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Christensen et al.

[11] **3,735,170**

[45] **May 22, 1973**

[54] COMMUTATOR FOR D.C. MACHINES

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[52] **U.S. Cl.** **310/219,** 310/82, 310/237

[51] **Int. Cl.**.....**H02k 13/00**

[58] **Field of Search**.....310/231, 232, 236, 310/237, 82, 46, 219

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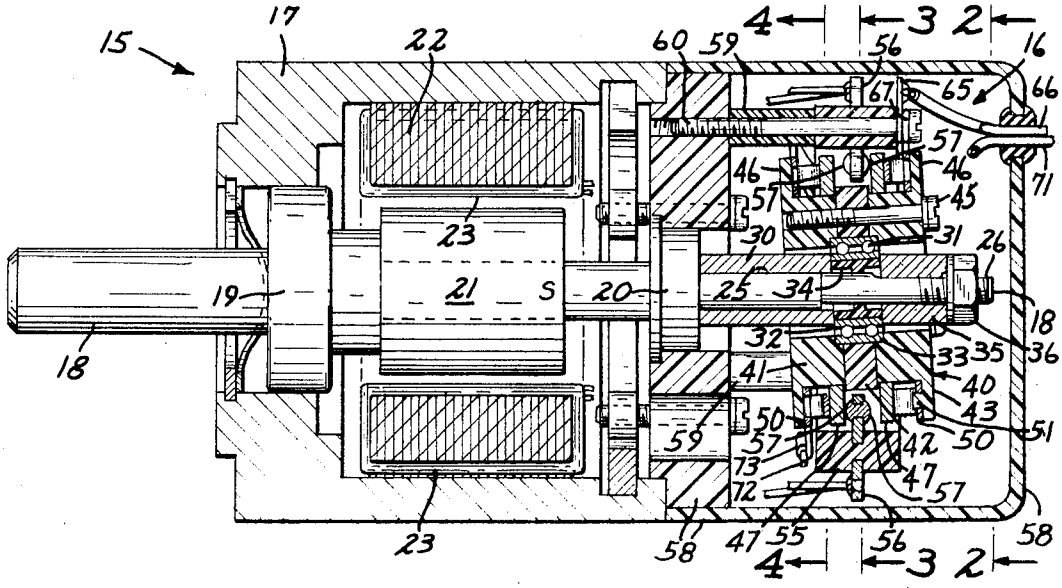
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[57] **ABSTRACT**

A pair of electrically conducting rings having continuous contact surfaces thereon positioned in parallel spaced apart relationship to form a channel, and a plurality of contacts adapted to be connected to the various windings of the machine and positioned in a circular spaced apart orientation within the channel so that at least one contact is engaged with one of the rings and an oppositely disposed contact is engaged with the opposite ring. A mounting device is engaged with the shaft to produce relative oscillatory movement between the pair of rings and the contacts so that the contacts sequentially engage each ring during each rotation of the shaft.

