Jan. 6, 1970 SHIGERU HAYASHI 3,488,538

SPARK SUPPRESSING ARRANGEMENT FOR COMMUTATORS

Filed Aug. 29, 1967 3 Sheets-Sheet 1

FIG. 1

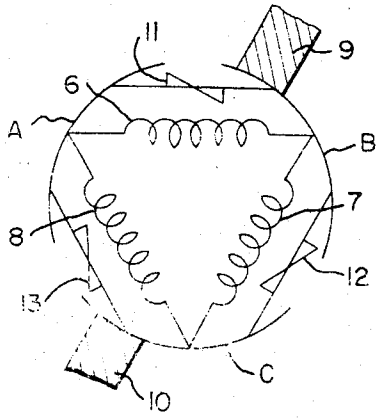


FIG. 2

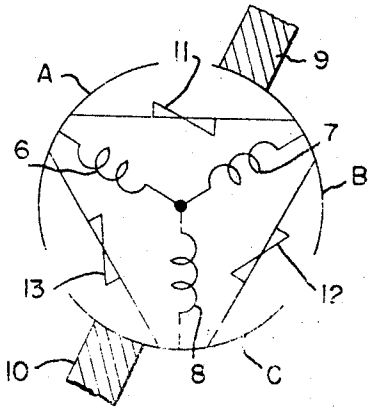


FIG. 3

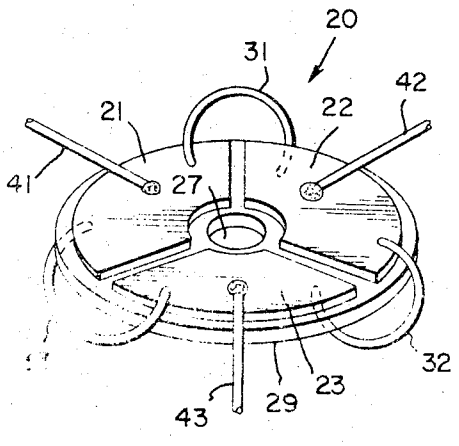
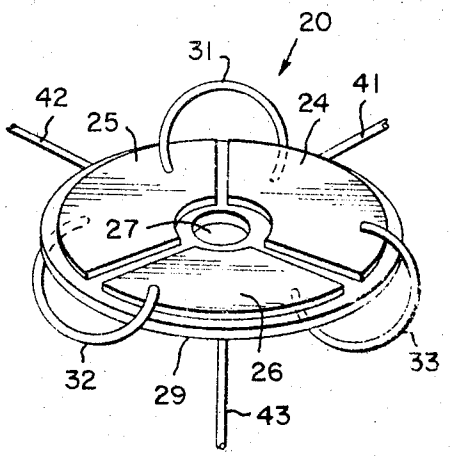


FIG. 4



INVENTOR
SHIGERU HAYASHI

BY Wenderoth, Lind & Ponack

ATTORNEYS

Jan. 6, 1970 SHIGERU HAYASHI 3,488,538

SPARK SUPPRESSING ARRANGEMENT FOR COMMUTATORS

Filed Aug. 29, 1967 3 Sheets-Sheet 2

FIG. 4'

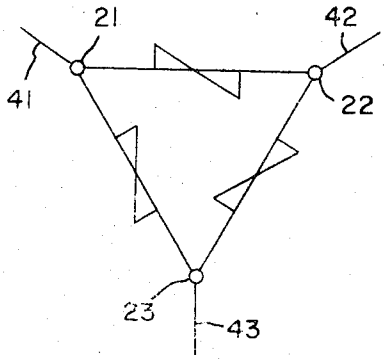


FIG. 5

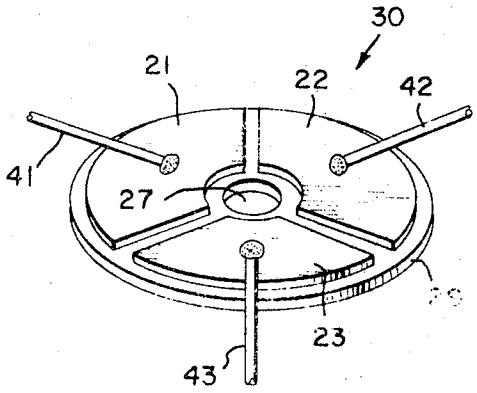


FIG. 5'

