Aug. 1, 1967 F. A. HILL 3,334,253
MAGNET TRACTION MOTORS
Filed April 25, 1966 4 Sheets-Sheet 1

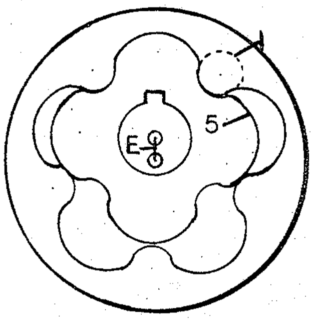

FIG. 1.

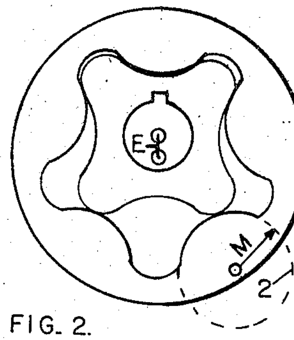

FIG. 2.

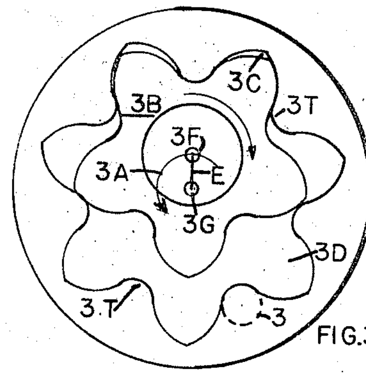

FIG.3.

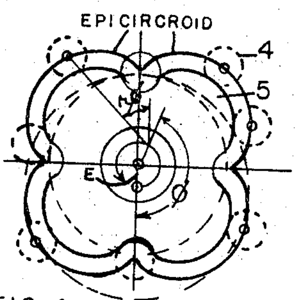

FIG. 4.

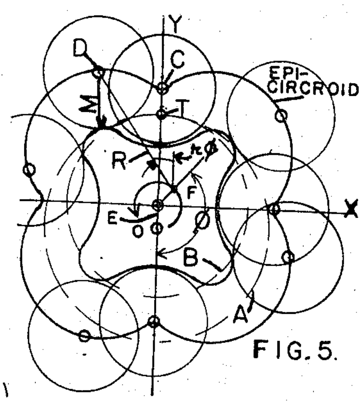

FIG. 5.

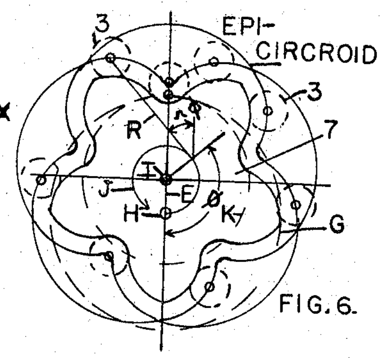

FIG. 6.

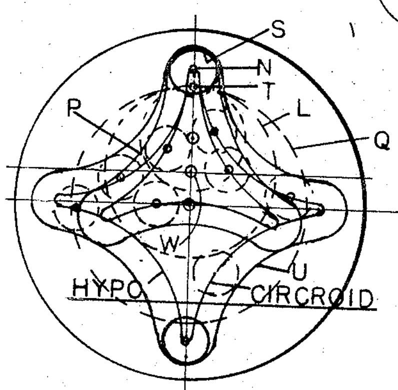

FIG.7.

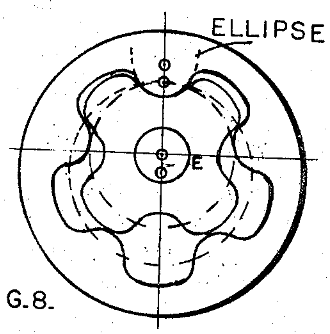

FIG.8.

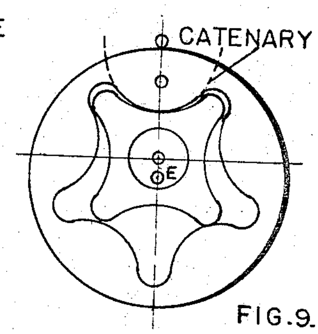

FIG.9.