16 Claims, 11 Drawing Figures



2 Sheets-Sheet 1

FIG. 1

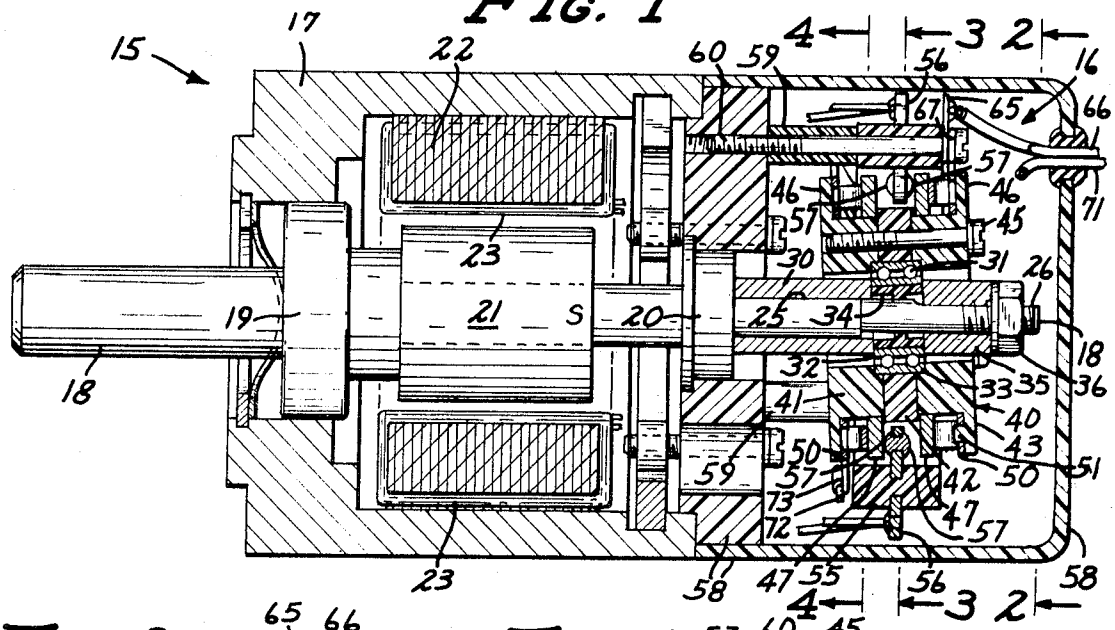


FIG. 2

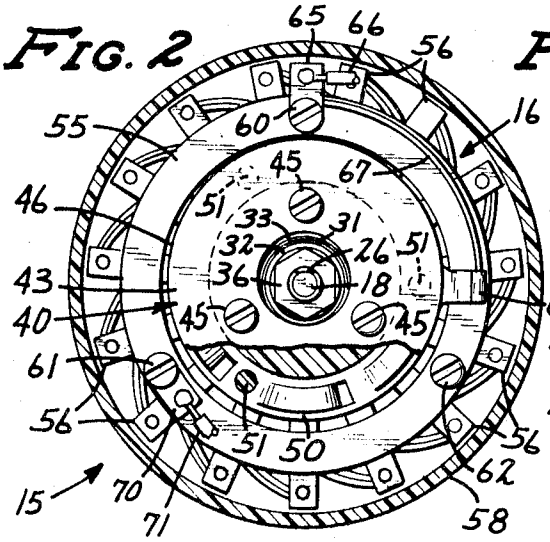


FIG. 3

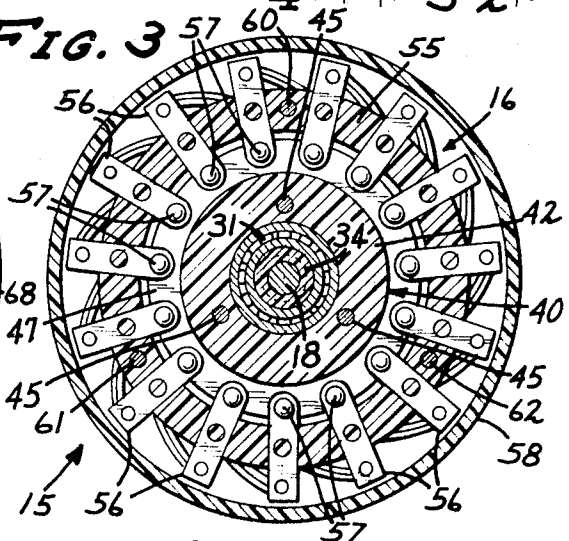


FIG. 4

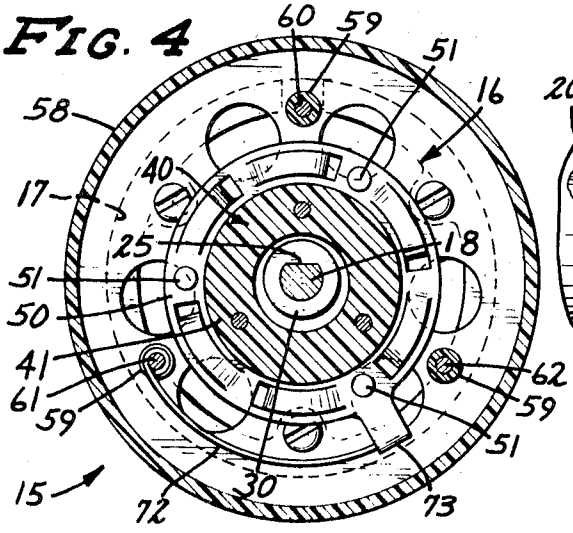
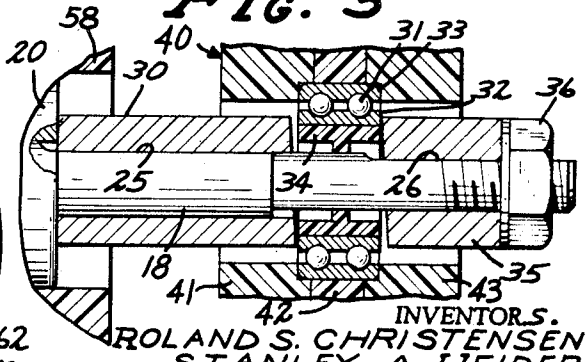


