere with movement of the movable body is created for the same reason as that explained in relation to the first invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a front elevational view, partly in section and partly omitted, of a motor according to a first embodiment of the invention;

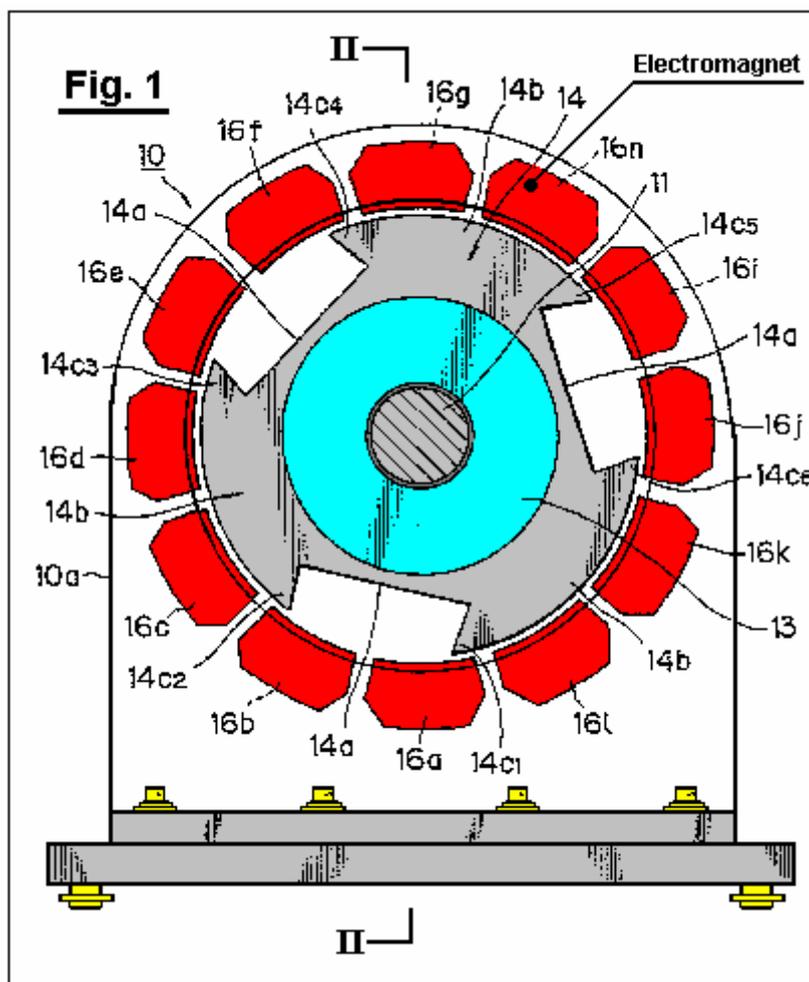


Fig.2 is a sectional view along line II--II in Fig.1;

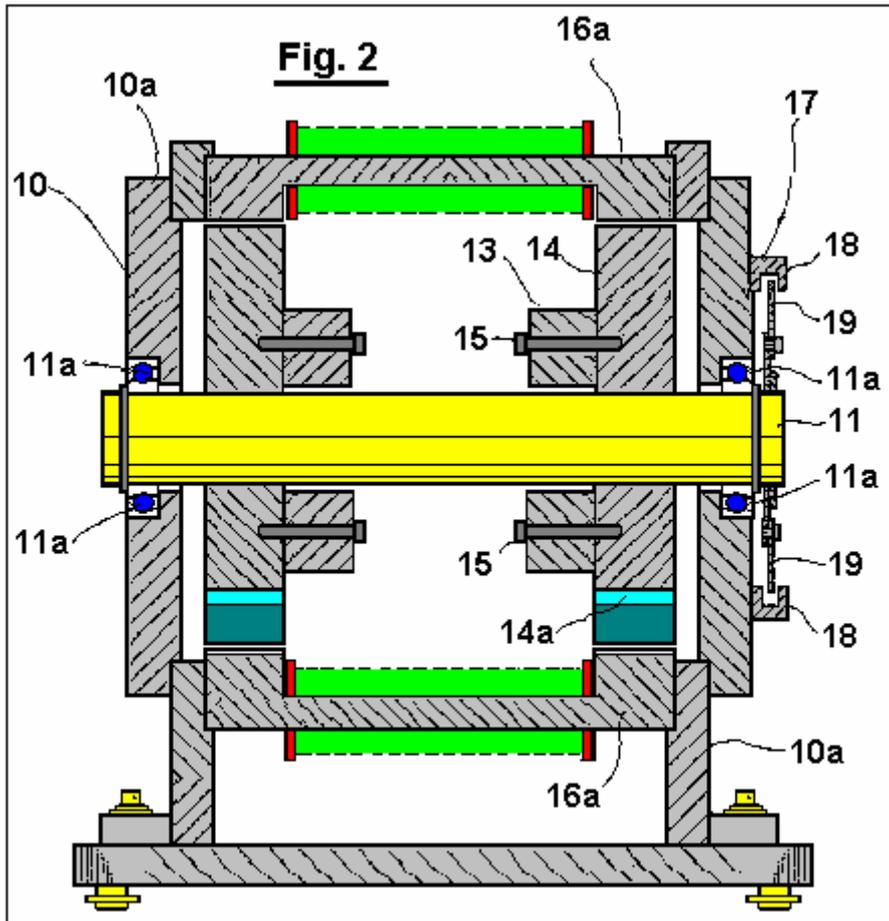


FIG. 3 is a rear elevational view of the motor provided with a light shield plate thereon;