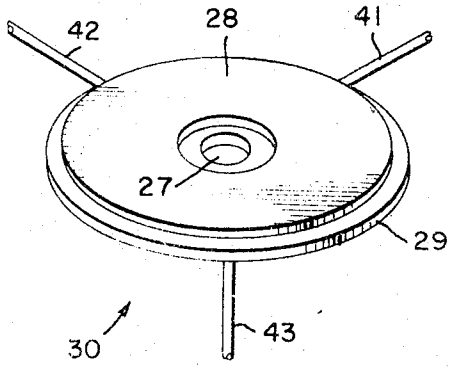
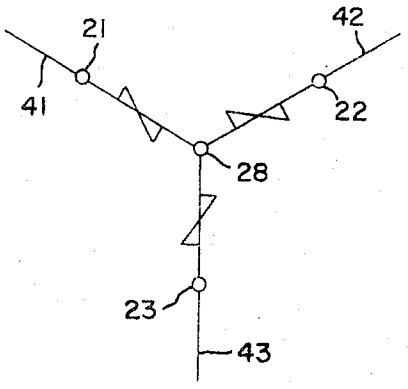


FIG. 6



INVENTOR
SHIGERU HAYASHI

BY, Wenderoth, Lind & Ponack

ATTORNEYS

Jan. 6, 1970 SHIGERU HAYASHI 3,488,538

SPARK SUPPRESSING ARRANGEMENT FOR COMMUTATORS

Filed Aug. 29, 1967 3 Sheets-Sheet 3

FIG. 7-1

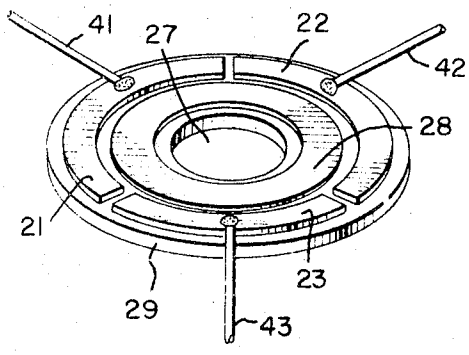
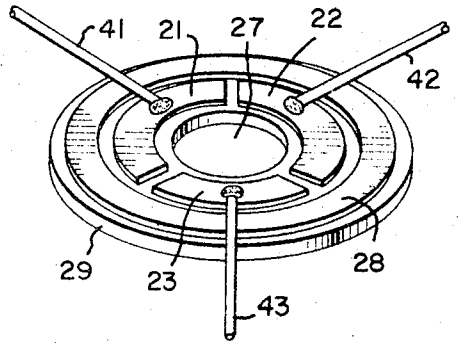


FIG. 7-2



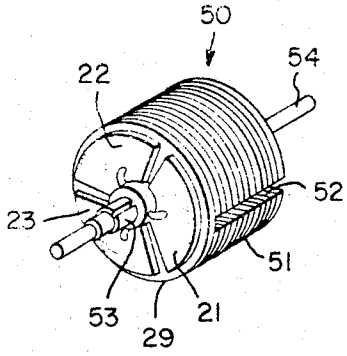


FIG. 8

FIG. 9

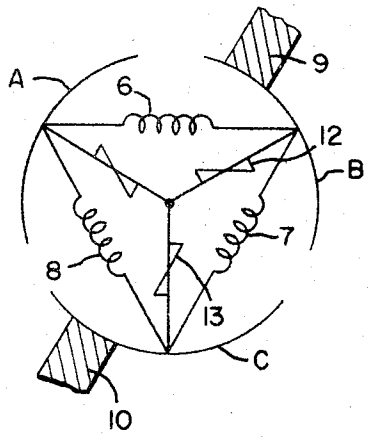
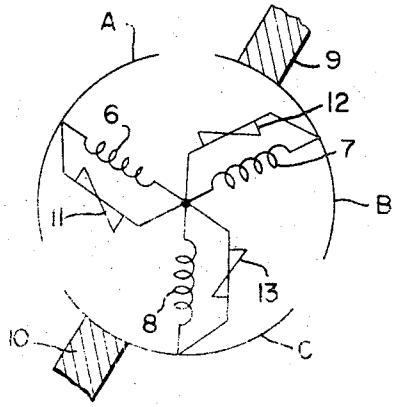