FIG. 5



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FIG. 6

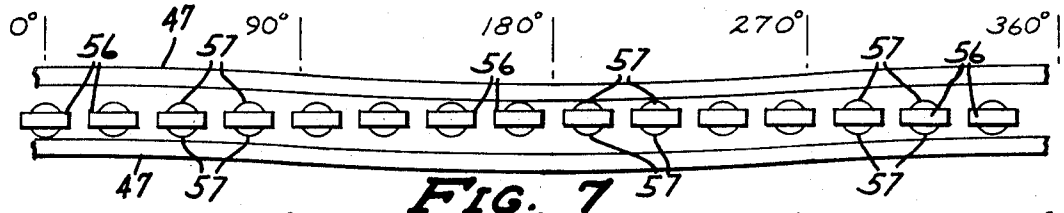


FIG. 7

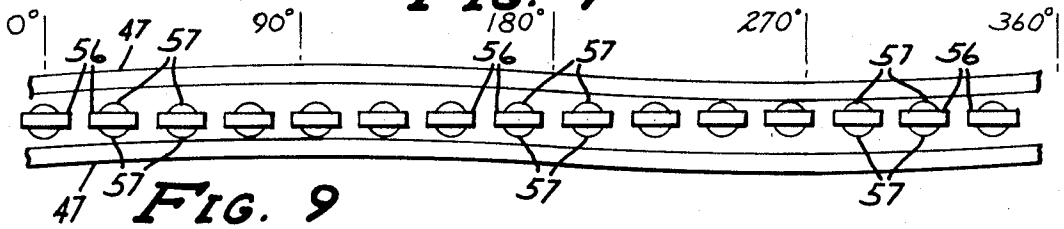
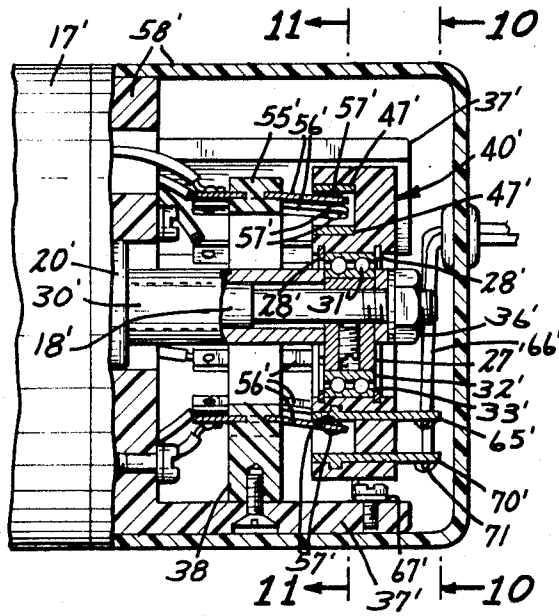


FIG. 9

FIG. 10



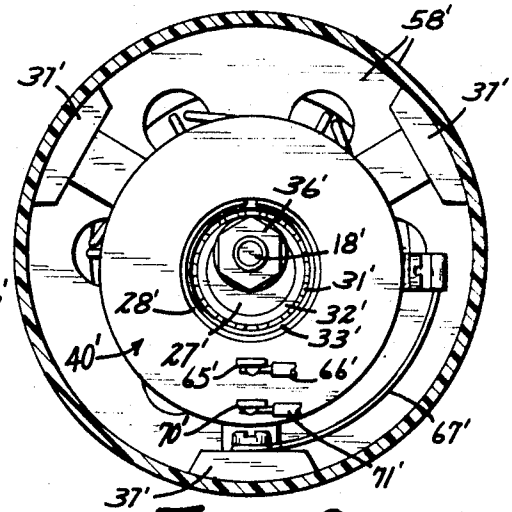
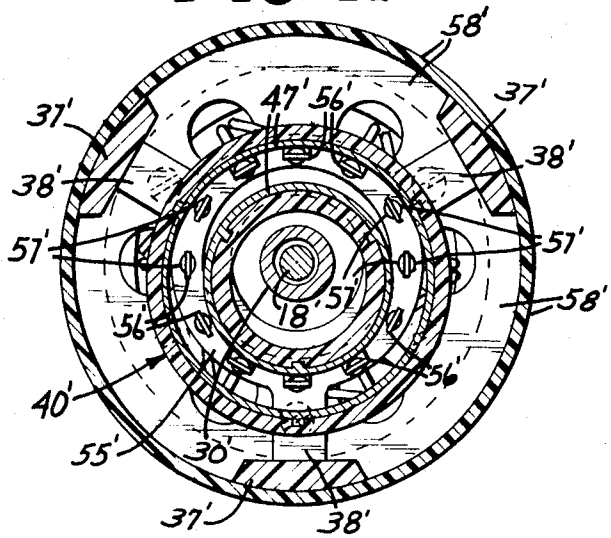
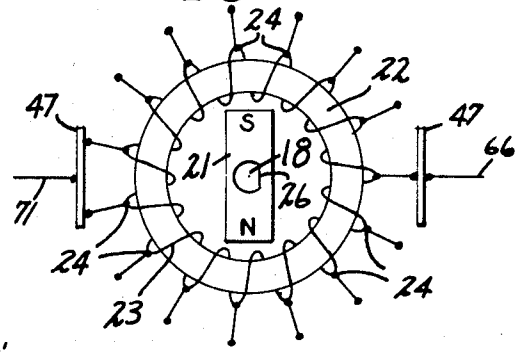


FIG. 8

FIG. 11





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COMMUTATOR FOR D.C. MACHINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

Throughout this disclosure the term "electric machines" is utilized to designate motors and/or generators, since they are constructed similarly but simply connected differently to produce torque or electric power. It is well known in the electric machine art that the fields of the rotor and stator in a machine must be substantially stationary relative to each other for the correct operation of the machine. For example, in a D.C. motor utilizing a permanent magnet rotor, the field of the rotor is traveling at the same speed as the rotor. It is essential, therefore, to produce a stator field which is rotating at the same speed as the rotor. Conversely, if the stator field is stationary in space it is essential that the rotor field be rendered stationary in space. This task can be performed mechanically by incorporating a commutator in the electrical circuitry of the machine.