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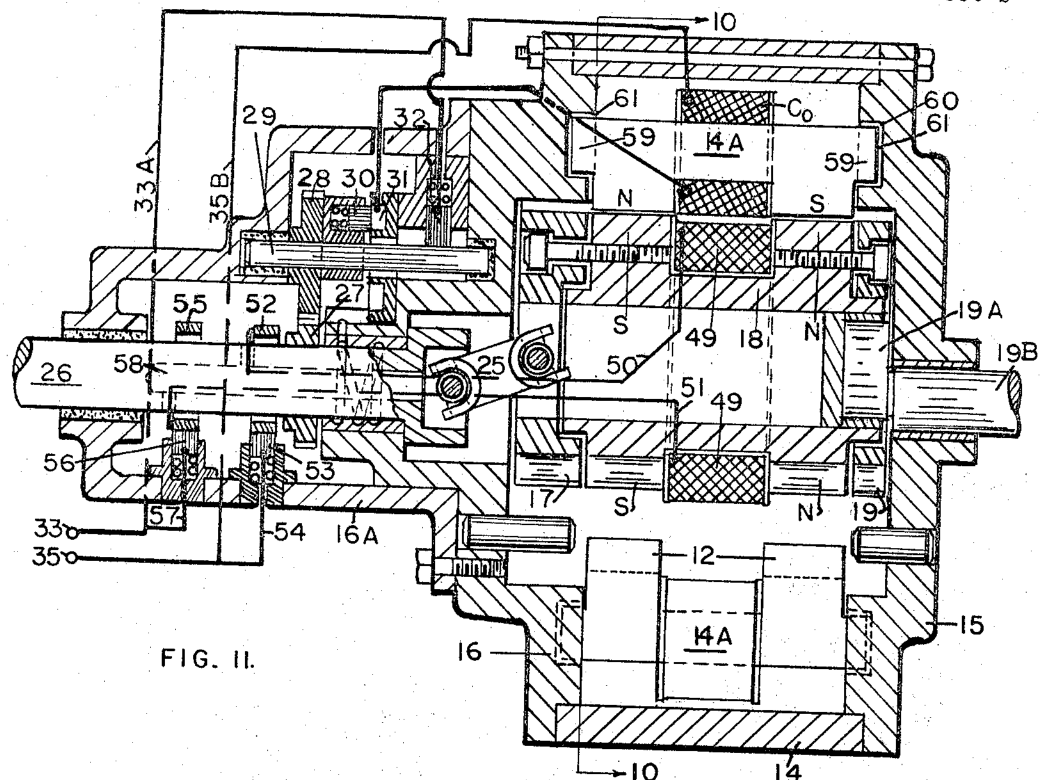

FIG. 11.

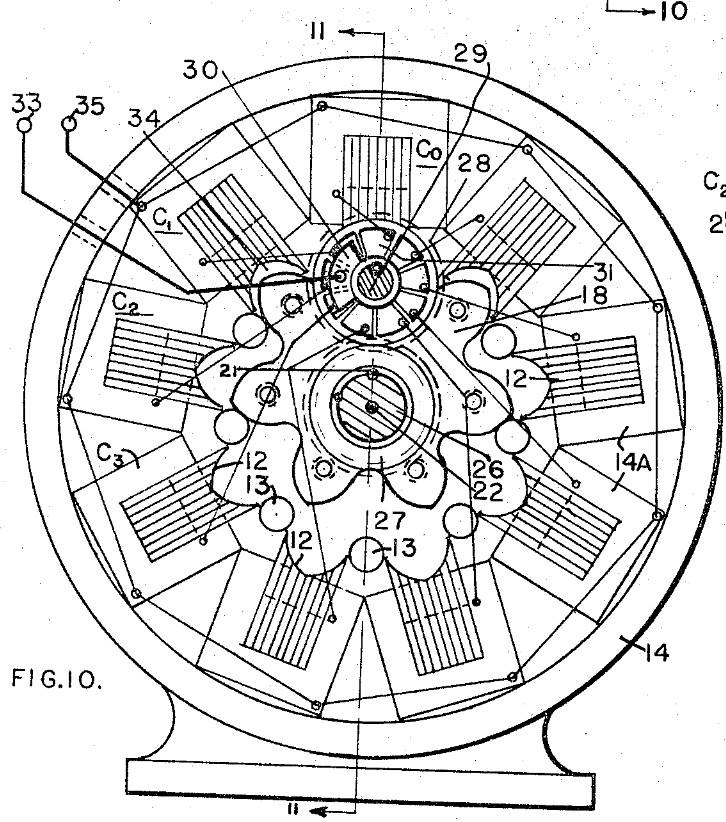

FIG. 10.