FIG. 10



INVENTOR
SHIGERU HAYASHI

BY, Wenderoth, Lind & Ponack

ATTORNEYS

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SPARK SUPPRESSING ARRANGEMENT FOR COMMUTATORS

Shigeru Hayashi, 1-chome 16–3 Makino Honmachi, Hirakata-shi, Osaka-fu, Japan

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Int. Cl. H02k *13/10;* H01r *39/46*
U.S. Cl. 310—220 10 Claims

ABSTRACT OF THE DISCLOSURE

A spark suppressing arrangement for commutators. A shaft with a plurality of commutator segments thereon has a plate-shaped varistor element which has a plurality of varistor portions equal in number to the number of commutator segment secured on the shaft perpendicular to the axis thereof. Each of said plurality of varistor portions is connected electrically to a respective one of said plurality of commutator segments.

BACKGROUND OF THE INVENTION

Field of the invention

A conventional commutator motor is apt to produce an undesirable spark discharge between the commutator and a brush during operation. Said spark discharge increases with an increase in the torque, because the increased torque enlarges the load current when the motor is rotating at a given speed. The spark impairs the commutator and the brush and shortens the life of the motor.

Description of the prior art

Three methods have previously been known for reducing the spark discharge voltage between the commutator and the brush, thus, prolonging the life of the motor. The first method is to employ a commutator and brush comprising a material which has a high resistance to wear due to spark discharging and which consequently is expensive. The second method is to reduce the induced voltage of the commutator by increasing the number of commutator segments. This increase in the number of commutator segments achieves the improved commutating characteristics thus reducing the spark but at the same time, it requires a larger number of coils and special care for obtaining a well balanced rotor with respect to the motor shaft. Such a requirement results in a higher price for the motor. The third method is to employ a plurality of spark suppressing elements such as resistors, capacitors or varistors. Said spark suppressing elements must be the same in number as the number of coils in the motor and must be connected in parallel to the coils or commutator segments of the motor. The voltage induced at the commutator is discharged through said elements thus reducing or eliminating the spark generated. As a practical matter, a resistor having a high electrical resistance does not suppress the spark sufficiently. A resistor having a low electrical resistance is superior in suppressing the spark but impairs the efficiency of the motor. A capacitor or a varistor does not have such a disadvantage and has been widely used for suppressing the spark in commutator motors. According to the prior art, capacitors or varistors, the same in number as the number of coils in the motor, are mounted in the slots of the motor and are connected in parallel to the coils. A motor having a large number of coils, requires a large number of capacitors or varistors. Said capacitors or varistors are difficult to mount in the small space available in the slots. In addition, it is difficult to balance the rotor with respect to the motor shaft when the rotor contains a large number of capacitors or varistors.

SUMMARY OF THE INVENTION

An object of this invention is to provide a commutator motor having a plurality of coils in which the spark generation during operation of the motor is suppressed by a single varistor element which functions as a plurality of varistors.

Another object of this invention is to provide a commutator motor having a plurality of coils in a star connection. Said coils being combined with a single varistor element acting as a plurality of varistors connected in a delta, i.e. a ring and a star connection.

A further object of this invention is to provide a commutator motor having a plurality of coils in a delta, i.e. ring connection, which are combined with a single varistor element acting as a plurality of varistors connected in a delta, i.e. ring and a star connection.

This invention achieves said objectives by employing a motor in which said varistor is secured to the motor shaft perpendicular to the axis thereof. The portions of the varistor are electrically connected to corresponding commutator segments.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the invention will be apparent upon consideration of the following description taken together with the accompanying drawings wherein:

FIG. 1 is a schematic diagram of a motor having the coils arranged in a delta connection and having the varistor portions connected in a ring connection;

FIG. 2 is a schematic diagram of a motor having the coils arranged in a star connection and having the varistor portions connected in a ring connection;

FIG. 3 is a perspective view of an embodiment of the varistor having three varistor portions connected in a delta connection;

FIG. 4 is a perspective view of the reverse side of the varistor shown in FIG. 3;

FIG. 4′ is a circuit diagram of the varistor shown in FIG. 3, having three varistor portions connected in a delta connection;

FIG. 5 is a perspective view of an embodiment of the varistor having three varistor portions connected in a star connection;