2. Description of the Prior Art

In the prior art, commutators consist of a plurality of arcuate sections spaced apart by non-conducting material and formed into a continuous ring. The sections are electrically connected to the windings of the motor and brushes, which are connected to a source of power or adapted to have power removed therefrom, are slidably engaged with the ring and disposed oppositely thereon to engage opposite sections of the ring simultaneously. The brushes are generally formed of relatively soft material and have a tendency to wear relatively quickly, so that they must be changed periodically. Further, because of this brush wearing, there is a tendency for brush-type commutators to produce substantial electrical noise and dust or particles of the brushes.

SUMMARY OF THE INVENTION

The invention pertains to a commutator for electric machines including a plurality of contacts adapted to be electrically connected to the coils of the machine and mounted in spaced apart relationship to define a circle, a pair of electrically conducting rings mounted in parallel spaced apart relationship to define a continuous circular channel therebetween and means mounting the contacts and rings with the contacts disposed within the channel and at least one contact engaged with one ring and an oppositely disposed contact engaged with the other ring, with said means engaging the shaft of the machine and responding to rotations thereof to produce relative oscillatory movement of said contacts within the channel so as to cause each contact to periodically engage each ring for each rotation of the shaft, thereby effecting sequential engagement of the contacts with each ring.

It is an object of the present invention to provide an improved commutator for electric machines.

It is a further object of the present invention to provide an improved commutator for electric machines which does not utilize brushes to provide contact between a stationary and a rotating surface.

It is a further object of the present invention to provide an improved electric machine having an improved commutator attached thereto, which machine can be utilized as a generator with a greatly reduced ripple in the output voltage.

These and other objects of this invention will become apparent to those skilled in the art upon consideration of the accompanying specification, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings, wherein like characters indicate like parts throughout the figures:

FIG. 1 is an axial sectional view of an electric machine having an embodiment of the improved commutator operatively attached thereto;

FIG. 2 is a sectional view as seen from the line 2—2 in FIG. 1, portions thereof broken away;

FIG. 3 is a sectional view as seen from the line 3—3 in FIG. 1;

FIG. 4 is a sectional view as seen generally from the line 4—4 in FIG. 1;

FIG. 5 is an enlarged fragmentary view of a portion of the apparatus illustrated in FIG. 1;

FIG. 6 is a developed view of the contacts and parallel conducting rings with the rotor shaft in a first position;

FIG. 7 is a view similar to FIG. 6 with the rotor shaft rotated 90 mechanical degrees;

FIG. 8 is a schematic representation of the electric machine illustrated in FIG. 1;

FIG. 9 is a fragmentary view in side elevation of another embodiment of the commutator, portions thereof broken away and shown in section;

FIG. 10 is a sectional view as seen from the line 10—10 in FIG. 9; and

FIG. 11 is a sectional view as seen from the line 11—11 in FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 through 8, the numeral 15 generally designates an electric machine, which may be utilized either as a motor or a generator, and the numeral 16 generally designates a commutator operatively attached to the electric machine 15. The electric machine 15 includes a tubular housing 17 having an elongated shaft 18 coaxially mounted for rotation therein by means of bearings 19 and 20. The shaft 18 has a permanent magnet rotor 21 (which in this embodiment is a two pole rotor) fixedly attached thereto. A toroidally shaped stator core 22 (which is formed of a plurality of annular laminations) has a continuous winding 23 therearound and is fixedly mounted in the housing 17 concentric with the rotor 21. The continuous winding 23 of the stator has a plurality of taps 24, in this embodiment fifteen taps are provided, which are equally spaced about the toroidally shaped winding 23 (see FIG. 8). While other types of electric machines might be utilized in the present disclosure, the present electric machine 15 is illustrated because it produces very little ripple voltage in the output when the electric machine 15 is utilized as a generator and, therefore, is extremely useful in applications, such as tachometers or the like.

Referring to FIGS. 1 and 5 specifically, the shaft 18 extends outwardly from the right side of the electric machine 15 and is formed with a first diameter having a flat side 25 and a second smaller diameter adjacent the end having a flat side 26. A first sleeve 30, having a flat portion on the inner surface thereof, is coaxially engaged over the flat side 25 of the shaft 18 with the

flat sides mating and correctly positioning the sleeve **30.** The end of the sleeve **30** closest to the right end of the shaft **18** is cut at an angle to the axis thereof, which angle in this embodiment is approximately 3°. A bearing **31,** having an inner race **32** and an outer race **33,** is coaxially mounted on the shaft **18** adjacent the angular end of the sleeve **30** by means of an at least slightly deformable spacer **34.** A second sleeve **35** having a flat on the inner surface thereof is coaxially engaged over the flat side **26** of the shaft **18,** with the flat sides engaged to correctly position the sleeve **35** on the shaft **18.** The end of the sleeve **35** adjacent the spacer **34** is cut at an angle to the axis equal to and parallel with the angular end of the sleeve **30.** The end of the shaft **18** is threaded and a nut **36** is threadedly engaged thereon to maintain the entire assembly in position.