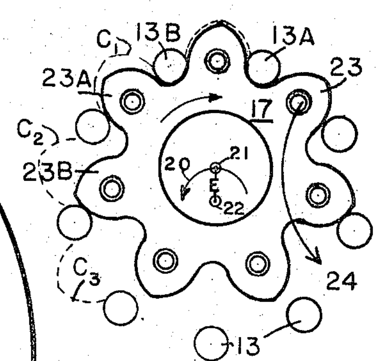

FIG. 11A.

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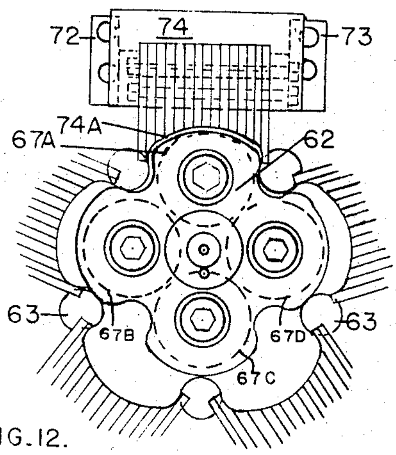

FIG. 12.

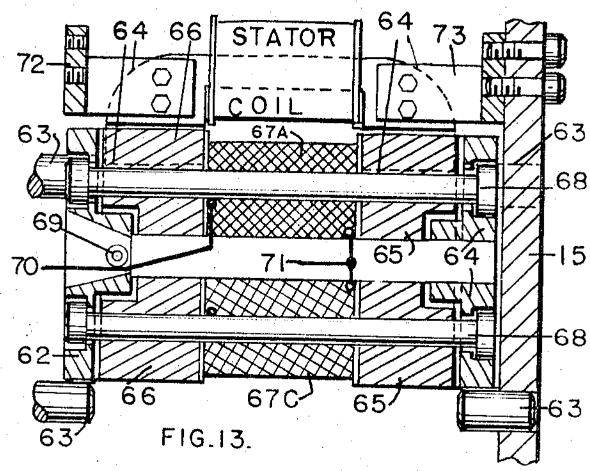

FIG. 13.

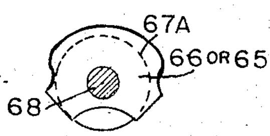

FIG. 14.

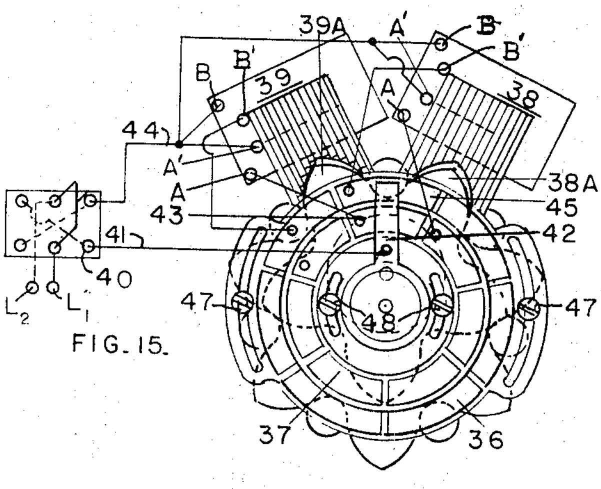

FIG. 15.

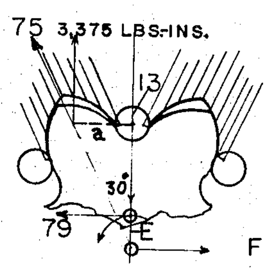

FIG. 16.