FIG. 5′ is a perspective view of the reverse side of the varistor of FIG. 5;

FIG. 6 is a circuit diagram of the varistor shown in FIG. 5 having three varistor portions connected in a star connection;

FIG. 7–1 is a perspective view of another embodiment of the varistor element having three varistor portions connected in a star connection;

FIG. 7–2 is a perspective view of still another embodiment of the varistor element having three varistor portions connected in a star connection;

FIG. 8 is a perspective view of a motor rotor comprising a varistor disc according to this invention;

FIG. 9 is a schematic diagram of a motor having the coils connected in a delta connection and having the varistor portions connected in a star connection; and

FIG. 10 is a schematic diagram of a motor having the coils connected in a star connection and having the varistor portions connected in a star connection.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A per se well-known commutator motor comprises a plurality of commutator segments and a plurality of coils which are connected in a star connection or in a delta, i.e. ring connection, and which are similar in number to the number of commutator segments. The spark discharge between the brush and the commutator has

previously been suppressed by using individual varistors or capacitors which are equal in number to the number of commutator segments and which are positioned at suitable places on the rotor. It has been discovered, according to the invention, that the individual varistors necessary for suppressing the spark charge can be replaced by a single varistor which functions as a plurality of varistors because it has more than three electrodes applied to the varistor body.

A varistor is essentially a non-linear resistor in which the electric resistance decreases with an increase in the applied voltage. A varistor comprising any suitable material can be employed as the active varistor material of the present invention. The preferable material for the varistor according to the invention is silicon carbide powder.

A varistor having a plate form is preferable for applying a plurality of electrodes to both surfaces. A more preferable form is a disc having a hole at the center. This form is preferred because of the ease of mounting it on the rotor and ease of obtaining a well balanced rotor.

A varistor disc which functions as a plurality of varistors in a star connection can be prepared by applying a plurality of electrodes, each provided with terminal lead wires, to one surface of the disc and one electrode to another surface.

A varistor disc functioning as a plurality of varistors in a delta connection can be prepared by applying a plurality of electrodes, each provided with terminal lead wires, to one surface of the disc and a similar number of electrodes to the other surface with the respective electrodes opposed to the corresponding electrodes on the opposite faces of the disc in pairs. Each of said plurality of electrodes on one surface is electrically interconnected to each of said plurality of electrodes on the other surface with each electrode on one surface connected to the electrode on the other surface which is on the opposite side of the varistor and opposed to the next adjacent electrode on the one surface.

For convenience, the following detailed illustration will be made with reference to a commutator motor having three commutator segments. The scope of the invention is not limited to a commutator motor having three commutator segments.

Referring to FIG. 1 and FIG. 2, reference characters **6**, **7** and **8** represent rotor coils connected together and A, B and C are commutator segments which are in contact with the brushes **9** and **10** during rotation of the rotor. Varistors **11**, **12** and **13** are connected between said commutator segments A and B, between said commutator segments A and C and between commutator segments C and B. Said varistors are in parallel with coils **6**, **7** and **8**, respectively and suppress the spark discharge between the brushes and the commutator segments. According to the prior art, said varistors **11**, **12** and **13** are three individual bodies and are mounted in available spaces such as the slots between the cores.

It has been discovered according to the invention that said varistors **11**, **12** and **13** of FIGS. 1 and 2 can be replaced by a single varistor element functioning as three varistors. The portions of said varistor element can be arranged in a delta connection or a star connection. Referring to FIG. 3, reference character **20** designates, as a whole, a single varistor element having three electrodes **21**, **22** and **23** on one surface of a disc **29** and three different electrodes **24**, **25** and **26** on the other surface. Said varistor has a hole **27** at the center of the disc **29**, which disc is made of non-linear resistance material. FIG. 3' is a perspective view of the reverse side of the varistor element shown in FIG. 3. The electrodes **21**, **22** and **23** are on the opposite side of the varistor and opposed to electrodes **24**, **25** and **26** respectively. There are interconnections between electrodes **21** and **25**, between electrodes **22** and **26** and between electrodes **23** and **24**. Said interconnection can be achieved, for example, by conventional soldered lead wires **31**, **32** and **33**. The electrodes **21**, **22** and **23** have connected thereto the terminal lead wires **41**, **42** and **43** by a conventional soldering technique. The varistor element thus produced forms a delta connection of three varistor portions as shown in FIG. 4, wherein the reference characters **41**, **42** and **43** indicate the terminal lead wires designated by similar numbers in FIG. 3.