A mounting block, generally designated **40** is formed from a first annular member **41,** an annular spacer **42** and a second annular member **43.** The diameter of the opening through the annular members **41** and **43** is slightly larger than the outer diameters of the sleeves **30** and **35** but smaller than the outer diameter of the outer race **33** of bearing **31.** The diameter of the opening through the spacer **42** is approximately equal to the outer diameter of the outer race **33** of bearing **31** and a portion of the openings through the annular members **41** and **43** are enlarged slightly to receive the outer race **33** of the bearing **31** snugly therein. Bolts **45** are threadedly engaged in an axial direction through the annular member **43,** spacer **42** and annular member **41** to clamp them tightly onto the outer race **33** of the bearing **31.** It should of course be understood that other mounting devices might be utilized but the present assembly is illustrated because of its simplicity and ease of assembly.

Each of the annular members **41** and **43** has a radially outwardly extending flange **46** in the periphery thereof adjacent the axially outwardly directed surface thereof. The spacer **42** extends radially outwardly a somewhat greater distance than the annular members **41** and **43,** but not as great a distance as the flanges **46.** The flanges **46** cooperate with the axial surfaces of the spacer **42** to provide two spaced apart circular grooves extending around the periphery of the mounting block **40.** Each of the grooves has a flat annular, electrical conducting ring **47** mounted therein for axial sliding movements along the outer surfaces of the annular members **41** and **43.** The rings **47** each have flat surfaces directed toward each other in a parallel relationship and spaced apart by the spacer **42.** Two annular springs **50,** having spring fingers pressed therefrom, are positioned in abutment with the flanges **46** so that the spring fingers bias the rings **47** inwardly against the edges of the spacer **42.** The annular springs **50** have a plurality of axially extending abutments or projections **51,** formed integral with the flanges **46,** to prevent rotary movement of the annular springs **50** relative to the mounting block **40.** It should be understood that the rings **47** are illustrated as continuous conducting surfaces for simplicity but a variety of embodiments, including arcuate sections electrically connected and not necessarily mechanically connected, might be devised by those skilled in the art.

A second mounting block **55** is formed by constructing a hollow cylinder having an inner diameter slightly larger than the outer diameter of the rings **47** and affixing a plurality (15 in this embodiment) of radially extending fingers **56** therethrough in equally spaced relation therearound. In this embodiment, each of the fingers **56** has a generally central opening therethrough and a non-conducting material, such as plastic or the like, is molded around and through the openings in the fingers **56** to form the cylindrical mounting block **55** with the fingers **56** rigidly engaged therein. The fingers **56** extend radially inwardly beyond the inner diameter of the mounting block **55** and into the channel formed between the adjacent surfaces of the conducting rings **47.** The inner end of each of the fingers **56** has a contact surface **57** extending outwardly from either axial side thereof so as to be in a position to engage the adjacent surfaces of either of the rings **47.** The contact surface **57** may be a single contact having opposed surfaces, they may be two contacts on opposite sides of the fingers **56** or they may be separate contacts and fingers each adapted to engage only the adjacent ring **47.** The fingers **56** extend radially outwardly beyond the outer diameter of the mounting block **55** and the outer ends form connecting lugs which have wires from the various taps **24** of the winding **23** fixedly attached thereto.

Three axially extending holes are formed in the mounting block **55** in spaced apart relationship and tubular non-conducting spacers **59** are aligned therewith between the mounting block **55** and a non-conducting end cap **58** of the electric machine **15.** Three bolts **60, 61** and **62** are engaged through the openings in the mounting block **55** and the spacers **59** and are threadedly engaged in openings in the end cap **58** to position the mounting block **55** in the desired position relative to the mounting block **40.** A lug **65** is engaged between the head of the bolt **60** and the outer surface of the mounting block **55,** which lug **65** has an externally extending, electrical conducting wire **66** attached thereto. The lug **65** also has one end of an arcuate shaped spring wire **67** attached thereto with the other end of the spring wire **67** being fixedly attached to a radially outwardly extending ear **68** of the annular spring **50** engaged with the flange **46** of the annular member **43.** A lug **70** is engaged between the head of the bolt **61** and the outer surface of the mounting block **55,** which lug **70** has an externally extending, electrical conducting wire **71** attached thereto. One end of a second arcuately shaped spring wire **72** is engaged over the bolt **61** between the rear surface of the mounting block **55** and the spacer **59** (not shown) and the other end of the spring wire **72** is affixed to a radially outwardly extending ear **73** on the annular spring **50** engaged with the flange **46** of the annular member **41.** The spring wires **67** and **72** provide an electrical connection from the wires **66** and **71,** respectively, through the annular springs **50** to the rings **47.** Also, the spring wires **67** and **72** prevent rotation of the mounting block **40** relative to the mounting block **55** while allowing oscillatory movements thereof, as will be described presently.