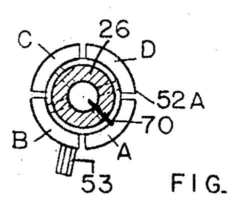

FIG. 18.

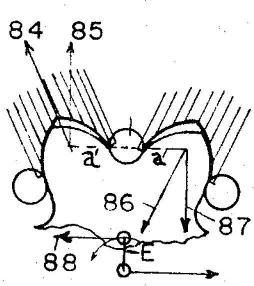

FIG. 17.

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MAGNET TRACTION MOTORS

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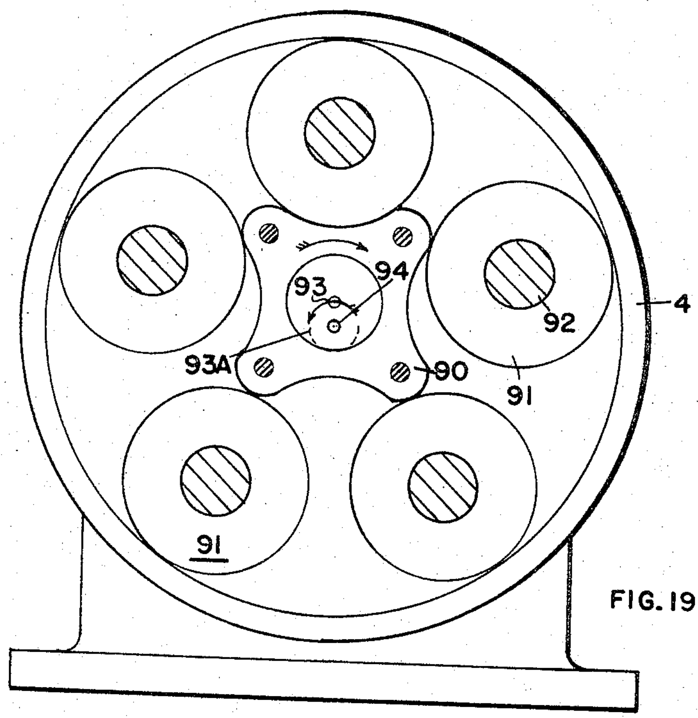

FIG. 19

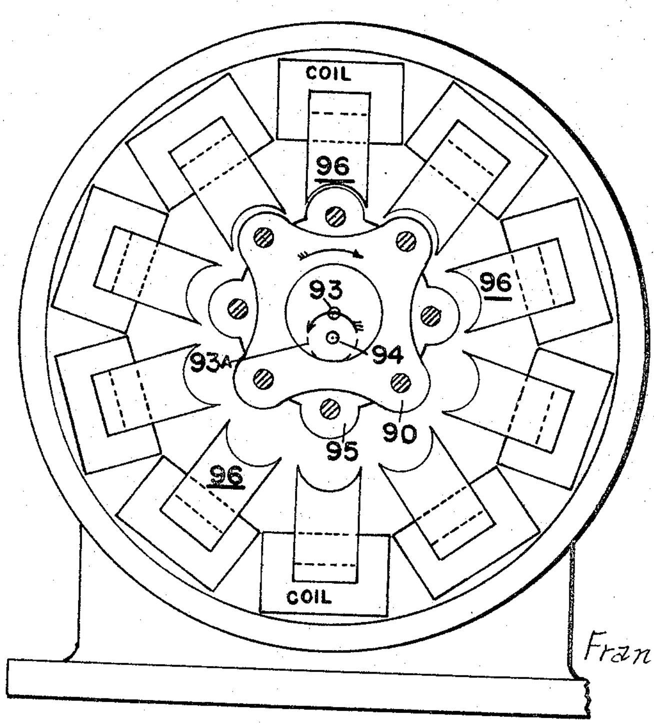

FIG. 20

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United States Patent Office

3,334,253
Patented Aug. 1, 1967

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3,334,253
MAGNET TRACTION MOTORS
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Filed Apr. 25, 1966, Ser. No. 552,362
8 Claims. (Cl. 310—82)

ABSTRACT OF THE DISCLOSURE

An electric motor with an armature mounted concentrically on at least one internal gear which can roll around inside stationary external gear teeth so that the armature turns in one direction on its center (clockwise) while being pulled around inside a ring of stator magnets in the opposite direction (counterclockwise) by an electric current energizing said stator magnet coils through a rotary brush commutator, said inner gear driving a power output shaft in said one direction (clockwise). The armature may also have energized poles coacting with the stator magnet poles.