In order to insure correct performance of such a novel varistor element functioning as three varistors connected in a delta connection, it is important that the shortest distance between adjacent electrodes on one surface be greater than the thickness of the varistor disc. The electrodes can be applied to the surface of the varistor in any shape or spacing as long as the above requirement is satisfied.

The following description illustrates another embodiment of the invention. It comprises a varistor element functioning as three varistors connected in a star connection.

Referring to FIG. 5, reference character **30** designates, as a whole, a varistor disc. Similar reference characters indicate similar components to those of FIG. 3. FIG. 5' is a perspective view of the reverse side of the varistor element shown in FIG. 5. Three electrodes **21**, **22** and **23** are applied to one surface of the varistor disc **29** and one circular electrode **28** is applied to the other surface. There is a hole **27** at the center at said varistor disc **29**. Said three electrodes **21**, **22** and **23** have terminal lead wires **41**, **42** and **43** connected thereto, respectively, by a conventional soldering method. The varistor element thus produced functions as three varistors arranged in a star connection as indicated in FIG. 6 wherein reference characters **41**, **42** and **43** indicate the terminal lead wires corresponding to the terminal lead wires **41**, **42** and **43** of the varistor disc of FIG. 5. The shortest distance between adjacent electrodes among said three electrodes **21**, **22** and **23** is required to be greater than the thickness of the varistor disc.

A varistor disc of silicon carbide powder can be made by a per se well-known method. Silicon carbide powder is mixed with from 20 to 45% by weight of a ceramic binding material consisting of, for example, 50% by weight of pottery stone, 30% by weight of kaolinite, 15% by weight of feldspar and 5% by weight of silica rock, and, if necessary, with a conductive material, such as graphite powder, metal powder or metal oxide powder, in a wet ball mill. The mixture is dried and pressed into a disc shape, having a hole at the center by a conventional ceramic fabrification technique. The pressed disc is heated at a temperature between 1100° C. and 1300° C. in air or if the pressed disc contains a conductive material, in a non-oxidizing atmosphere such as hydrogen or nitrogen. The sintered disc is then provided with the necessary number of electrodes, for example, three electrodes on one surface and three electrodes on the other surface. The electrodes can be applied by any suitable technique such as painting, screening or metallizing. The electrode material can be made of any suitable, conventional material such as copper, nickel or silver. The electrodes, if necessary, are coated with any conventional soldering material by a prior art method such as dipping. They are then provided with lead wires for the terminal lead wires and for making the interconnections between the electrodes in the way described above.

The varistor element which functions as three varistor functions in a star connection can also be made by another method. Said method consists of applying four electrodes to only one surface of the varistor disc. Referring to FIG. 7–1 and FIG. 7–2 wherein similar reference characters designate similar components to those of FIG. 5, and reference character **40** designates, as a whole, a varistor element having four electrodes **21**, **22**, **23** and **28** on one surface and no electrodes on the other surface. Said electrodes **21**, **22** and **23** are provided with terminal lead wires **41**, **42**, and **43** respectively. They are spaced

from each other in such a way that the current flowing between the adjacent electrodes among electrodes **21, 22** and **23** is less than one tenth the current flowing between electrodes **21** and **28**, between electrodes **22** and **28** and between electrodes **23** and **28**. It is preferred that the spacing be from 0.7–1.0 mm.

The spark discharge of the commutator motor having more than three commutator segments, i.e. three coils, can be suppressed by attaching a varistor element having the same number of varistor portions as there are commutator segments. A varistor functioning as any plurality of varistors can be made by applying a corresponding plurality of electrodes to a varistor disc in a way similar to that described above. For example, a varistor element functioning as four varistors in a star connection can be prepared by applying four electrodes to one surface and one electrode to the other surface. Each of said four electrodes applied to said first surface is provided with a terminal lead wire in a way similar to that illustrated in FIG. 6. A varistor element which is to function for example, as five varistors in a ring connection can be prepared, in accordance with the invention, by applying five electrodes to each of the opposite surfaces, interconnecting these electrodes in a manner similar to that of FIG. 3 and providing five terminal lead wires for each of the five electrodes on one of the surfaces.