Referring to FIG. **5** wherein the nut **36** is loosely engaged on the shaft **18,** it can be seen that the mounting block **40** lies generally coaxial with the shaft **18.** However, as the nut **36** is tightened the adjacent angular ends of the sleeves **30** and **35** force the bearing **31** into an angular position wherein the axis of the bearing **31** and mounting block **40** is oriented at an angle (in the present embodiment approximately 3 degrees) to the axis of the shaft **18.** Thus, rotation of the shaft **18** causes the mounting block **40** and the rings **47** thereon

to describe a wobbling oscillatory movement, while the spring wires 67 and 72 prevent rotation thereof. With the nut 36 threaded onto the shaft 18 so that the angular sides of the sleeve 30 and 35 are in tight abutting engagement with the inner race 32 of the bearing 31, the mounting block 40 is tilted sufficiently, relative to the shaft 18, to bring one of the rings 47 into engagement with the contact 57 on one of the fingers 56 and the other ring 47 into engagement with at least one of the contacts 57 on an oppositely disposed finger 56.

Referring to the development diagram of FIG. 6, it can be seen that the first contact 57 in the line is in engagement with the lower ring 47 and the eighth and ninth contacts 57 in the line are in engagement with the upper ring 47. In FIG. 7 the shaft 18 is rotated 90° and the fourth and fifth contacts 57 are engaged with the lower ring 47 while the twelfth contact 57 is engaged with the upper ring 47. It is therefore apparent that, for each complete rotation of the shaft 18, each of the contacts 57 periodically engages each of the rings 47 in a manner to effect sequential engagement of the respective contacts with each ring. The rings 47 are slidably mounted on the mounting block 40 and biased by the annular springs 50 to allow slight axial movement thereof upon engagement with any of the contacts 57 so that each of the contacts 57 engages either of the rings 47 with a slight sliding movement to insure positive contact therebetween.

The flat sides 25 and 26 on the shaft 18 are provided so that the rings 47 are engaged with contact 57 and, therefore, taps 24 which are oriented in a plane generally perpendicular to a plane through the poles of the rotor 21 (see FIG. 8). It should of course be understood that this specific orientation is desirable for the electric machine 15 illustrated and if the commutator 16 is utilized with other electric machines the orientation thereof may vary. The present electric machine 15 operates on the basis that a flux pattern is produced between the poles of the permanent magnet rotor 21 and the stator core 22. Rotation of the shaft 18, by connecting it to a motor or the like, causes the flux lines in this pattern to be cut by the coils of the stationary winding 23, which produces a voltage in the winding 23. This voltage is at a minimum in a plane perpendicular to a plane through the poles of the rotor 21 so that there is a minimum of arcing in the commutator 16 is the induced current is removed at these points. To utilize the electric machine 15 as a motor, it is necessary to apply a D.C. voltage to the wires 66 and 71 so that the winding 23 sets up a field, which coacts with the field produced by the permanent magnet rotor 21 and causes rotation thereof. It has been found that the specific electric machine 15 illustrated, in conjunction with the disclosed commutator 16, can be utilized as a tachometer (generator) and produces a very low ripple in the output voltage thereof.

Referring to FIGS. 9, 10 and 11, a second embodiment of the commutator is illustrated wherein similar numbers are utilized to designate similar parts and primes are added to all of the numbers to indicate the different embodiment. A shaft 18' extending outwardly from a housing 17', containing an electric machine, has a bushing 27' eccentrically mounted thereon. A bearing 31' is mounted on the bushing 27' by means of an inner race 32'. An outer race 33' of the bearing 31' has an annular mounting block 40' coaxially mounted thereon for rotation therewith. The outer race 33' of the bearing 31' is fixedly engaged within the mounting block 40' by means of a pair of snap rings 28'. A groove is formed in the side of the mounting block 40' directed toward the electric machine and having upper and lower parallel surfaces coaxial with each other and with the mounting block 40'. A pair of electrical conducting rings 47' are affixed to the upper and lower surfaces of the groove in the mounting block 40' in concentric spaced apart relationship to define a continuous circular channel therebetween.

A pair of lugs 65' and 70' are formed as an integral part of the rings 47' and electrical conducting wires 66' and 71', respectively, are affixed thereto. An arcuate spring wire 67' is affixed to an axially extending portion 37' of an end cap 58' and to the mounting block 40' to substantially prevent rotation thereof relative to the end cap 58'. Because the mounting block 40' is mounted concentric with the bushing 27' which is in turn mounted eccentrically on the shaft 18' and because the spring wire 67' prevents rotation thereof, the conducting rings 47' affixed to the mounting block 40' describe an oscillatory motion relative to a point adjacent thereto.