This application in a continuation-in-part of my application Ser. No. 386,162, now abandoned and relates to the use of Gerotor gears described and claimed in U.S. Patent No. Re. 31,216 and rotoid gears described and claimed in U.S. Patent No. 2,666,336 in combination with traction magnet motors, with added new matter.

Heretofore these gears have been used in hydraulic pumps and motors in which both the inner and outer gear rotate.

When used in traction magnet motors the outer gear teeth are held stationary while the inner gear rolls around inside of the outer gear teeth, which are evenly spaced in a circle inside a cylindrical motor shell. These gears have teeth engaging each other in such a way that when the inner gear rolls around inside stationary outer gear teeth the center of the inner gear follows the path of a true circle around the center of the said outer gear teeth (i.e. the center of the casing).

Consequently, when an armature is fastened to the inner gear its center will follow the path of a true circle and will turn at steady angular velocity for any given speed.

One object of my invention is to arrange the magnets so that like poles are adjacent to each other in order to avoid stray magnetic flux fields.

Another feature of my invention is to use relatively small outer gear teeth as compared to the spaces between them in order to provide wide magnetic pole faces for greater flow of magnetic flux.

Another feature of my invention is to use laminated horse shoe shaped magnets with thin sheets of soft iron so as to reduce hysteresis, remanent magnestism and stray flux as much as possible.

Another feature of my invention is to show how the stator magnets can be larger in number than the outer gear teeth and the armature have more poles than the inner gear teeth.

FIG. 1 shows a pair of Gerotors having 4 and 5 teeth with small outer gear teeth.

FIG. 2 shows a pair of Gerotors having large outer gear teeth.

FIG. 3 shows rotoids having 7 and 5 teeth.

FIG. 4 shows the "epi" system of geometry for the gears in FIG. 1.

FIG. 5 shows the "epi" system of geometry for the gears in FIG. 2.

FIG. 6 shows the "epi" system of geometry for the gears in FIG. 3.

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FIG. 7 shows the "hypo" system of geometry for a gear having 3 and 4 teeth.

FIGS. 8 and 9 show gears having non-circular teeth. The tooth profile may be parts of an ellipse, catenary or other curve when used for generation of the teeth of the other gear.

FIG. 10 is a sectional view on line **10—10** of FIG. 11 of my magnetic traction motor with a schematic electric circuit superimposed on it.

FIG. 11 is a sectional elevation on line **11—11** in FIG. 10 showing the horse shoe shaped stator magnet, the wiring for one magnet, the commutator, the universal joint for driving the output power shaft, the floating armature of soft iron with a coil around its central portion for use when the polarity of a stator magnet is reversed and the rotating commutator brush.

FIG. 11A shows the mechanical motion of the floating armature which drives the output power shaft.

FIG. 12 is a left-hand view of FIG. 13 showing 4 exciting coils, one each for the armature's 4 toothed gear teeth and one stator magnet with its Square D coil.

FIG. 13 is a partly schematic drawing of a vertical section of FIG. 12 showing the armature mounted between two inner gears on through bolts and one cooperating stator Square D coil.

FIG. 14 shows an end view of one soft iron core armature magnet and its coil.

FIG. 15 is an enlarged view of two adjustable commutator rings and two stator coils wired so that one pulls an armature tooth pole into its stator tooth space while the other stator pole repells the adjacent armature pole out of its concave pole face.

FIGS. 16 and 17 show vector diagrams of the electrical and mechanical forces about an outer gear tooth at full mesh.

The geometry in FIGS. 1 to 9 inclusive is described in the above mentioned patents and also in "Kinematics of Gerotors, Rotoids and Gears" by Myron F. Hill, the father of applicant.

FIG. 18 shows a cross section of a four sector commutator for FIGS. 12 and 13.

FIG. 19 shows a small toothed inner gear rolling around inside 5 large stationary outer gear teeth.