The varistor disc, according to the invention, can be attached to any type of commutator motor by placing the disc on the motor shaft with the shaft through the hole of the varistor disc. Referring to FIG. 8, reference character **50**, as a whole designates the motor rotor; **54** designates the motor shaft; and **51** designates the motor cores secured to said motor shaft **54**. Said cores are provided with coils **52** which are electrically connected to the commutator segments **53**. A varistor element **29**, having the same number of varistor portions as there are commutator segments **53**, is secured on the shaft **54** perpendicular to the axis thereof, or, if convenient, to the motor core **51**. Care is necessary to match the center of the varistor body **29** to the center of the motor shaft **54**. The varistor electrodes **21, 22** and **23** are electrically connected to said commutator segments **53** in the manner illustrated above. According to the above assembly the varistor body **29** does not always need the lead wires **41, 42** and **43** as shown in FIG. 3, FIG. 5, FIG. 7–1 or FIG. 7–2, but can be soldered directly to the terminal of the commutator segment. Accordingly, special care is not required to obtain a motor which is well balanced with respect to the motor shaft. In these cases, the electrical connections among the coils, commutator segments and varistor portions are shown, for example in FIGS. 1, 2, 9 and 10. The varistor portions in FIGS. 1 and 2 are connected in a ring connection, while the portions in FIGS. 9 and 10 are in a star connection. The rotor so produced is combined with a brush means and a stator means comprising a magnet or an electric magnet and a frame in the conventional manner for assembling a commutator motor. It is obvious that such commutator motor is subjected to less spark discharge and can be constructed more easily and less expensively than the conventional commutator motor having a plurality of individual varistors or capacitors for suppressing the spark discharge.

What is claimed is:

1. A commutator structure comprising a shaft with a plurality of commutator segments thereon, a plate-shaped varistor element which has a plurality of varistor portions equal in number to the number of commutator segments and which is secured on the shaft with the plane thereof perpendicular to the axis thereof, each of said plurality of varistor portions being connected electrically

to a respective one of said plurality of commutator segments and bridging at least two of said segments.

2. A commutator structure as claimed in claim **1**, wherein said varistor element is a plate in the shape of a disc and has a hole at the center through which said motor shaft extends.

3. A commutator structure as claimed in claim **2**, wherein said disc has a plurality of electrodes on one surface and one electrode on the other surface thereof, the number of said plurality of electrodes being equal to the number of varistor portions, each of said plurality of electrodes being spaced from the adjacent electrodes by a distance greater than the thickness of said disc.

4. A commutator structure as claimed in claim **3**, wherein said varistor disc has three electrodes on said one surface.

5. A commutator structure as claimed in claim **2**, wherein said disc has a plurality of electrodes on only one surface thereof, one of said plurality of electrodes being a ring extending around the remaining electrodes said electrodes being spaced from each other such that the electric current flowing between adjacent electrodes among said remaining electrodes is less than the electric current flowing between said ring electrode and each of said plurality of remaining electrodes.

6. A commutator structure as claimed in claim **4**, wherein said varistor disc has four electrodes on said one surface.

7. A commutator structure as claimed in claim **2**, wherein said disc has a plurality of electrodes on only one surface thereof, one of said plurality of electrodes being a ring positioned inside of said remaining electrodes, said electrodes being spaced from each other such that the electric current flowing between adjacent electrodes among said remaining electrodes is less than the electric current flowing between said center positioned electrode and each of said remaining electrodes.

8. A commutator structure as claimed in claim **7**, wherein said varistor disc has four electrodes on said one surface.

9. A commutator structure as claimed in claim **2**, wherein said disc has a plurality of electrodes on one surface each having terminal lead wires thereon and a plurality of electrodes on the other surface which are opposed to the electrodes on the one surface, respectively, each of said plurality of electrodes on each surface being spaced from the adjacent electrodes a distance greater than the thickness of said disc, each of said plurality of electrodes on said one surface being electrically connected to an electrode on the other surface which is opposed to the next adjacent electrode on the one surface.

10. A commutator structure as claimed in claim **7**, wherein said disc has three electrodes on one surface and three electrodes on the other surface.

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MILTON O. HIRSHFIELD, Primary Examiner

R. SKUDY, Assistant Examiner