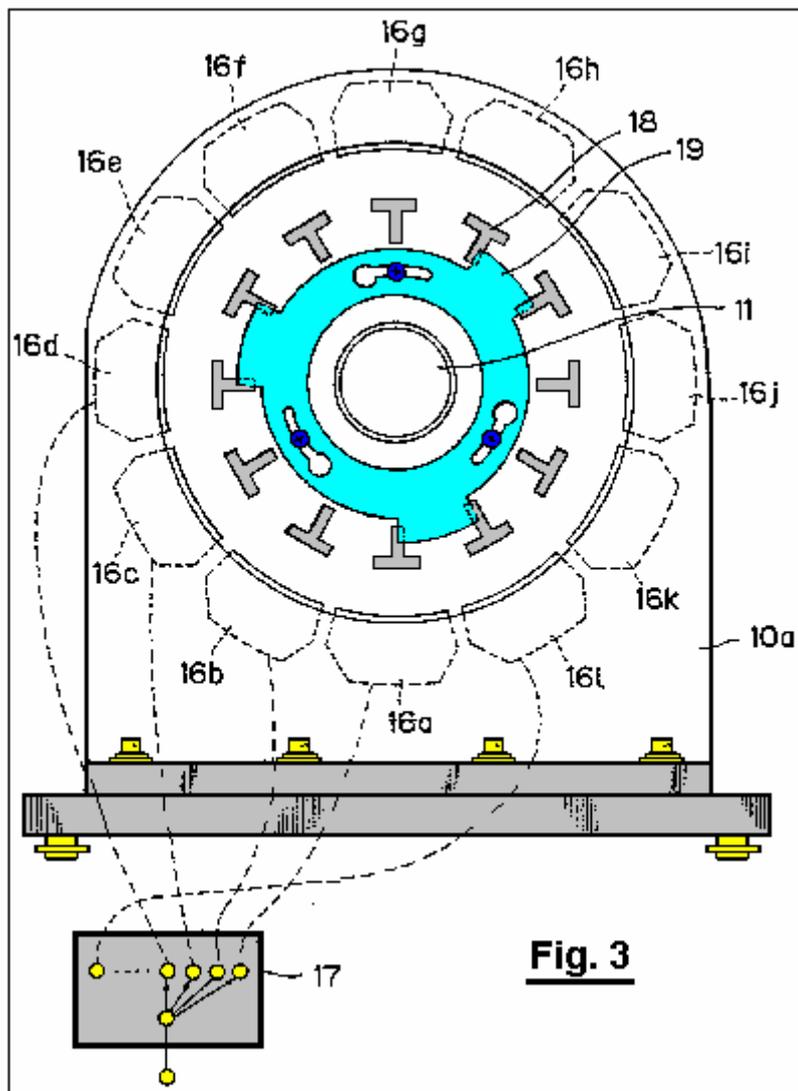
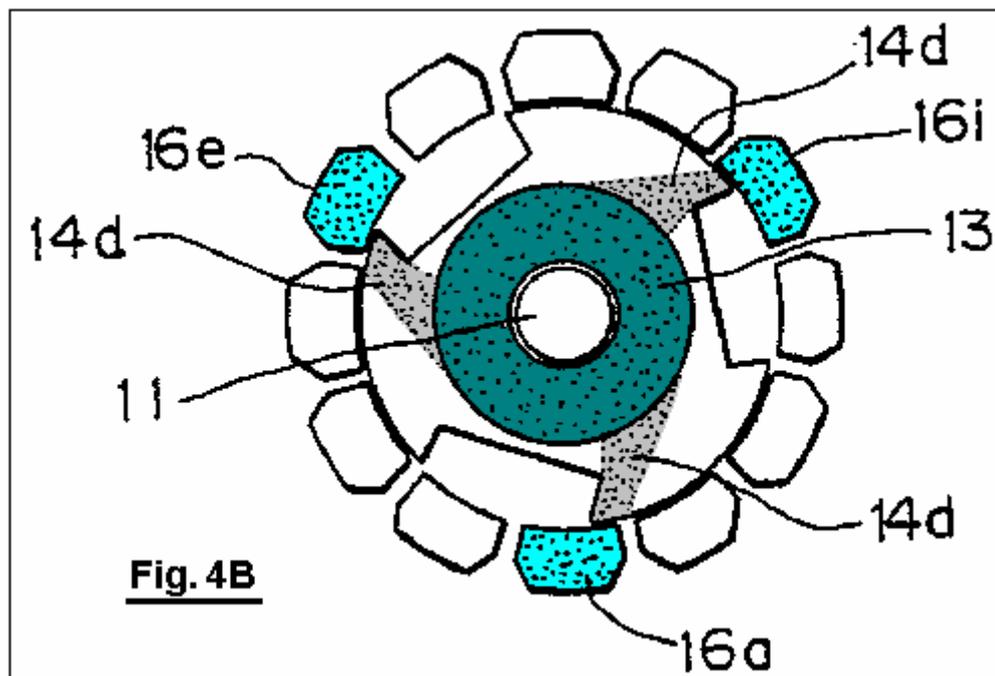
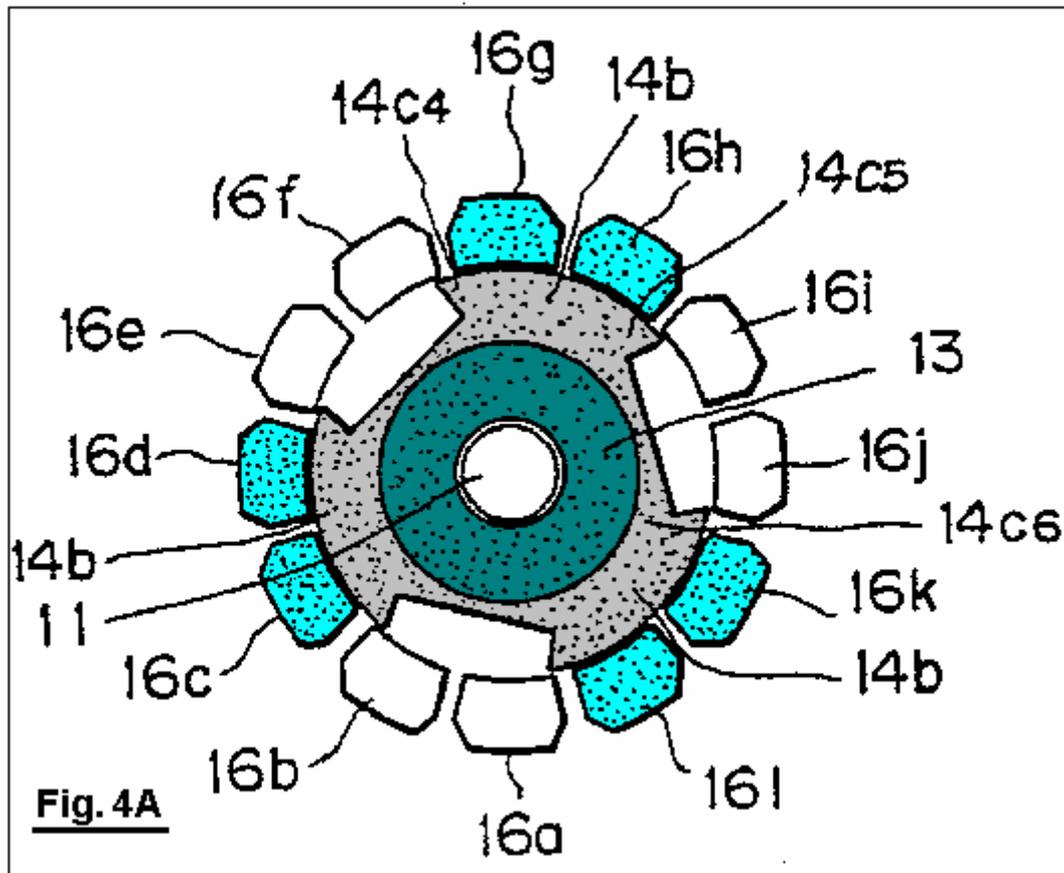
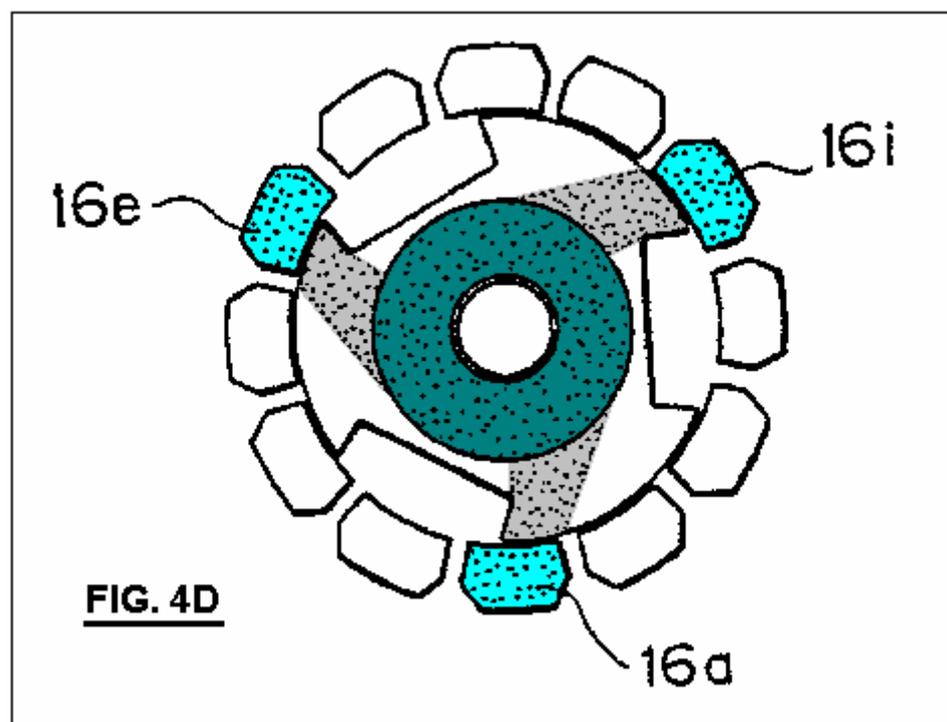
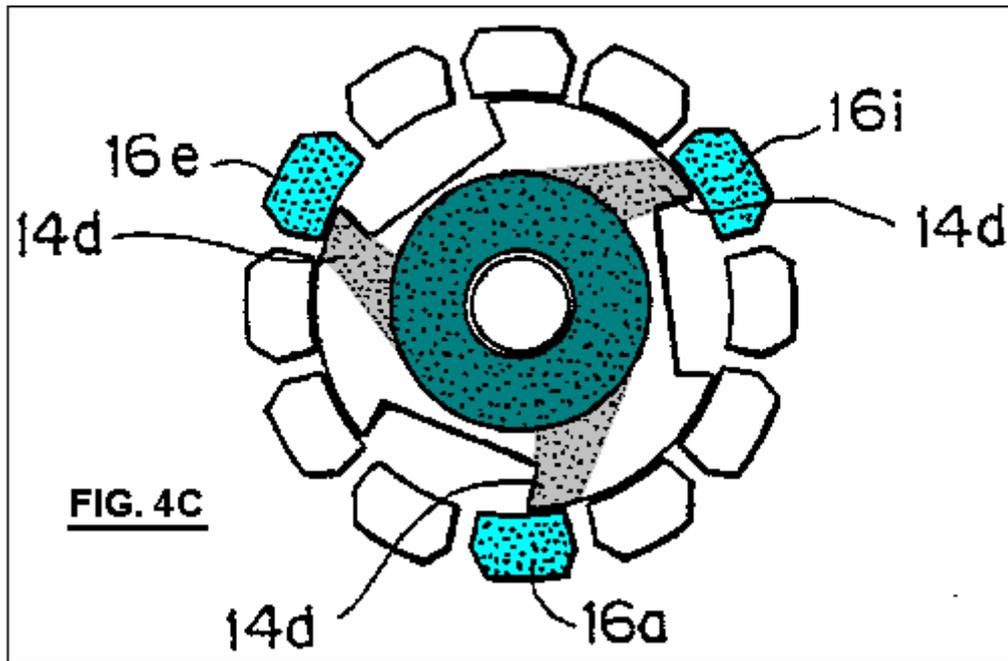
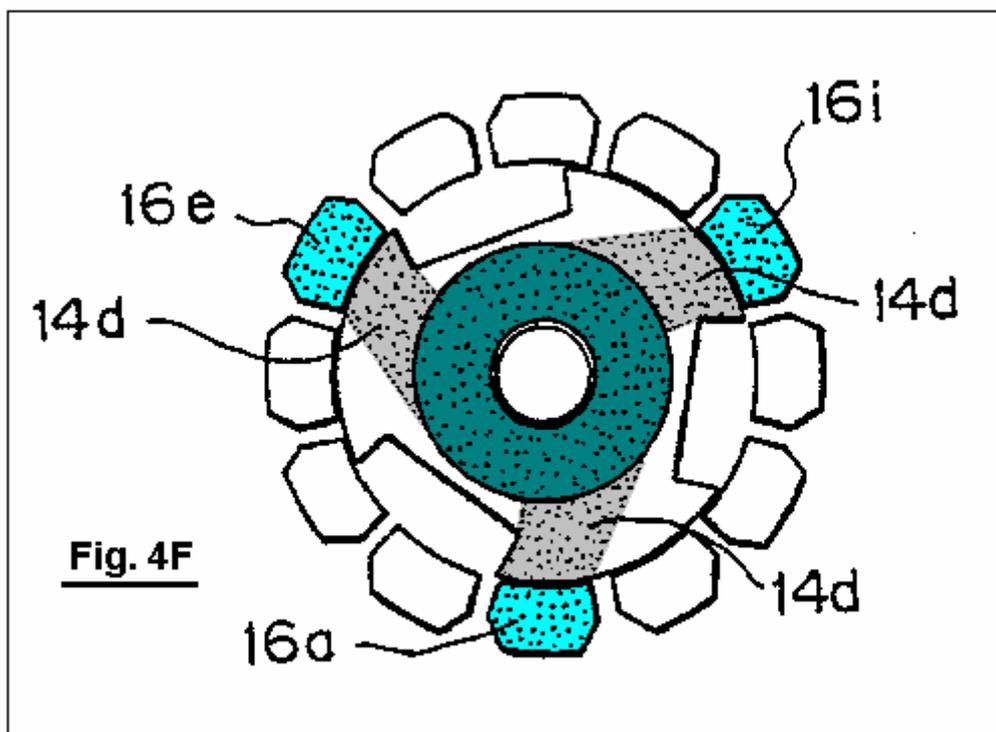
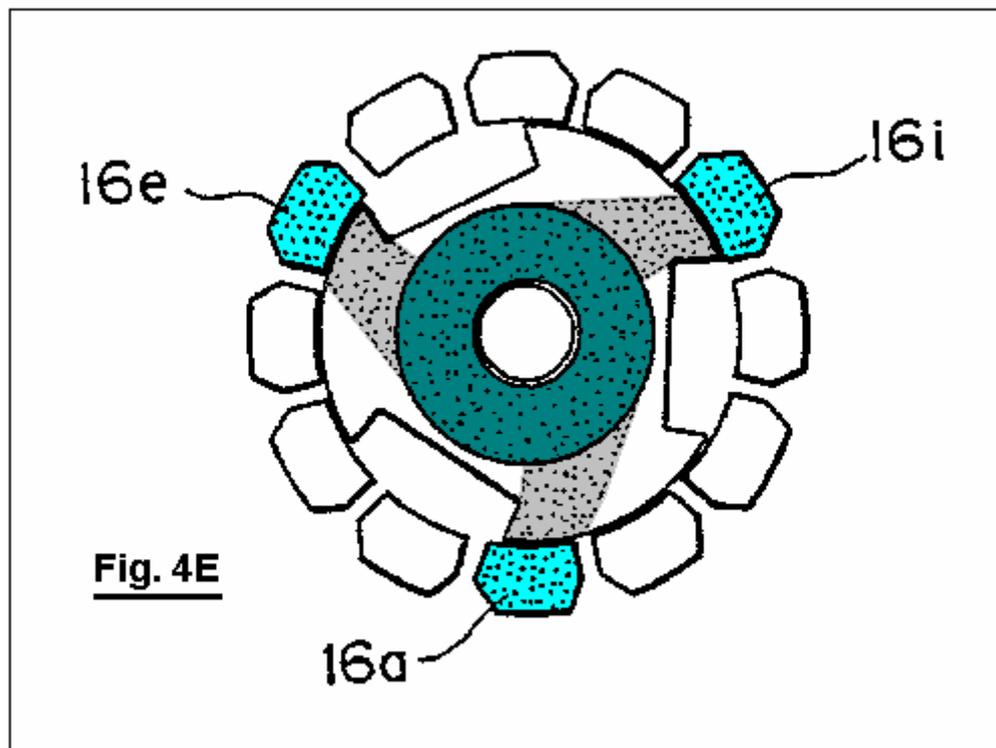


Fig.4A through Fig.4H illustrate operation of the motor when the electromagnets are excited or magnetised;







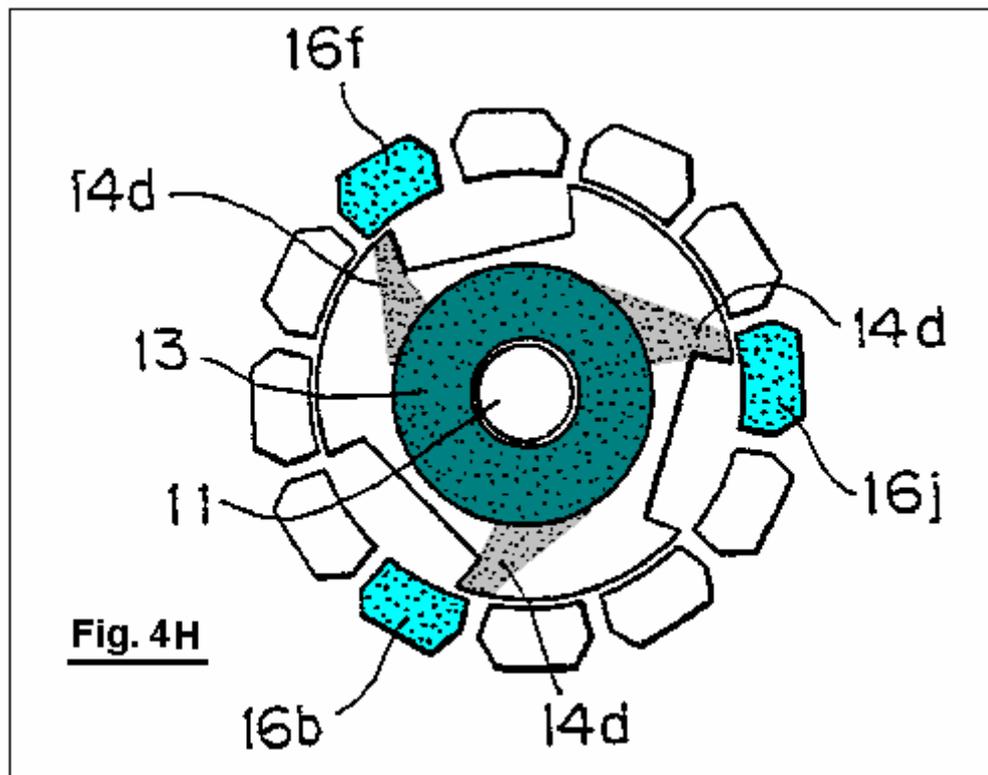
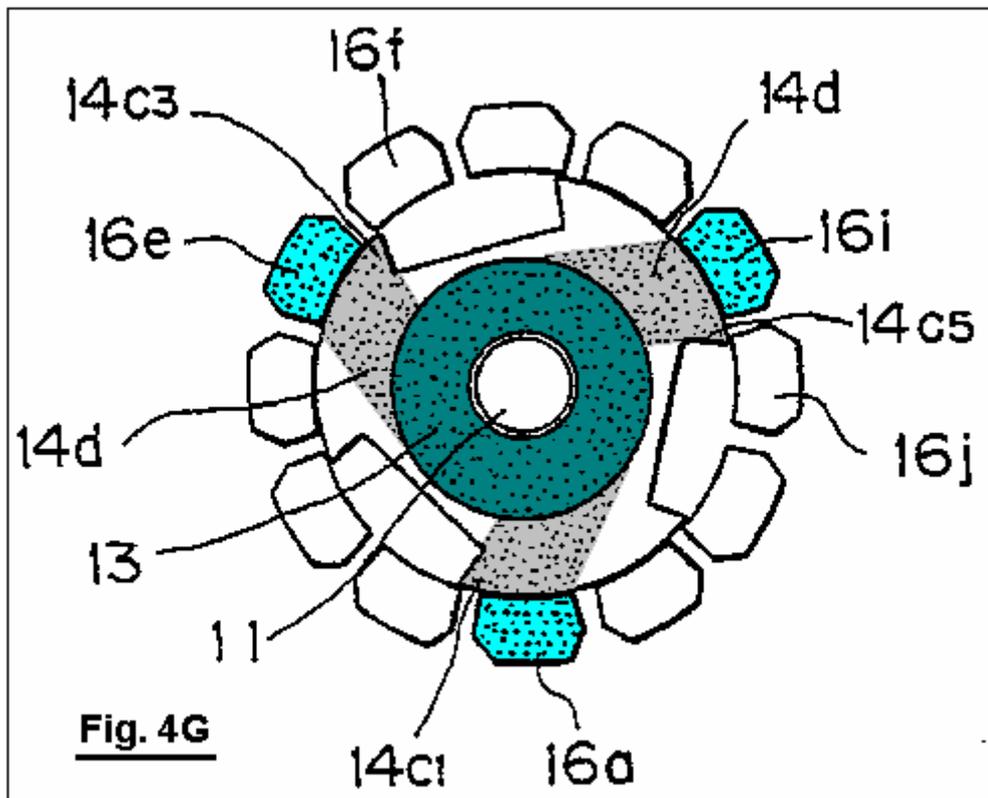


Fig.5A is an illustrative view showing a magnetic path of magnetic flux created by a permanent magnet of the motor when the electromagnets are not magnetised;