FIG. 20 shows 10 stator coils and 10 stator concave pole faces with an 8 toothed armature having 8 pole faces rolling around inside stator magnets and mounted on 4 toothed inner gear in FIG. 19.

FIG. 10 shows a cross section of my magnetic traction motor partly on line **10—10** in FIG. 11 and partly schematic. A casing **14** encloses 9 traction magnet **14A** evenly spaced around inside it. Each magnet **14A** has concave space curves **12** at each end. FIG. 11 shows the horse shoe shape at N and S. The space curves **12** at one end have an opposite polarity from the space curves **12** at the other end. Between each magnet **14A** is a pin or outer stationary gear tooth **13**. The armature poles have the same shape as the inner gear teeth. The stator concave pole faces just clear the armature poles at the position of "full mesh" so as never to touch the armature while it rolls around inside the stator magnets. The teeth **13** are rigidly mounted in end walls **15** and **16**.

The soft iron armature **18** has gears **17** and **19** bolted to it. **17** and **19** engage the teeth **13** with which they have a generative relation. In FIGS. 11 and 11A seven inner gear teeth engage 9 outer gear teeth **13**.

FIG. 11A shows the mechanical action. The gears **17** and **19** (in FIG. 11) carry the armature **18** around inside the stator poles when they roll around inside the teeth **13**. **18** turns clockwise while its center moves counter clockwise (see arrow **20**). The power output shaft **26** is driven by the gear **17** through the universal joint member **25**. The members **17**, **18** and **19** have no bearings. At least 6 outer gear teeth **13** are always in contact with some part of the inner gear tooth surfaces **17** and **19** in theory. Actually either 3 or 4 outer gear teeth are always in contact with some part of the inner gear tooth surfaces. At full mesh in FIG. 11A there is a rolling drive between the teeth **13A** and **13B** with the inner gear **17**.

A high speed shaft **19B**, centered at **22** with its cam centered at **21** will be driven 4½ times faster than that of the armature around its own center **21**. A fan can be mounted on it to cool the magnetic traction motor.

The output shaft **26** drives the commutator shaft **29** through the gears **27** and **28**. **26** and **29** rotate at the same speed. The stationary commutator sectors are connected each to its own Square D coil. Current from line terminal **33** flows through the wire **33A** to brush **32**, through shaft **29** which is insulated to magnet coils C_1, C_2 and C_3 pulling the armature by induction to the left in FIG. 10 and then out through wire **35B** to the other line terminal **35**.

Two enlarged commutators **36** and **37** in FIG. 15 are like **31** in FIG. 10. Stator magnets **38** and **39** have two separate windings A–A′ and B–B′. When the double-pole double-throw switch **40** connects L_1 to wire **41** the current flows through the brush **42**, sector **43** and through the coil from A to A′ and out through line **44** to terminal L_2. At the same time brush **42** also contacts sector **45** connected to coil B–B′ but its direction is reversed so that the current flows from B′ to B. This reverses the polarity of the magnet **38** from that of **39**. Magnet **39** exerts a pull on the left armature tooth **39A** while magnet **38** repulses the armature tooth **38A**. Coil B–B′ may have just enough coils to offset hysteresis or remanent magnetism. Or it may have enough turns to act as an electrical cushion to offset the eccentric throw of the armature. Or it may have enough coils to do all three. Commutator rings **36** and **37** are adjustable. When switch **40** is reversed shaft **26** will rotate in the reverse direction.

When coil **49** surrounds the central portion of the armature **18** one end **50** can be connected to an insulated slip ring **52**, brush **53** and wire **54** to terminal **35**. The other end **51** is connected to another insulated slip ring **55**, brush **56**, wire **57** and terminal **33**.

When coil **49** is used it should be so wound as to make the armature poles the reverse polarity of the poles of the magnets **14A**. This will increase the tractive force per pole area for a given number of ampere turns. The sector **45** connected to the reversed windings B′–B should be long enough in the circumferential sense to maintain the reverse polarity until the armature tooth **38A** is withdrawn from the concave stator pole face.

Less than half the stator magnets are electrically energized at any one time while my traction magnet motor is running. The circumferentially adjacent poles of the stator magnets have the same polarity at each end of the magnets. This is true of the armature poles also. Consequently there are no stray paths for the loss of flux.