In the present embodiment, three axially extending portions 37' are affixed to the end cap 58' and space peripherally therearound. Each of the axially extending portions 37' has a radially inwardly projecting portion 38' affixed thereto with an annular mounting block 55' affixed to the inner ends thereof coaxial with the shaft 18'. A plurality of axially extending fingers 56' are molded into the annular mounting block 55' so as to extend outwardly from either side thereof. The ends of the fingers 56' extending toward the housing 17' are electrically connected to the winding of the electric machine and the opposite ends of the fingers 56' extend into the channel defined by the rings 47' and have contacts 57' affixed thereto so as to extend radially outwardly from either side thereof. The radius of the circle formed by the contacts 57' is approximately equal to a mid radius of the channel defined by the rings 47' and the eccentricity of the mounting block 40' is sufficient to bring at least one contact 57' into engagement with the lower ring 47'. In the present embodiment the fingers 56' are relatively long and flexible and the eccentricity of the mounting block 40' is sufficient to engage the contacts 57' and flex the fingers 56' slightly to insure a positive contact between the contacts 57' and the rings 47'. Thus, for each complete rotation of the shaft 18' each of the contacts 57' engages each of the rings 47' by virtue of its oscillatory movement; and sequential engagement of the contacts 57' with each of the rings 47' is thereby effected.

While two embodiments are illustrated wherein contacts and parallel rings form first and second pluralities of contact surfaces it should be understood that many other embodiments and types of contact surfaces may be devised by those skilled in the art. Further the means for providing relative oscillatory movement (sleeves 30–35 in FIG. 1–8 and eccentric bushing 27' in FIGS. 9–11) may be modified or altered by those skilled in the art and may include, for example, magnets to cause the required movement. If magnets or the like are utilized the contacts of the commutator may be hermetically sealed so that the electric machine can be used in atmospheres where arcing would be dangerous. It is also possible to incorporate additional mechanism between the commutator and the electric machine, i.e.,

for example, connecting the contact surfaces of the commutator to the windings of the electric machine through semiconductor circuits or the like.

An improved commutator for electric machines has been disclosed wherein a relatively small oscillatory motion is provided between the parts of the commutator, as opposed to the rotating motion provided in prior art devices. Because the contact surfaces, 47–57 and 47'–57', oscillate relative to each other, there is a relatively short frictional engagement therebetween and, therefore, relatively little wear. In fact it has been found that the frictional wear is cut to approximately 2 percent of prior art commutation apparatus. A slight sliding contact is provided between the contacts and conducting rings to insure clean contacts and positive engagement. Further, because of the unique configuration of the present commutator the contacts can be oriented to provide continuous engagement with one or more contacts, as desired, which, in conjunction with the sliding effect described above, aids in providing less arcing, less electrical noise and less resistance across the interface. The unique configuration also renders the coil contacts easily accessibile for the addition of auxiliary circuitry and/or trimming networks connected across windings to improve ripple, etc. The accessibility renders the commutator easily replaceable without disassembly of the rotor or removal of the electric machine from its installed location. Further, an electric machine has been described in conjunction with the commutator which provides a substantially decreased ripple voltage in the output thereof when utilized as a generator.

While we have shown and described specific embodiments of this invention, further modifications and improvement will occur to those skilled in the art. We desire it to be understood, therefore, that this invention is not limited to the particular forms shown, and we intend in the appended claims to cover all modifications which do not depart from the spirit and scope of this invention.

What is claimed is:

1. A commutator for electric machines having a rotor mounted on an externally accessible shaft for rotation within a stator, said commutator comprising:

a. a pair of conducting rings adapted to receive opposite polarities of a voltage thereon, each ring having at least one contact surface extending therearound with said rings being mounted so that said contact surfaces are generally parallel and uniformly spaced apart to define an annular channel of uniform width therebetween;

b. a plurality of contact adapted to be electrically connected to coils of the machine, said contacts being mounted on a mounting member in a circular spaced apart orientation with a diameter approximately equal to the mid diameter of the annular channel between said rings;

c. means fixedly mounting one of said mounting member and said pair of rings concentrically relative to the shaft of the machine; and

d. bearing means mounting the other of said mounting member and said pair or rings on said shaft to effect relative oscillatory movement between the plurality of contacts and said rings in response to rotation of said shaft, said mounting member being positioned so that said plurality of contacts lie within said circular channel and at least one contact engages one ring while at least one opposed contact engages the other ring.

2. A commutator as set forth in claim **1** wherein the pair of rings are mounted coaxially and are axially spaced apart to define a radially extending channel.

3. The commutator as set forth in claim **2** wherein the pair of rings are mounted on the shaft and the plurality of contacts are fixedly mounted on radially inwardly directed fingers.

4. A commutator as set forth in claim **1** wherein the pair of rings are mounted concentrically and are radially spaced apart to define an axially extending channel.

5. A commutator as set forth in claim **4** wherein the plurality of contacts are mounted on fixed finger members extending axially from the mounting member.

6. A permanent magnet direct current machine comprising:

a. a housing;

b. a permanent magnet rotor having at least a north and south pole mounted on a shaft for rotation within said housing;

c. a generally toroidally shaped stator having a continuous winding therearound along substantially the entire periphery, said winding having a plurality of taps thereon positioned in substantially equally spaced relationship therearound;

d. a commutator including

1. a pair of conducting rings adapted to receive opposite polarities of a D. C. voltage thereon, each ring having at least one contact surface extending therearound with said rings being mounted so that said contact surfaces are generally parallel and uniformly space apart to define an annular channel of uniform width therebetween,

2. a plurality of contacts each connected to a separate one of said taps of said winding, said contacts being mounted on a mounting member in a circular spaced apart orientation with a diameter approximately equal to the mid diameter of the annular channel between said rings,

3. means fixedly mounting one of said mounting member and said pair of rings concentrically relative to said shaft, and

4. bearing means mounting the other of said mounting member and said pair of rings on said shaft for relative oscillatory movement between each of said contacts and and said rings in response to rotation of said shaft, said mounting member being positioned so that said plurality of contacts lie within said circular channel and at least one contact engages one ring while at least one opposed contact engages the other ring; and

e. said rotor being affixed to said shaft so that the north and south poles thereof are aligned approximately perpendicular to a line through the taps of said winding connected to the contacts in engagement with the pair of rings.

7. A permanent magnet direct current machine as set forth in claim **6** wherein the contacts are affixed to the housing on radially inwardly extending fingers and the bearing means includes a bearing having independently rotatable inner and outer races affixed to the shaft by the inner race, said rings being affixed to the outer race and flexibly attached to the housing to permit oscillatory movement with substantially no rotating movement.

8. A commutator for electric machines having a rotor mounted on an externally accessible shaft for rotation within a stator, said commutator comprising:

a. a plurality of contacts adapted to be electrically connected to coils of the machine, said contacts being mounted in spaced apart relationship to define a circle;

b. a pair of electrically conducting rings having contact surfaces thereon mounted so that said contact surfaces are substantially parallel and spaced apart to define a circular channel therebetween;

c. first means for mounting one of said plurality of contacts and said pair of conducting rings in a stationary position;

d. second means including bearing means for mounting the other of said plurality of contacts and said pair of conducting rings on the shaft for free rotation relative thereto, the plurality of contacts disposed within said channel and at least one contact engaged with one ring an at least one oppositely disposed contact engaged with the other ring;

e. the contact surfaces of the conducting rings and the circularly arranged contacts being cooperably constructed to permit relative rotational movement therebetween when engaged;

f. and means for resiliently restraining relative rotational movement between the conducting rings and the plurality of contacts.

9. The commutator defined by claim 8, wherein the resilient restaining means comprises a plurality of wire springs operatively connected between the first and second mounting means.

10. The commutator defined by claim 8, wherein said plurality of electrical contacts are carried by the first mounting means.

11. The commutator defined by claim 10, and further comprising means cooperable with the second mounting means for urging each of said conducting rings into engagement with said plurality of contacts.

12. An electric machine comprising:

a. a housing

b. a straight shaft rotatably carried by the housing;

c. a stator mounted in a stationary position within the housing and having a continuous winding there around with a plurality of taps;

d. a rotor mounted on the shaft for rotation within the housing relative to the stator;

e. and a commutator comprising:

i. a plurality of contacts respectively electrically connected to the taps of said winding, the contacts being in spaced apart relationship to define a circle;

ii. contact means defining a pair of electrically conducting contact surfaces, the surfaces being spaced apart to define an annular channel therebetween;

iii. first means carried by the housing for mounting one of said plurality of contacts and said contact means in a stationary position;

iv. second means including bearing means for mounting the other of said plurality of contacts and said contact means on the shaft for free rotation relative thereto with the plurality of contacts disposed in said channel and at least one contact engaged with one contact surface and at least one oppositely disposed contact engaged with the other contact surface;

v. the bearing means having a rotational axis disposed at an angle relative to the rotational axis of the shaft and responding to rotation of the shaft to produce relative oscillatory movement of each contact within said annular channel and cause sequential engagement of the contacts with the respective contact surfaces.

13. The electric machine defined by claim 12, and further comprising first and second sleeves mounted on the shaft in spaced relation with the bearing means disposed therebetween, the sleeves having opposed, parallel end surfaces angularly formed relative to the shaft and cooperable to force the bearing means into a position defining said angular rotational axis.

14. The electric machine defined by claim 12, wherein the contact means comprises first and second electrically conducting rings each having a contact surface thereon and mounted so that said contact surfaces are substantially parallel and spaced apart to define said annular channel therebetween.

15. The electric machine defined by claim 12, wherein said plurality of contacts are carried by the first mounting means.

16. The electric machine defined by claim 12, wherein the rotor comprises a permanent magnet having a north pole and a south pole, and the contact surfaces of the contact means are adapted to receive opposite polarities of a D.C. voltage thereon.

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