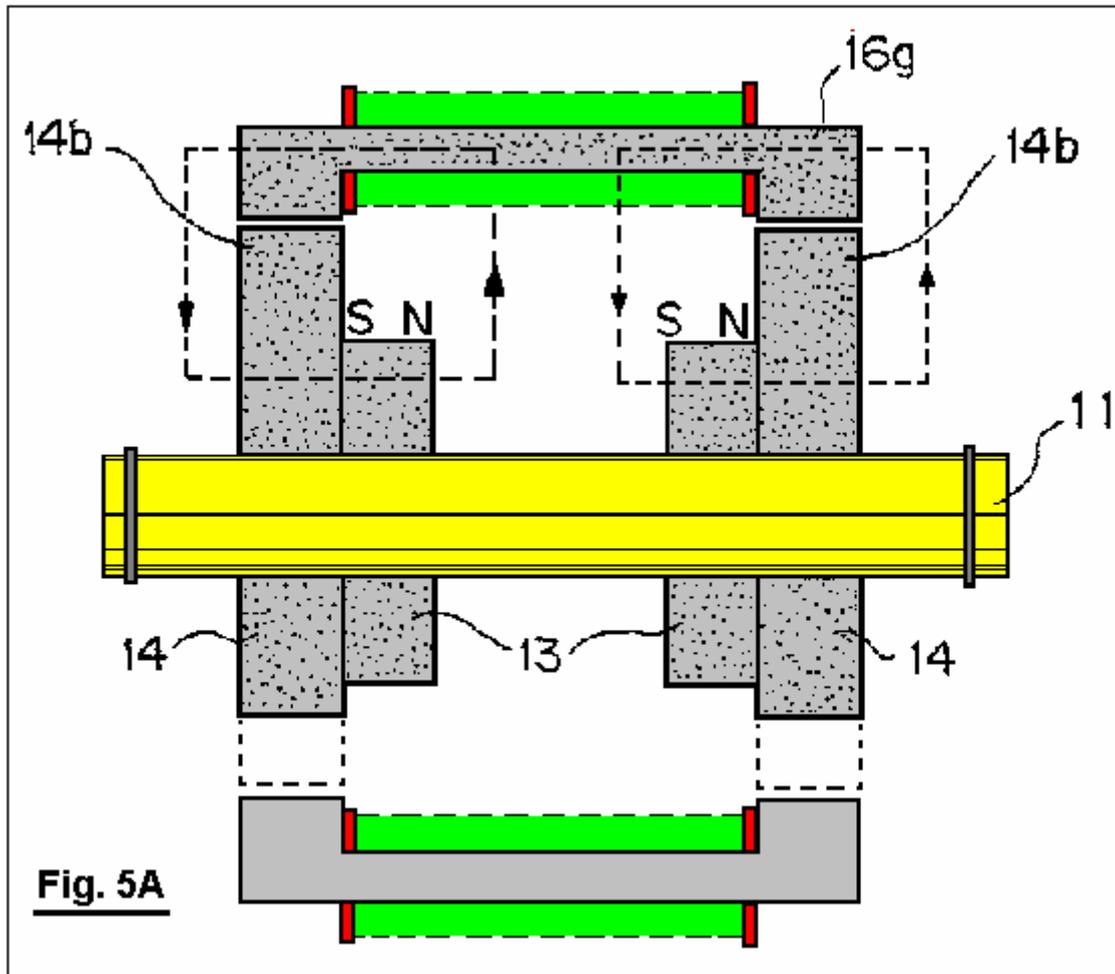
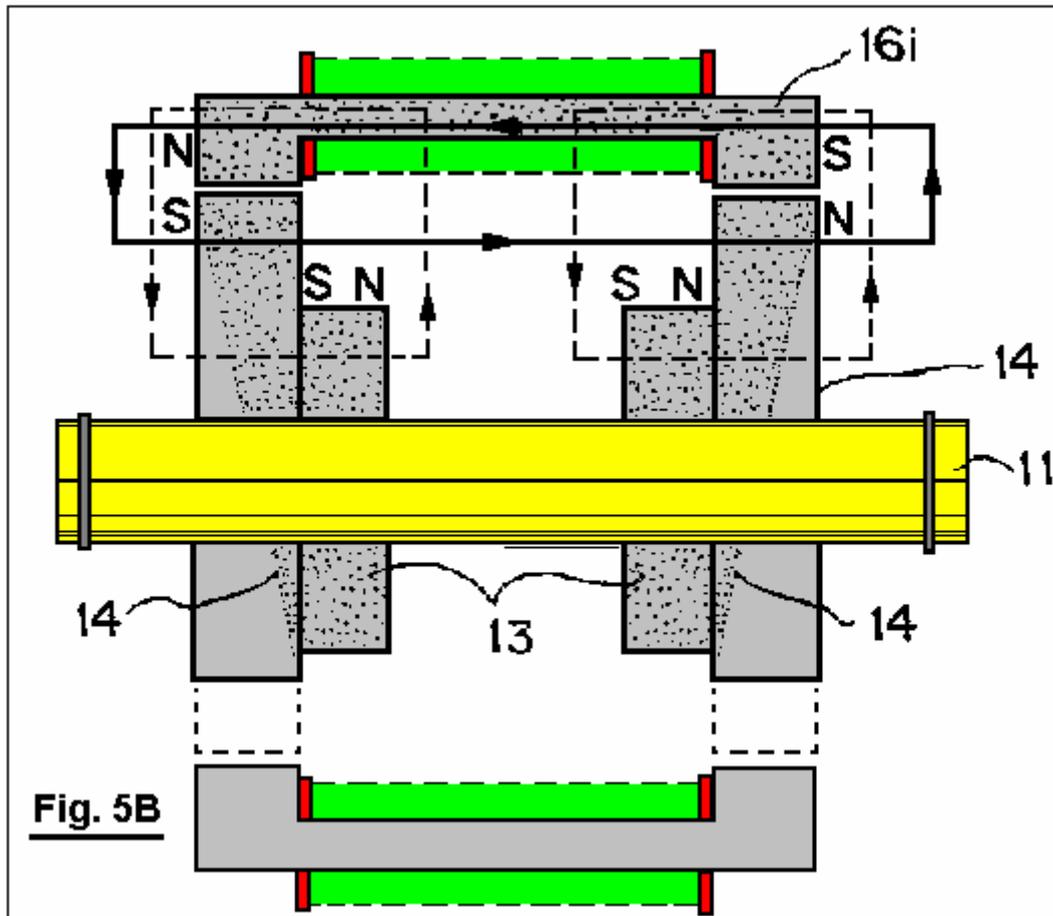
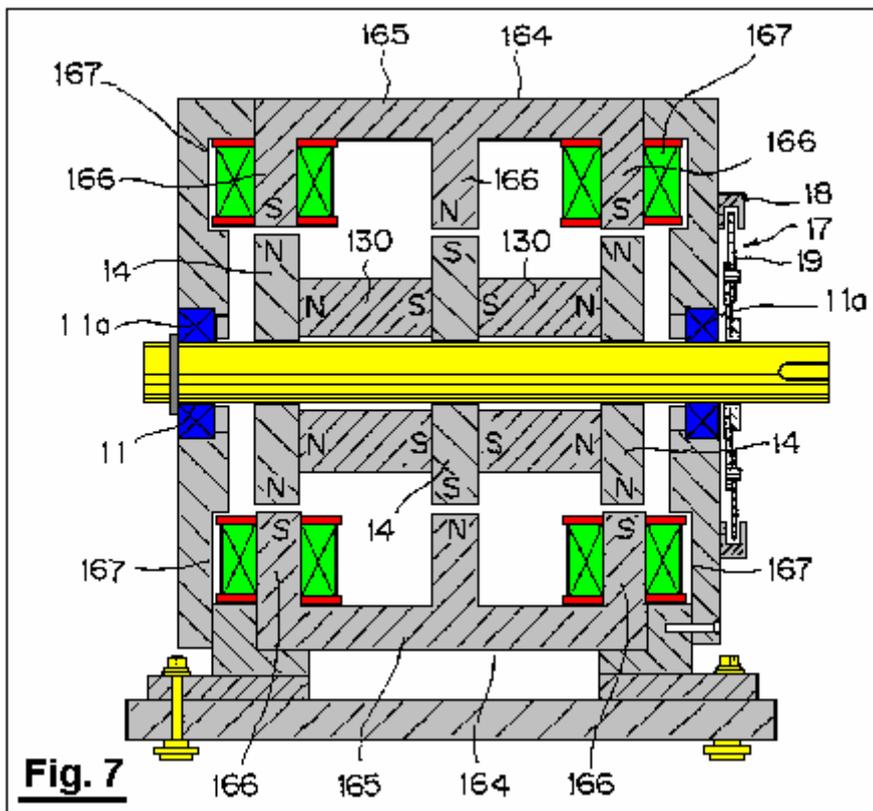
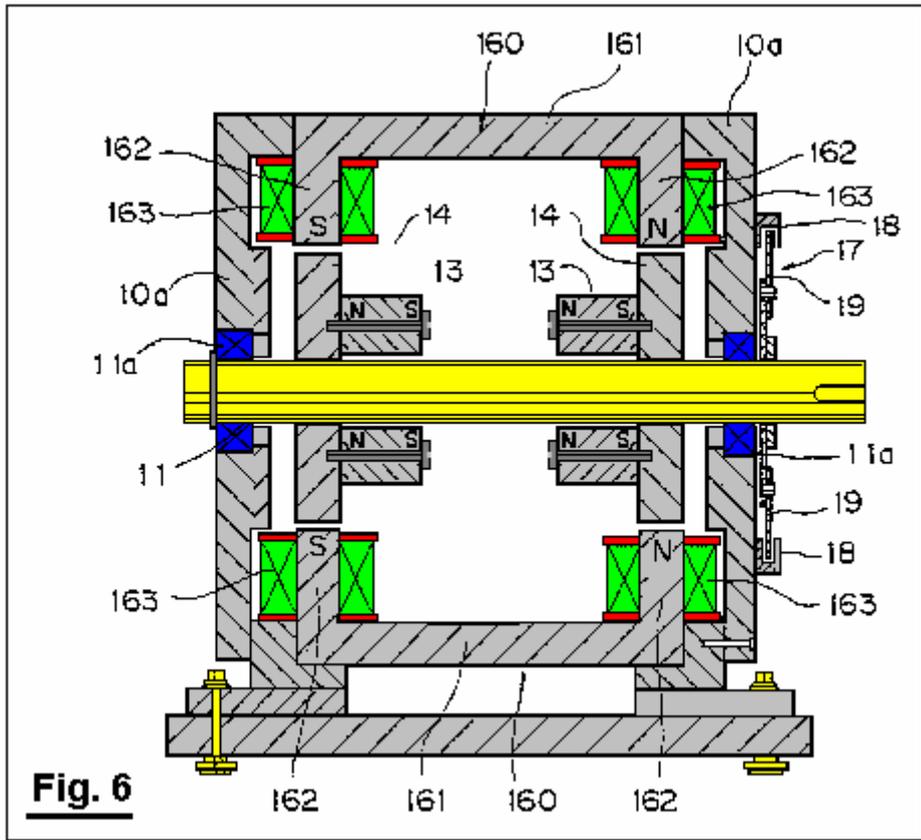
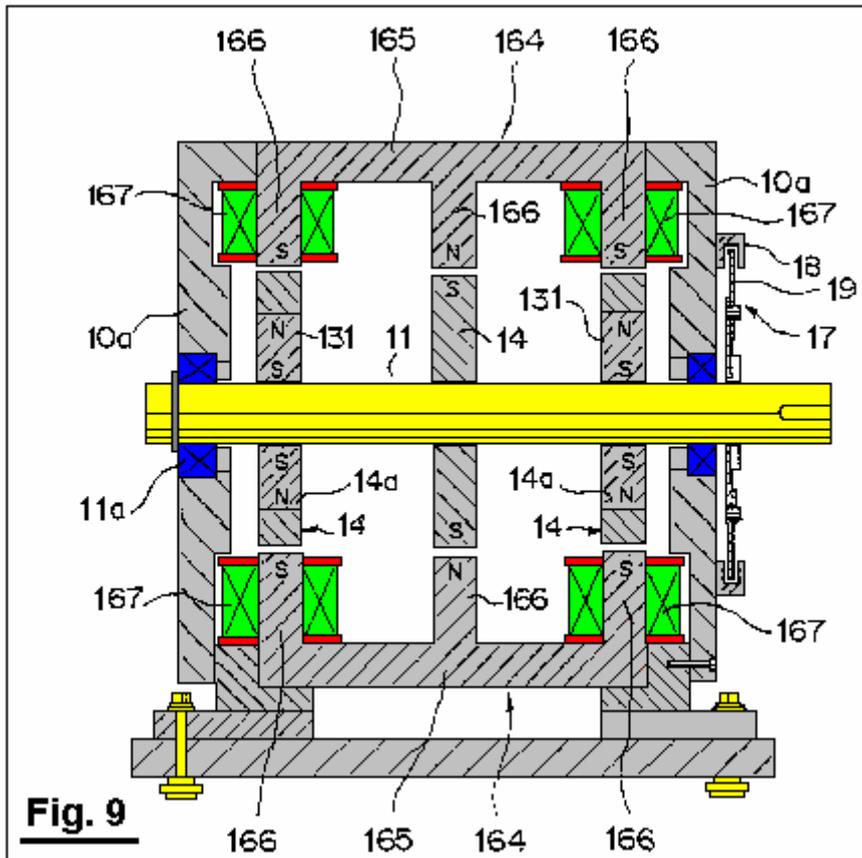
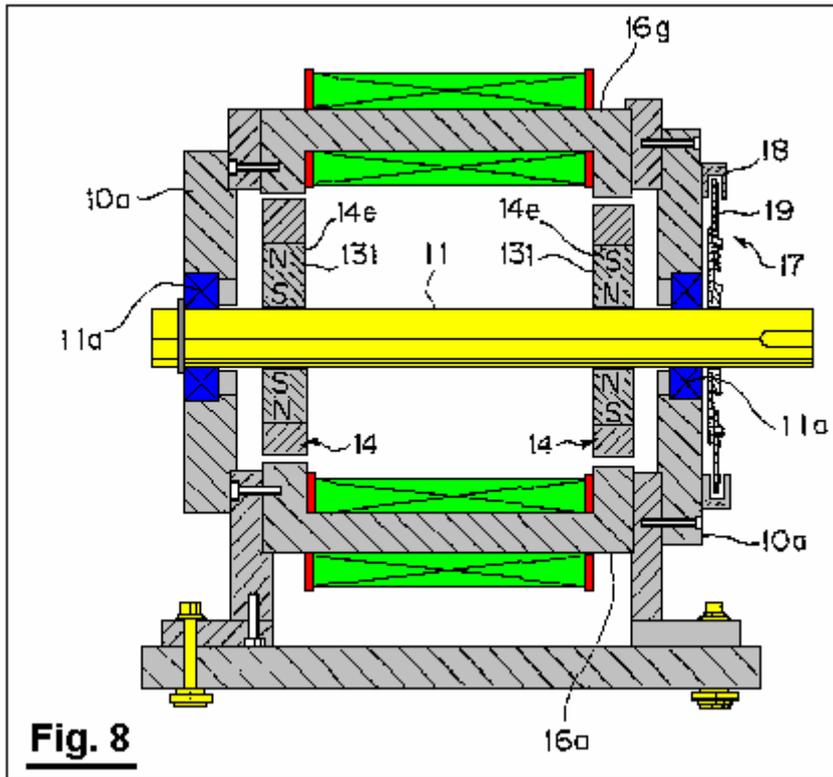


Fig.5B is an illustrative view showing a magnetic path of magnetic flux created by the permanent magnet of the motor, as well as magnetic path of magnetic flux created by the electromagnets;

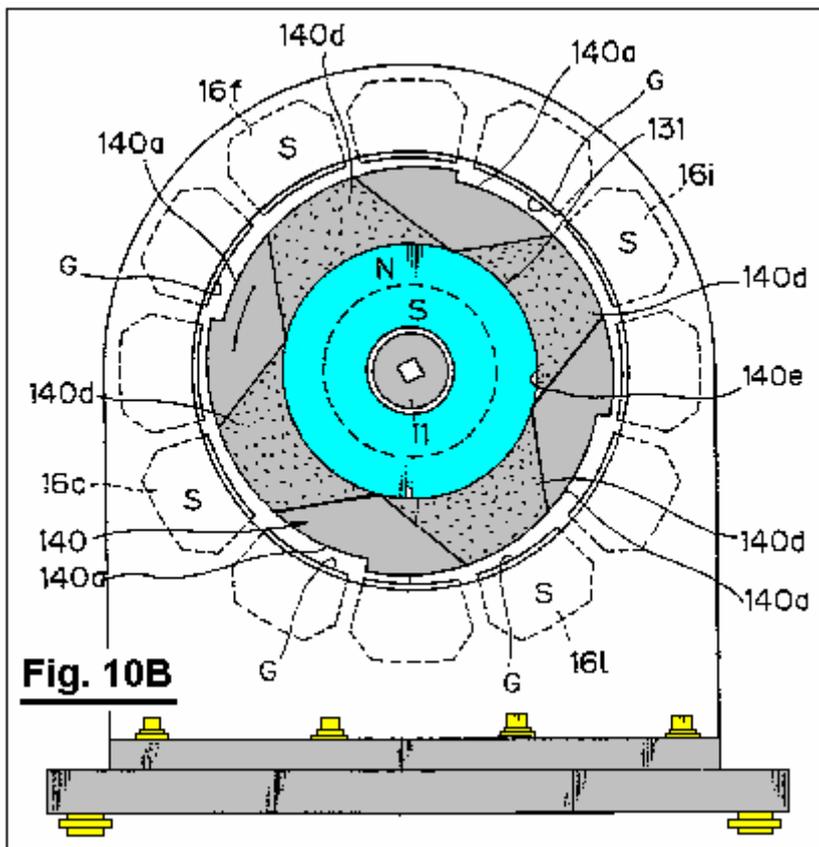
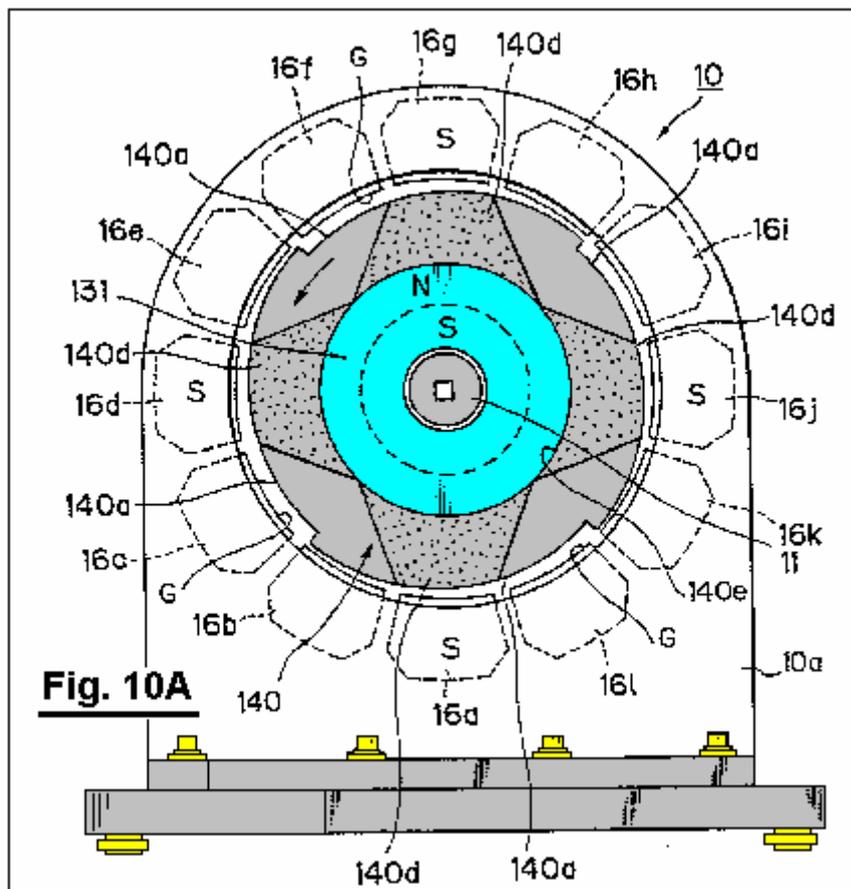


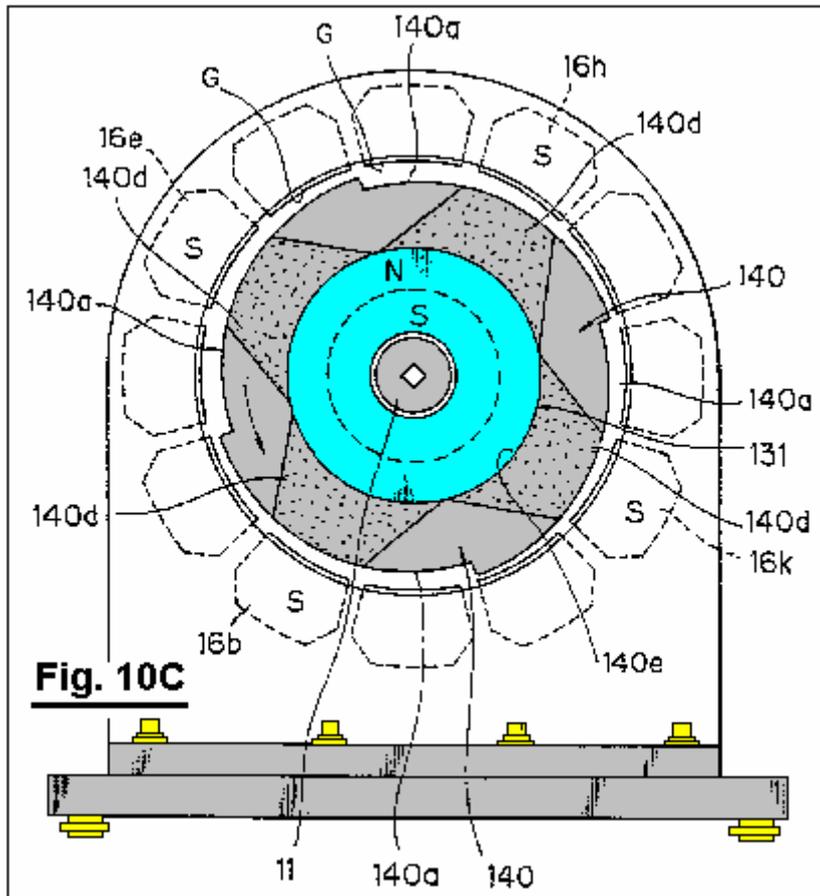
FIGS. 6 through 9 are cross-sectional view illustrating a modified form the motor;





FIGS. 10A through 10C are cross-sectional views illustrating operation of the modified motor;





FIGS. 11A through 11H are illustrative diagrams showing operation of a motor in a form of a linear motor according to a second embodiment of the invention;

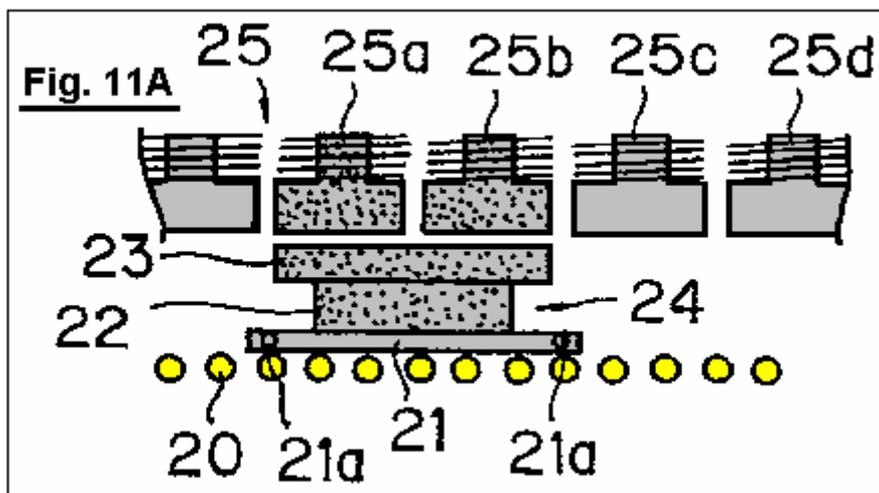


Fig. 11B

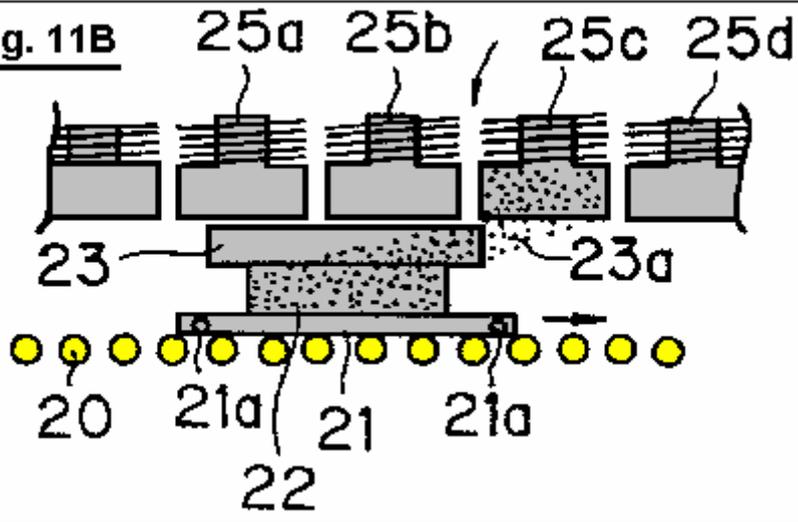


Fig. 11C

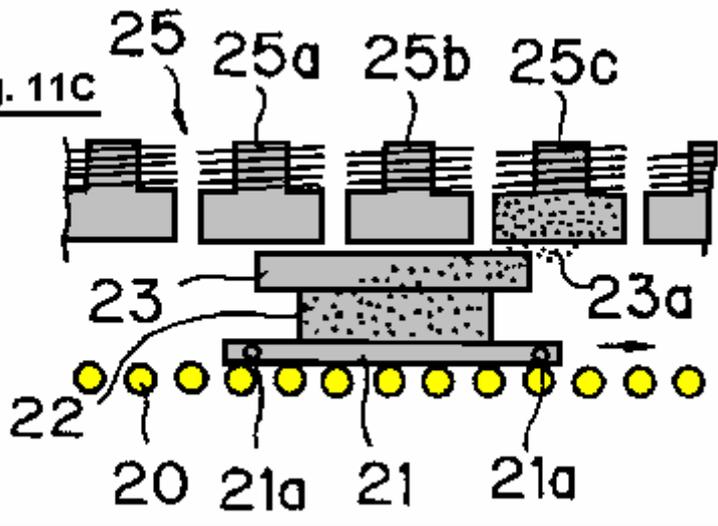
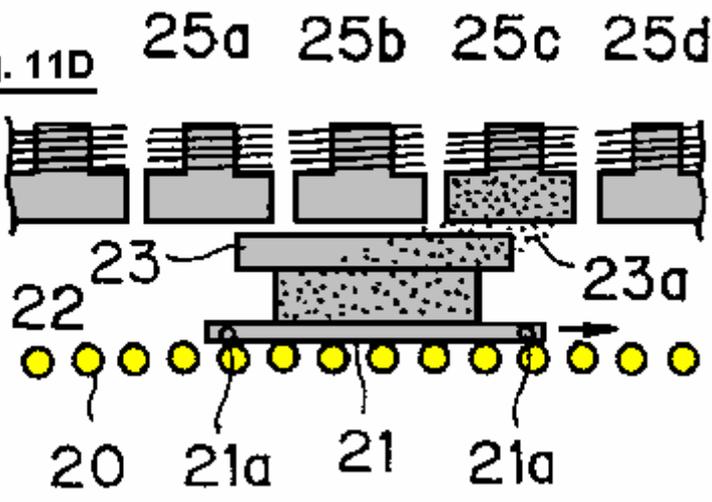
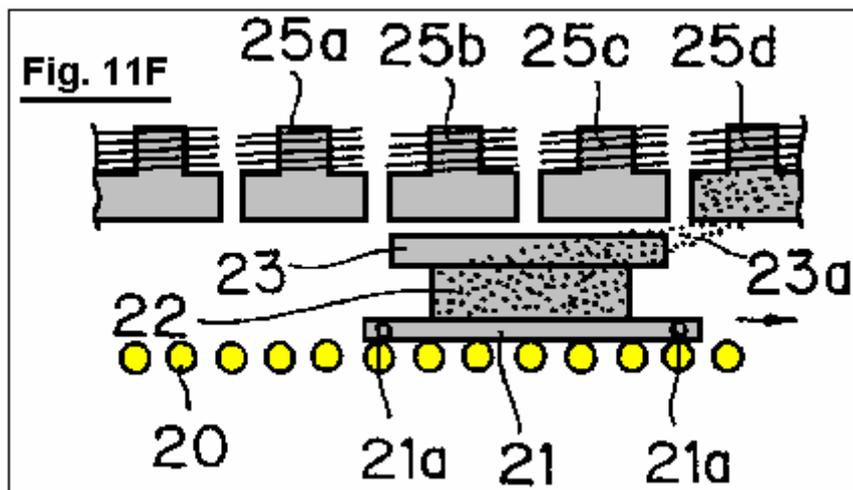
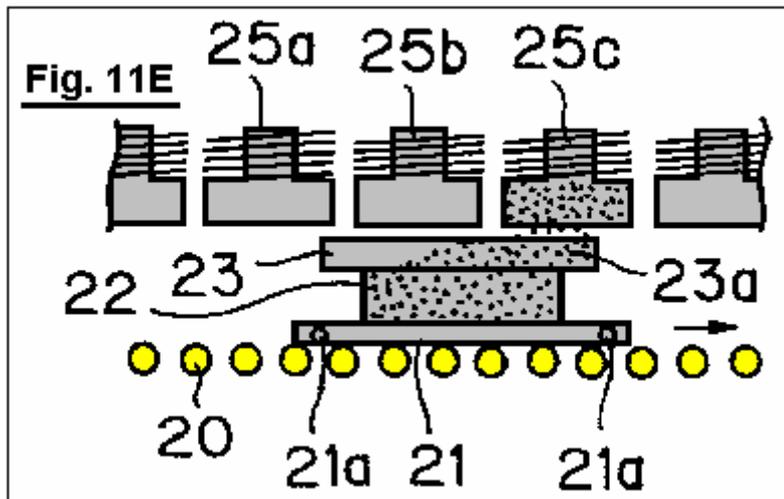


Fig. 11D





DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of the invention will be explained in detail below with reference to the attached drawings.

According to a first embodiment of the invention, a rotational output shaft **11** is mounted in a bearing between front and rear side plates **10a** of a support member **10** through bearings **11a**, as shown in **Fig.1** and **Fig.2**. A ring of permanent magnets **13** are fitted over the opposite ends of the output shaft, inside the side plates **10a** and these move with the rotor shaft **11**. The permanent magnets are magnetised in the axial direction. A magnetic body **14** is rigidly mounted between each of the side plates **10a** of the rotor shaft **11** and the permanent magnets **13**. Each of these magnetic bodies **14** has alternate notches **14a** and magnetic teeth **14b**. It should be noted that the flux of the permanent magnets **13** passes through the respective magnetic bodies **14**. For example, **Fig.1** shows the magnetic body **14** with three notches **14a** and three magnetic teeth **14b**. The permanent magnets **13** and magnetic bodies **14** are positioned co-axially with the rotor output shaft **11**. The corresponding permanent magnets **13** and magnetic bodies **14** are shown connected together by bolts **15** so as to form a rotor **12** which is attached to the rotational output shaft **11**.

It should be noted that the support member **10** and rotational output shaft are both made from a non-magnetic material. The support member **10** may be formed, for example, from stainless steel, aluminium alloys, or synthetic resins, while the rotational output shaft **11** may be formed from stainless steel, for example. Thus, the magnetic circuit formed by the permanent magnet **13** and magnetic body at one axial end of the rotational output shaft **11** and the magnetic circuit formed by the permanent magnet **13** and magnetic body at the opposite axial end of the output shaft, are independent of one another. The

magnetic bodies **14** may be formed from magnetic materials having a high magnetic permeability, such as various kinds of steel materials, silicon steel plate, permalloys, or the like.

The stator contains electromagnets **16a** through **16l**, which are positioned between the side plates **10a**. The electromagnets are evenly spaced around the magnetic pieces **14** so that they surround the magnetic bodies. As shown in **Fig.1**, twelve electromagnets may be used. The magnetic circuit of each of the electromagnets **16a** through **16l** is arranged so as to be independent of each other, so that no flux of a magnetised electromagnet passes through the iron cores of the adjacent electromagnets.

The iron cores of the electromagnets **16a** through **16l** are positioned parallel to the rotor axis shaft **11**, and positioned with only a slight gap between them and the magnetic bodies **14**.

Some of the electromagnets **16a** through **16l** are located at a position corresponding to boundary portions **14c1** through **14c6** between the notch **14a** and the magnetic tooth **14b**. For example, as shown in **Fig.1**, electromagnets **16a**, **16b**, **16e**, **16f**, **16i** and **16j** are positioned opposite the boundary portions **14c1**, **14c2**, **14c3**, **14c4**, **14c5**, and **14c6**, respectively.

Fig.5A shows a path of magnetic flux created by the permanent magnet **13** when the electromagnets are not excited or magnetised, while, **Fig.5B** shows a path of magnetic flux created by the permanent magnet **13** and a path of magnetic flux created by the windings of the electromagnets when the electromagnets are magnetised. As will be clear from **Fig.5A** and **Fig.5B**, both paths of magnetic flux represent a uni-polar distribution in which N-pole or S-pole evenly appears at the opposite axial ends. When the electromagnets are magnetised, the magnetic fields of the permanent magnet and electromagnets cooperate or interact with each other so as to generate a rotational torque.

Excitation change-over mechanism **17** for sequentially exciting or magnetising the electromagnets **16a** through **16l** is basically consisted of a conventional excitation circuit for supplying direct current to each windings of the electromagnets **16a** through **16l**. In this embodiment, the change-over portion for changing electric feed to the electromagnets **16a** through **16l** includes a plurality of optical sensors **18** and a light shield plate **19** for turning the optical sensors ON and OFF as shown in **Fig.6**.

The optical sensors **18** are spaced apart from one another with a space between them for permitting the light shield plate **19** to pass through a light emitting element and a light receiving element. The optical sensors **18** are disposed in the outer surface of one of the side plates **10a** equally spaced apart along the circumference, so that they are positioned to correspond to the electromagnets **16a** through **16l** (for example, the optical sensor **18** is shown to be disposed in the outer surface of the rear side plate). The light shielding plate **19** is fixed to the rotational output shaft **11** at the end thereof, the light shielding plate protruding from the rear side plate **10a** on which the optical sensors are mounted.

According to the illustrated embodiment, when a particular optical sensor **18** is blocked by the light shielding plate **19**, the electromagnet corresponding to such optical sensor **18** is supplied with electricity.

The operation of the first embodiment described above will be explained with reference to **Fig.4A** through **Fig.4H**.

When the electromagnets **16a** through **16l** are not supplied with electricity by means of the excitation changeover mechanism **17**, the electromagnets **16c**, **16d**, **16g**, **16h**, **16k** and **16l** opposed to the magnetic teeth **14b** with a small gap between them merely serve as a magnetic material disposed within the magnetic field of the permanent magnet **13** (refer to shaded portion in **Fig.4A**), so as to absorb the magnetic teeth **14b**, and the rotor **12** remains stationary.

When the electromagnets **16a**, **16e** and **16i** positioned adjacent to the boundary portion **14c1**, **14c3** and **14c5** formed between the respective notches **14a** and the magnetic teeth **14b** are magnetised or excited simultaneously by means of the excitation change-over mechanism, as shown in **Fig.4B**, the magnetic field of the permanent magnet **13** and the magnetic fields of the electromagnets **16a**, **16e** and **16i** interact with each other, so that a magnetic flux **14d** passing through the magnetic body **14** instantaneously converges to the electromagnets **16a**, **16e**, and **16i**. In this way, the rotor **12** is imparted with a rotational torque in a direction in which the magnetic flux **14d** will be widened, i.e., counterclockwise direction as viewed in **Fig.4B**.

Fig.4C through **Fig.4G** illustrate change in the width of the magnetic flux **14d** in accordance with rotation

of the rotor **12**. When the width of the magnetic flux becomes maximised, i.e., when only the magnetic teeth **14b** are opposed to the electromagnets **16a**, **16e** and **16i**, while the notches **14a** are displaced completely away from the electromagnets **16a**, **16e** and **16i**, the width of the magnetic flux **14d** is maximised. Thus, an absorption force acting between the permanent magnet **13** and the electromagnets **16a**, **16e** and **16i** is maximised. On the other hand, the rotational torque acting on the rotor **12** becomes zero.

Before the rotational torque acting on the rotor **12** becomes zero, i.e., as the boundary portion **14c1**, **14c3** and **14c5** approach another electromagnets **16b**, **16f** and **16j** positioned ahead of (with regard to the rotational direction), respectively, the electromagnets **16a**, **16e** and **16i** are demagnetised and the electromagnets **16b**, **16f** and **16j** are excited or magnetised by means of the excitation change-over mechanism **17**. Thus, the magnetic flux **14d** converges toward the electromagnets **16b**, **16f** and **16j**, as shown in **Fig.4H**, so that a rotational torque acts upon the rotor, as described above.

Then, the electromagnets **16c**, **16g** and **16k** are excited. When the boundary portion **14c1**, **14c3** and **14c5** approach another electromagnets **16d**, **16h** and **16l** positioned ahead with respect to the rotational direction, in response to rotation of the rotor **12**, the electromagnets **16c**, **16g** and **16k** are de-magnetised and the electromagnets **16d**, **16h** and **16l** are energised or excited.

As explained above, sequential excitation or energising of the electromagnets **16a** through **16l** causes interaction between the magnetic flux of the permanent magnet **13** and the electromagnets **16a** through **16l**, whereby a rotational torque is applied to the rotor **12**.

When this occurs, a rotational torque is generated between one of the magnetic poles of the permanent magnet **13** (for example, N-pole) and the magnetic poles (for example, S-poles) of the electromagnets **16a** through **16l** positioned at their respective axial ends. A rotational torque is also generated between the other magnetic pole (for example, S-pole) of the permanent magnet **13** and the other magnetic pole (for example, N-pole) of each of the electromagnets **16a** through **16l** positioned at the other axial end.

It should be noted that, at one magnetic pole, for example N-pole, of the permanent magnet **13**, certain of the electromagnets **16a** through **16l** are magnetised only to S-pole, thus preventing formation of a magnetic circuit, due to passage of magnetic flux from the excited electromagnets through either of the adjacent electromagnets, which tends to bring about N-poles magnetically similar to the permanent magnet **13**. It is also noted that, at the other magnetic pole, for example S-pole, of the permanent magnet **13**, certain of the electromagnets are magnetised only to N-pole, thus preventing formation of a magnetic circuit, due to passage of magnetic flux from the excited electromagnets through adjacent electromagnets, which tends to bring about S-poles magnetically similar to the permanent magnet **13**. The magnetic flux of the permanent magnet **13** passes through the magnetic bodies **14** so as to be converged to the excited electromagnets (refer to the magnetic flux **14d** shown in **Fig.4** through **Fig.4H**), thus forming dead zones, through which no magnetic flux passes, in the magnetic bodies **14** at a position opposite to the un-excited electromagnets. Accordingly, no force is generated which would tend to prevent rotation of the rotor **12**.

In view of electric energy applied to the electromagnets **16a** through **16l**, substantially all the electric energy applied is used to contribute to the rotation of the rotor **12**. On the other hand, and in view of magnetic energy of the permanent magnet **13**, all the magnetic energy contributes to the rotation of the rotor **12**.

It is also noted that, since the notches **14a** and the magnetic teeth **14b** are alternately disposed in the outer periphery of the magnetic materials **14** in an acute angle configuration seen in **Fig.4A** to **Fig.4H**, and the electromagnets are disposed at a position each corresponding to the boundary portions between the notches and the magnetic teeth, it is possible for the line of the magnetic force, generated in each gap between the boundary portions and the electromagnets when the electromagnets are excited, to be inclined to a substantial degree, so that a sufficient degree of rotational torque may be obtained upon initial excitation of the electromagnets.

The result obtained during an actual running test of the motor according to the first embodiment is shown in **Fig.1** to **Fig.3**.

Pure steel was used as a magnetic material. The magnetic material was 30 mm in thickness and formed to have magnetic teeth of 218 mm diameter and notches of 158 mm diameter. A ferrite magnet was used

as a permanent magnet. The magnetic force of the magnet was 1,000 gauss. Electric power of 19.55 watts was applied to the electromagnets at 17 volts and 1.15 amperes. The above conditions produced a rotational speed of 100 rpm, with a torque of 60.52 Kg-cm and an output of 62.16 watts.

Alternative embodiments will be explained below with reference to **Fig.6** through **Fig.9**.

The modified embodiment shown in **Fig.6** is similar to the motor presented as the first embodiment as shown in **Fig.1** through **Fig.3**, with the exception that each electromagnet **160** used as part of the stator, comprises an iron core **161** having a pair of legs **162** which extend towards the outer periphery of the magnetic bodies (outer periphery of the magnetic teeth **14b**), each of the legs being wound with coils **163**. The remaining components are basically identical to those in the motor shown in **Fig.1** through **Fig.3**. In **Fig.6**, the components similar to those in **Fig.1** through **Fig.3** are denoted by like reference numerals. It should be noted that each coil **163** is supplied with electricity so that one leg **162** (left-hand side in **Fig.6**) of each of the iron cores **161** is magnetised to be S-pole which is magnetically opposite to the magnetic pole (N-pole) of the confronting magnetic body **14**, while the leg **162** disposed at the other end of each of the iron cores is magnetised to be N-pole which is magnetically opposite to the magnetic pole (S-pole) of the confronting magnetic body **14**.

According to this modified embodiment, it is possible to significantly reduce leakage of the magnetic flux created by the electromagnets **160** in gaps each defined between the surfaces of the magnetic poles of the electromagnets **160** and the outer peripheries of the magnetic teeth **14b** of the magnetic bodies **14**.

An alternative embodiment shown in **Fig.7** is similar to the motor shown in **Fig.1** through **Fig.3**, with the exception that: an additional magnetic body **14** is mounted on the rotational output shaft **11** at its axial midpoint; two permanent magnets **130** are freely mounted on the output shaft **11** in the manner shown in **Fig.6**; and each iron core **165** is provided with three legs **166** positioned at the opposite axial ends and midpoint thereof and extending toward the respective outer periphery of the magnetic bodies, with the legs **166** positioned at axial opposite ends of the respective iron cores **165** being wound with a coil **167**, which form electromagnets **164**. The remaining components are substantially the same as those in the motor shown in **Fig.1** through **Fig.3**. It should be noted here, that the rotational output shaft **11** may be formed from either magnetic materials or non-magnetic materials.

As shown in **Fig.7**, each of the coils **167** is supplied with electricity so that the legs **166** positioned at the opposite axial ends of each of the iron cores **165** is magnetised to be S-pole which is magnetically opposite to the magnetic pole (N-pole) of the confronting magnetic body **14**. By this, the leg **166** positioned at the midpoint of the iron core **165** is magnetised to be N-pole which is magnetically opposite to the magnetic pole (S-pole) of the confronting magnetic body **14**.

In this embodiment, it is also possible, as in the modified embodiment shown in **Fig.6**, to significantly reduce the leakage of the magnetic flux generated by the electromagnets **164**. In addition to this, it is also possible to obtain a rotational torque between the leg **166** positioned at the midpoint of the iron core and the magnetic body **14** positioned at the axial midpoint of the rotational output shaft **11**. Accordingly, a higher rotational torque may be obtained with the same amount of electrical consumption, in comparison with the embodiment shown in **Fig.6**.

A further embodiment shown in **Fig.8** is similar to the motor shown in **Fig.1** through **Fig.3**, with the exception that a permanent magnet magnetised in the radial direction, rather than in the axial direction is employed. The permanent magnet **131** of an annular configuration has, for example, N-pole in the outer periphery and S-pole in the inner periphery. The permanent magnet **131** is received within a cavity **14e** provided in the respective magnetic body **14** at the intermediate portion thereof as disposed at the opposite axial ends of the rotational output shaft **11**. The remaining components are identical to those in the motor shown in **Fig.1** through **Fig.3**. The components identical to those in the motor shown in **Fig.1** through **Fig.3** are denoted by the same reference numerals. It should be noted that this embodiment may also employ the electromagnets **160** shown in **Fig.6**.

In this embodiment, the rotational output shaft **11** may be formed from magnetic materials, rather than non-magnetic materials.

Further embodiment shown in **Fig.9** is similar to the motor shown in **Fig.1** through **Fig.3**, with three exceptions. The first exception is that a permanent magnet magnetised in the radial direction, rather than in the axial direction is employed. The permanent magnet **131** having an annular configuration has, for

example, N-pole in the outer periphery and S-pole in the inner periphery. The permanent magnet **131** is received within a cavity **14e** provided in the respective magnetic body **14** at the intermediate portion thereof as disposed at the axial opposite ends of the rotational output shaft **11**. The second exception is that an additional magnetic body **14** is disposed at the axial midpoint of the rotational output shaft **11**. Finally, the third exception is that the iron core **165** is provided with three legs **166** disposed at the axial opposite ends and the midpoint thereof, respectively, and extending toward the outer periphery of the magnetic body **14**, with the legs positioned at the opposite axial ends being wound with respective coils so as to form an electromagnet **164**. The remaining components are identical to those in the motor shown in **Fig.1** though **Fig.3**. The components identical to those in the motor shown in **Fig.1** though **Fig.3** are denoted by the same reference numerals.

As shown in **Fig.9**, each coil is supplied with electricity so that the legs **166** disposed at opposite axial ends of the iron core **165** are magnetised to be S-pole which is magnetically opposite to the magnetic pole (N-pole) of the confronting magnetic body **14**. By this, the leg **166** disposed at the midpoint of the iron core **165** is magnetised to be N-pole which is magnetically opposite to the magnetic pole (S-pole) of the confronting magnetic body **14**.

According to the embodiment described above, the rotational output shaft **11** may be formed from magnetic materials rather than non-magnetic materials. With this embodiment, it is possible to obtain the same effect as that obtained with the embodiment shown in **Fig.7**.

Further the alternative embodiments shown in **Fig.10A** to **Fig.10C** are similar to the motor shown in **Fig.1** though **Fig.3**, with the exception that: like the embodiments shown in **Fig.8** and **Fig.9**, an annular permanent magnet **131** is employed which is received in a cavity **140e** provided in the central portion **140** of the magnetic body **140**; the magnetic body **140** is provided with notches **140a** in the outer peripheral portion thereof, so that the gap **G** between the magnetic body **140** and the electromagnet becomes gradually broader in the rotational direction of the rotor; and the electromagnets confronting to the gap **G** with an intermediate width as positioned between the electromagnets confronting to the gap **G** with a narrower width and the electromagnets confronting to the gap **G** with a broader width are excited or magnetised in a sequential manner. The remaining components are identical to those in the motor shown in **Fig.1** though **Fig.3**. In **Fig.10A** to **Fig.10C**, the components identical to those in **Fig.1** though **Fig.3** are denoted by the same reference numerals. In this regard, it should be noted that reference numeral **140d** indicates magnetic flux passing through the magnetic body **140**, so as to illustrate converged condition of such magnetic flux upon excitation of the electromagnets.

In the embodiment Just described above, it is possible to rotate the rotor in the counter clockwise direction as viewed in **Fig.10A**, for example, by exciting the electromagnets **16a**, **16d**, **16g** and **16j**, as shown in **Fig.10A**, then, the electromagnets **16c**, **16f**, **16i** and **16l**, as shown in **Fig.10B**, and then the electromagnets **16b**, **16e**, **16h** and **16k**. According to this embodiment, it is possible to obtain a stable rotational force, as well as a higher rotational torque, even though number of rotations is reduced in comparison with the above embodiment.

As shown in **Fig.10A**, four notches **140a** are provided. It should be noted, however, that two or three notches may be provided. It is also possible to attach the magnetic material **140** to the rotational output shaft **11** in an eccentric manner in its entirety, without providing notches **140a**.

Fig.11A through **Fig.11H** are illustrative diagrams showing the operation of the second embodiment of the invention when developed into a linear motor type.

According to this embodiment, a movable body **21** is adapted to be moved along a linear track **20** of a roller conveyor type. The track includes a frame on which a plurality of rollers are positioned in parallel relative to one another. A permanent magnet **22** is mounted on the movable body **21**. A magnetic body **23** of a plate-like configuration is fixed to the permanent magnet **22** in the upper surface, so as to form a movable element. It should be noted that magnetic flux from the permanent magnet **22** passes through the magnetic body **23**. A plurality of electromagnets **25a**, **25b**, **25c**, **25d** and so on are disposed above the movable element **24** along the linear track positioned parallel to each other. These electromagnets constitute a stator **25**. Magnetic circuits of the electromagnets **25a**, **25b**, **25c**, **25d**, and so on, are independent from one another, so that the electromagnets are magnetised in a sequential manner by means of excitation change-over mechanism (not shown), so as to have a magnetic polarity opposite to the magnetic pole of the permanent magnet **22**. Power output shafts **21a** are attached to a side surface of the movable body **21**.

Operation of the above second embodiment will be explained below.

As shown in **Fig.11A**, and when no electricity is supplied to the electromagnets, the electromagnets **25a** and **25b** positioned just above the movable element **24** are subjected to magnetic field of the permanent magnet **22** (refer to shaded portion in **Fig.11A**). Thus, such electromagnets magnetically absorb the magnetic body **23**, so that the movable element **24** remains to be stopped.

As shown in **Fig.11B**, and when the electromagnet **25c**, positioned ahead with respect to the direction in which the movable element **24** moves, is excited, the magnetic field of the permanent magnet **22** and the magnetic field of the electromagnet **25c** interact with each other, so that magnetic flux **23a** passing through the magnetic body **23** converges instantaneously toward the electromagnet **25c**. By this, the movable element **24** is magnetically absorbed to the electromagnet **25c**, so that it is moved along the linear track **20** under the propulsive force acting in the direction in which the width of the magnetic flux **23a** becomes broader, i.e., in the direction of an arrow mark shown in **Fig.11B**.

Fig.11C through **Fig.11E** illustrate a change in width of the magnetic flux **23a** in response to movement of the movable element **24**. At the point at which the width of the magnetic flux **23a** becomes maximised, i.e., when the forward end of the magnetic material **23** of the movable element **24** is positioned just before passing by the electromagnet **25c**, the width of the flux **23** becomes maximised. At this time, magnetic absorption acting between the permanent magnet **22** and the electromagnet **25c** becomes maximised, but the propulsive force acting on the movable element becomes zero.

Before the propulsive force acting on the movable element **24** becomes completely zero, i.e., when the forward end of the magnetic body **23** of the movable element **24** is about to pass the electromagnet **25d**, the excitation changeover mechanism is actuated so as to stop excitation of the electromagnet **25c** and so as to initiate excitation of the electromagnet **25d**. Thus, the magnetic flux **23a** converges to the electromagnet **25d**, as shown in **Fig.11F**, so that a propulsive force acts on the movable element **24**, as in the previous stage.

Subsequently, and in response to further movement of the movable element **24**, the width of the magnetic flux **23a** is reduced as shown in **Fig.11G** and **Fig.11H**, and thus a similar operation will be repeated.

The sequential excitation of the electromagnets, as explained above, causes interaction between the magnetic fields of permanent magnet **22** and electromagnets, whereby a propulsive force is applied to the movable element **24**.

It should be noted that, when the magnetic polarity of the permanent magnet **22** confronting the electromagnets is assumed to be N-pole, the electromagnet **25c** is magnetised solely to be S-pole, so as to prevent formation of a magnetic circuit by virtue of passage of magnetic flux from the electromagnet **25c** through to the adjacent electromagnets **25b** and **25d**, which formation, if it occurs, tends to cause the polarity of the electromagnets to be N-pole identical to the magnetic pole of the permanent magnet **22**. Accordingly, and in a manner similar to that in the first embodiment, no force is generated which tends to interfere with movement of the movable element **24**.

In the present invention, a plurality of electromagnets serving as a stator are so arranged that their respective magnetic circuits become independent from one another. The electromagnets are also arranged so that they are solely magnetised or excited to have a magnetic polarity opposite to the magnetic pole of the confronting permanent magnet. Thus, each electromagnet is prevented from becoming magnetised to the same polarity as that of the permanent magnet, which may occur when magnetic flux from a particular electromagnet passes through to adjacent electromagnets. Accordingly, no force will be exerted which tends to interfere with the intended movement of a rotor or a movable element. As a result, electric energy applied to the electromagnets may be efficiently utilised, while, at the same time, magnetic energy contained in the permanent magnet may also be efficiently utilised.

The coils constituting the electromagnets are consistently supplied with electric current with the same polarity, without any change, so that heating of coils may be prevented. Further, it is possible to obviate the problems of vibration and noise which might occur due to a repulsive force being generated when polarity of an electric current supplied to the coils is changed.