In FIG. 12 two 4 toothed inner gears **62** and **64** roll around inside the five teeth **63** carrying the armature members **65** and **66** and coils **67A**, **67B**, **67C** and **67D** with them. The soft iron cores **65** and **66** have sufficient clearance **74A** between them and the concave pole faces of the magnets **74** so as to have no metallic contact. The steel bolts **68** conduct the magnetic flux to each soft iron armature poles **65** and **66**. The stator magnets are mounted on brackets **72** and **73**. One end **70** of each coil such as **67A** connects with a rotating ring **52A** (on shaft **26** in FIG. 11 in place of ring **52**) in FIG. 18 at one of its four sectors such as A. Coil **67B** is connected to sector B; Coil **67C** to sector C; and Coil **67D** to sector D. A common wire **71** to the other ends of these coils connects with the other rotating ring **55** (in FIG. 11) to complete the armatures circuit between the terminals **33** and **35**.

This same electric circuit can be used with the 7 and 9 toothed gears in FIGS. 10 and 11. It is also possible to combine this type of individual armature pole coils with the reverse polarity of the stator magnets as illustrated in FIG. 15 when magnetic polar repulsion is desired.

FIG. 16 shows the directions of the moments of force about the outer gear tooth **13**. With ⅓ of an inch air gap and 3,000 ampere turns the pull on a tooth of a 2 inch diameter inner gear amounts to 200 lbs. inches. With a 1⁄16 of an inch air gap the pull becomes 6,930 lbs. inches in the direction of the arrow **75**. The resultant vertical pull around tooth **13** in the direction of the arrow **76A** is 6,930 multiplied by the cosine of the 30° angle between the arrows **75** and **76A** which is 6,000 lbs.×½ inch moment arm=3,000 inch pounds torque. When the stator tooth space clearance over the top of an armature tooth pole is reduced to .005 of an inch this torque becomes over 50,000 lbs. inches. These torques are for poles having one square inch of area. In order to prevent this high torque from wrecking a small motor mechanism the brush **30** in FIG. 10 is shown as having left the commutator sector connected to coil C_0. It contacts sectors connected to coils C_1, C_2 and C_3.

FIG. 17 shows the force couples **84** and **85**, and **86** and **87** when one stator magnet pulls an armature pole towards itself and the adjacent stator magnet repels an armature away from itself when the electric circuit is like that in FIG. 15.

In a cheaper form of magnet motor, the stator coils can be omitted when the commutator ring in FIG. 18 is used with separate armature coils like those in FIGS. 12 and 13. This cheaper construction can include the use of one long or thick or wide internal gear with one set of matching external gear teeth.

A permanent minimum air gap at full mesh between the armature poles and the stator pole faces prevents magnetic "sticking."

In FIG. 19 the 4 toothed inner gear **90** (of the type shown in FIGS. 2 and 5) rolls around inside 5 large circular outer gear teeth mounted on bolts inside the casing **4**. The action is the same as that in FIG. 12 except that the gear **90** has small teeth while the gear **62** has large teeth.

In FIG. 20 the gear **90** carries an armature **95** having 8 or twice as many poles as there are teeth in the inner gear **90**. The 4 teeth in the gear **90** are generated by the large circular outer gear teeth **91**. The 8 convex poles in the armature can have the same generated shape as the teeth in the gear **90** or they can be circular. For ease of manufacture I prefer to have them circular. As the 8 poles are carried around by the gear **90** they will generate 10 concave pole faces in the stator magnets **96**. By moving the magnets **96** radially outward several thousandths of an inch magnetic sticking can be prevented as explained above.

Due to the fact that for any given speed the inner gear center **93** always moves at a steady angular velocity about the center **94** of the outer gear teeth any type of inner gears and outer gear circular teeth can be used with any other type such as in FIGS. 3, 6, 7 and 10 or with those in FIGS. 1, 2, 4, 5, 8, 9, 20 and 21 provided the armature poles generate the concave stator pole faces and provided the same eccentricity or distance between the centers **93** and **94** are maintained throughout the mechanism.

What I claim is:

1. A magnet traction motor comprising a casing, a plurality of horse shoe stator magnets, each with concave poles evenly spaced apart and arranged in a circle inside said casing, a plurality of stationary outer gear teeth arranged in a circle on at least one end member in said casing, a power output shaft in said casing, at least one inner gear driving said power output shaft and having fewer teeth than the number of outer gear teeth so as to roll around inside said outer gear teeth smoothly and evenly at steady angular velocity for any given speed while carrying an armature fastened to it, said armature having fewer poles than the number of poles in said stator magnets, said stator magnet pole faces just clearing with a small air gap the pole faces of said armature, an electric energizing coil surrounding each stator magnet, an electric circuit for energizing said coil comprising a line stator magnet, an electric circuit for energizing said coil comprising a line terminal connected to a slip ring and rotating brush in a commutator, said brush contacting a ring of sectors in said commutator successively, each sector connected to one end of a stator magnet coil, all the other ends of the stator magnet coils being connected together and to another line terminal, an electric current flowing through said circuit to energize successive magnets only while at least one armature pole is being pulled towards at least one stator pole after which said rotating brush disconnects said current from said one stator coil, whereby said electric circuit causes said armature to revolve around its own center in a first direction while being carried around by said inner gear in a circular path in the opposite direction causing said armature and said inner gear to drive a universal joint member and rotate said power shaft in said first direction.

2. A magnet traction motor according to claim 1 having two insulated slip rings on said power shaft, each ring connected to a stationary brush and to a line terminal, one of said rings having as many sectors as there are positive or negative armature poles, each sector connected to one end of an armature magnet coil so that the armature poles will have the reverse polarity from that of the stator poles, having the other ends of said armature magnet coils connected to the other slip ring, whereby an electric current flowing through each armature coil will increase the numbers of lines of force and increase the power output only while said armature poles are under the influence of the stator poles.

3. A magnet traction motor according to claim 1 having two insulated slip rings on said power output shaft, each ring connected to a stationary brush and to a line terminal, one of said rings having as many sectors as there are positive or negative poles in said armature, each sector connected to one end of an armature magnet coil so that the armature poles will have the reverse polarity from that of said stator poles, having the other ends of said armature magnet coils connected to the other slip ring, whereby an electric current flowing through each armature coil will increase the numbers of lines of force and increase the power output only while said armature poles are under the influence of said stator poles, having a

second commutator ring with the same number of sectors as there are stator magnets, said rotating brush also contacting said latter sectors, each of said latter sectors connected to a second coil around said stator magnets so as to reverse the current and the polarity of said stator magnets only while said armature poles are receding from said stator poles, having all the other ends of said second coils connected to the other line terminal, whereby the electric current flowing through said second coils causes said stator magnets to repel said armature magnets.

4. A magnetic traction motor according to claim 1, in which all the stator magnets with positive poles are provided at one end of said casing and the negative poles at the other end of said casing to reduce stray flux leakage.

5. A magnet traction motor according to claim 1, having two insulated slip rings on said power output shaft, each ring connected to the ends of a coil completely surrounding the body of the armature so as to have all the poles at one end of the armature of opposite polarity from those at the other end, having the stator poles of opposite polarity to those at the ends of said armature and having said stator poles attract said armature poles only while said armature poles are approaching said stator poles.

6. A magnetic traction motor according to claim 1, in which the number of armature magnets and the number of stator magnets are multiples of the number of teeth in the inner gear and the number of teeth in the outer gear respectively.

7. A magnet traction motor according to claim 1 having a larger number of stator and armature magnets than there are teeth in the outer and inner gears respectively.

8. The combination claimed in claim 1, and having a second inner gear rigidly fastened to the other end of said armature and rolling around inside another set of stationary outer gear teeth mounted in the other end of said casing, so that the armature is supported and carried by two inner gears while rolling around inside said stator magnets.

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MILTON O. HIRSHFIELD, *Primary Examiner.*

J. D. MILLER, *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,334,253 August 1, 1967

Francis A. Hill

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, lines 7 and 8, strike out "comprising a line stator magnet, and electric circuit for energizing said coil -

Signed and sealed this 11th day of June 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents