Jan. 26, 1971 G. S. SPENCER 3,559,145

BRUSH AND BRUSH HOLDER

Filed April 8, 1968 2 Sheets-Sheet 1

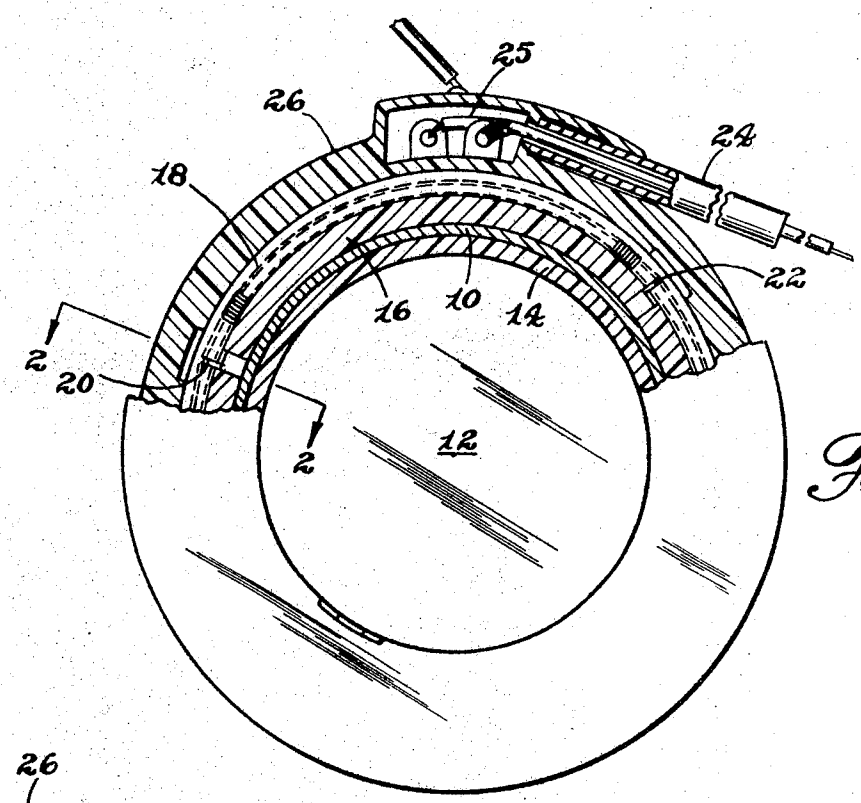

Fig. 1

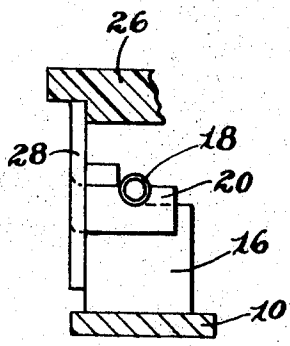

Fig. 2

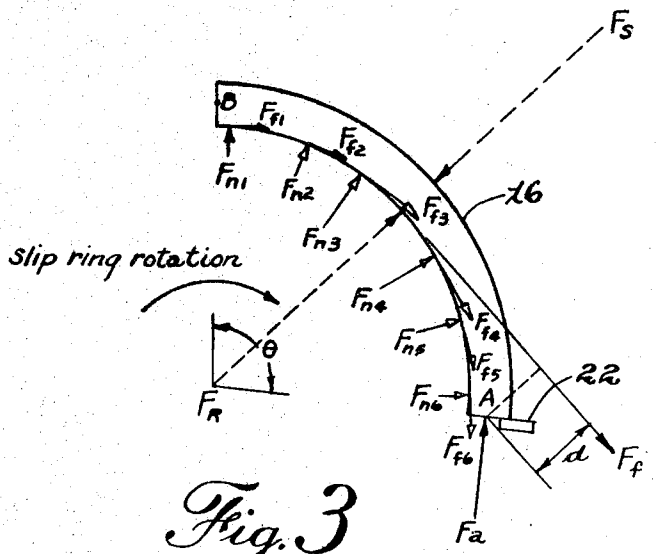

Fig. 3

INVENTOR.
Glenn S. Spencer
BY
W. J. Champion
ATTORNEY

WITNESS:
Esther M. Stockton

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BRUSH AND BRUSH HOLDER

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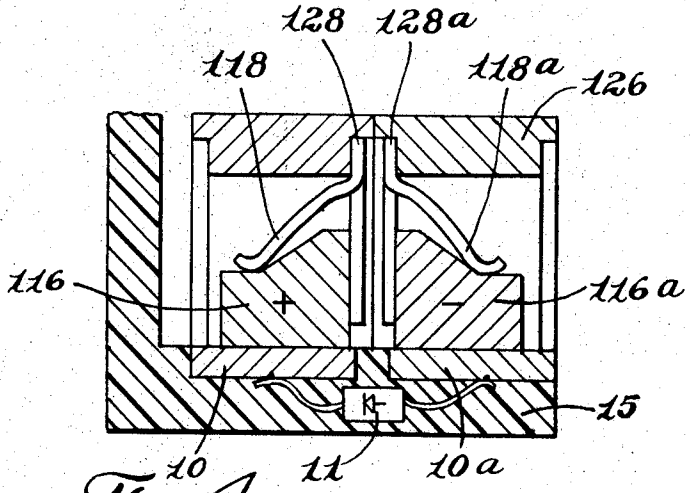

Fig. 1

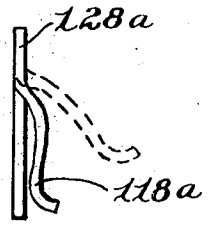

Fig. 6

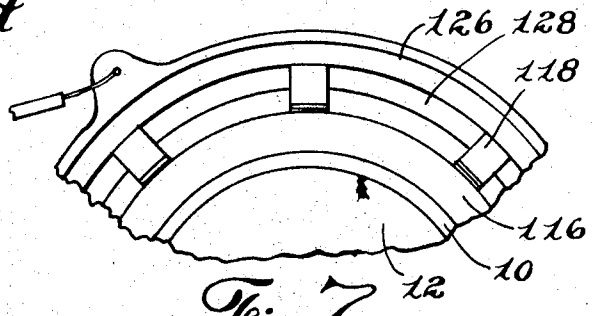

Fig. 7

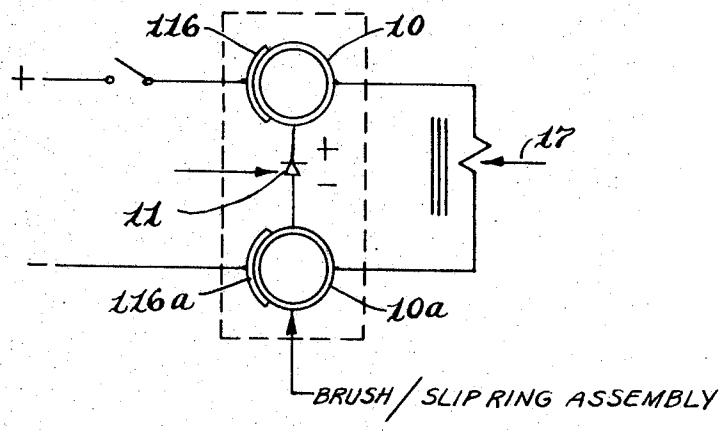

Fig. 5

WITNESS:

Esther M. Stockton

INVENTOR.

Glenn S. Spencer

BY

W. S. Thompson

ATTORNEY

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BRUSH AND BRUSH HOLDER

Glenn S. Spencer, Big Flats, N.Y., assignor to The Bendix Corporation, a corporation of Delaware

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Int. Cl. H01r 39/18
U.S. Cl. 339—8 5 Claims

ABSTRACT OF THE DISCLOSURE

A brush and brush holder for use with a conventional slip ring for conducting electricity between components when there exists a relative rotation therebetween. The brushes are loosely retained by springs in a circular brush holder with the springs providing the force to keep the brushes in contact with the slip ring. The brushes are separated from each other by only a few degrees of arc and are free to rotate with the slip ring for this short distance until they abut a stop on the brush holder. The brushes themselves have a large contact area compared to the spacing between brushes and this feature of large contact area, combined with the slight freedom of movement, provides a bi-directional brush structure having a low current density and longer life.

BRIEF SUMMARY OF INVENTION

In the use of brushes and slip rings to transfer electrical energy between a stationary body and a rotating body, the prior art discloses the use of one or more brushes in contact with a slip ring with each brush in contact for a small percentage of the circumferential area of the slip ring. In order to maintain contact, strong bias springs have been used, but these have increased the frictional forces acting on the brush and increased wear and decreased rotational speed capabilities. In order to reduce these effects, the brushes have been tilted or advanced to follow the rotation of the slip ring. This results in increased wear because the combination of frictional force vectors tends to add to the spring force. If, however, the brush is tilted in the direction opposing rotation, or retarded, the frictional force vectors oppose the spring force and tend to cause brush bounce and chatter.

The prior art brushes, because of their high current densities, also tend to burn up at a faster rate and any reduction in the contact area further increases current densities and burn-up rate. It is an object of this invention to provide a brush and brush holder which insures a maximum contact area between brush and slip ring. It is also an object of this invention to provide a brush and slip ring in which the brush dynamics automatically correct any forces tending to cause chattering or large increase in current densities. It is a further object of this invention to provide a brush and slip ring which has the aforementioned objects and is bi-directional in use and operation. It is a still further object of this invention to provide a brush having low friction and wear characteristics.

In the farm implement field, brush bounce and loss of continuity between brush and slip ring create an additional problem, as farm implements are subjected to a high amount of sharp jolts and bumps which could momentarily separate the brushes from the slip ring, causing loss of continuity and frequent arcing. This is made more serious by the dirty environment in which electrical brushes on farm implements would be required to function. This arcing causes exensive brush and slip ring burn and accelerates wear. It is, therefore, an object of this invention to provide a current-conducting brush which is less susceptible to bounce.

Since in the experimental application of this invention to farm implements, it has been found that the brush

bounce due to vehicle jolting creates brush and slip ring separation of short duration, it is a further object of this invention to provide a dual structure and protective circuit which will prevent loss of continuity for a period of time greater than brush and slip ring separation due to jolting, but which will not delay shutdown of the implement when current flow is purposely shut off. This becomes important when consideration is given to the safety of the operator.

Further objects and advantages will become clear to the man skilled in the art from the detailed description and claims which follow and from the appended drawings wherein:

BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a part-sectional, part-elevational view of a brush and slip ring structure made according to the teachings of this invention.

FIG. 2 is a sectional view taken along line 2—2 in FIG. 1.

FIG. 3 is a diagram of the forces acting on a brush.

FIG. 4 shows a second embodiment of the invention with a dual brush structure, different biasing means and a continuity protective element.

FIG. 5 shows the protective circuit as it applies to the brush combination of FIG. 4.

FIG. 6 shows, in profile, the brush holder of FIG. 4.

FIG. 7 shows, in elevation, a portion of the structure shown in FIG. 4.

DETAILED DESCRIPTION

Referring now to FIG. 1, a brush and slip ring structure is shown with slip ring **10** connected to rotatable shaft **12** and insulated therefrom by insulating ring **14**. In contact with the slip ring **10** is arcuate brush **16** which is one of a plurality of arcuate brushes equidistantly spaced about the circumference of the slip ring **10**. Brush **16** is resiliently retained in contact with the circumferential surface of slip ring **10** by garter spring **18**. The garter spring **18** and brush **16** are retained by the stops **20** and **22** which are, in turn, connected to and form a part of the annular brush holder **28**, best shown in FIG. 2.

Clockwise rotation of the slip ring **10**, relative to the brush **16**, will cause clockwise rotation of the brush **16** until the brush **16** abuts the stop **22**. Counterclockwise rotation of the slip ring **10**, relative to the brush **16**, will cause counterclockwise rotation of the brush until it abuts stop **20**. The tendency to follow the slip ring **10** is caused by the non-rigid retention of the brushes by the brush retainer and garter spring.

Additional associated hardware is shown which includes electrical current leads **24**, terminals **25** connected to brush holder **28** and non-rotating body **26**. It will be obvious to the observer that the component parts of this conductor may be altered and their relative locations varied without departing from the spirit of the invention.

Turning now to FIG. 2, the brush **16**, brush holder **28** and slip ring **10** are shown, but more particularly, the interrelation of these components is shown. As can be seen from the figure, garter spring **18** maintains sufficient force upon the brush to bias it against slip ring **10**. Current can flow to the brush through the brush holder **28**, through the stop **20**, or through the garter spring **18**. Stop **20** is also shown as a tab projecting from brush holder **28**.

Turning now to FIG. 3, a single brush **16** is shown subtending an arc whose angle is θ. The various forces acting on the brush are shown as F_r, F_s, F_f and F_a. These forces are shown having particular magnitudes and directions, but this is for illustration purposes only and does not represent a single state of operation, but rather, shows all the forces that may be expected to act on the brush. F_s is the resultant force exerted by the spring. F_r is the summation of the radial forces exerted on the brush by the

slip ring. F_f is the summation of the frictional forces acting on the brush due to the rotation of the slip ring. F_a is the force exerted by the stop **22** in resisting rotation of the brush with the slip ring.

Assuming that the brush is not in contact with the stop when relative rotation begins, an unbalanced force condition will exist since F_a will be zero. F_r and F_s will be equal and opposite and, therefore, will cancel and F_f will cause the brush **16** to be pushed into the stop. When the brush makes contact with the stop, the magnitude of F_a will equal the magnitude of F_f since the brush will stop rotating and the sum of the moments about the center of rotation will be zero. However, the summation of the moments about the stop will not be zero and the brush will begin to rotate about the stop. The end of the brush, not in contact with the stop, will begin to lift off of the slip ring. This will have the effect of shifting the resultant forces F_r and F_s because the incremental spring force at the "free" end of the brush will increase as spring tension increases and the friction force will decrease as the end of the brush begins to lift. This will have the effect of moving the resultant force F_r clockwise towards the stop and the resultant force F_s counterclockwise away from the stop. Both resultants will, however, continue to be readily-acting forces.

As the force F_r approaches the stop, the point at which F_f appears to act will also approach the stop and as F_f acts tangentially to cause rotation about the stop, the moment caused by F_f about the stop will lessen because the distance (*d*) will be decreasing. There will also be an unbalanced condition between forces F_r and F_s with the resultant moment of these two forces tending to offset the moment of F_f. This offsetting force will have the effect of causing the forces acting on the brush to seek a dynamically-balanced state and this mode of operation will be quite stable.

From this description of the operation of a brush and a brush holder constructed according to the teachings of the present invention, it will be obvious that the shifting of the forces acting upon individual brushes causes the brush to have a very stable mode of operation. That is, as soon as an instability appears, as for instance when rotation starts or rotational speed changes, the forces acting on the brushes will cause them to rotate slightly about their respective stops in such a way that the unbalance is automatically and promptly eliminated. Furthermore, this configuration is not limited to unidirectional operation, but is equally effective for either clockwise or counterclockwise rotation. The large brush contact area insures that a substantial contact area will remain even at the extreme of operating conditions, thereby maintaining the low current density necessary to prolong brush life. It can be readily seen that this invention accomplishes its stated objectives.

This feature, degenerative displacement, has been found to increase as the sine of the angle subtended by the arc of the brush. That is, for small angles, the degenerative displacement is small, but as the angle increases, the degenerative displacement effect increases until a maximum at about 90°. From there, it remains approximately constant until the angle reaches 180°. At this point, of course, a rigid brush could not begin to rotate about a stop without binding on the slip ring. As an example, a brush which defined an arc which subtended an angle of 30° would have only about 50% of the degenerative displacement effect of a similar brush operated under a similar set of conditions, but subtending a 90° angle.

FIG. 4 shows the brush and brush holder, according to the present invention, in an embodiment in which two slip rings are used. For convenience, component parts which correspond to components of the single slip ring embodiment are numbered accordingly, but in the **100** series, while identical parts have identical numbers. Since this embodiment shows a module construction, including ground return brush and slip ring, and assuming negative ground, parts associated with ground will include an *a*

as part of their identifying number. This also applies to FIGS. 5, 6 and 7.

In this embodiment, brush holders **128** and **128***a* include fingers **118** and **118***a* which take the place of garter spring **18**. Brushes **116** and **116***a* are urged toward slip rings **10** and **10***a* which are retained in insulated holder **15** and are mounted for rotation on a shaft, not shown. Diode **11** is shown imbedded in the insulating material and provides continuity protection for the brushes **116** and **116***a* and slip rings **10** and **10***a*.

FIG. 5 shows the circuit associated with the dual configuration of FIG. 4. The diode **11** interconnects the slip rings with its positive terminal connected to the electrically more positive slip rings. Conventional arc suppression and protective circuits include a resistor in series with the diode, but this results in a short period of time elapsing between open-circuiting of the circuit and current decay to a level corresponding to "off." On the other hand, I have found that a diode alone allows current to decay more slowly so that during the time of typical brush bounce and continuity loss, the current decay is not sufficient for arcing to occur, thereby protecting the brush and slip ring from pitting and burning. The electrical load **17** may be any device which utilizes an electrical current such as an electromagnetic clutch or the like.

FIG. 6 shows the brush holder **128***a* from FIG. 4 with the finger **118***a* relaxed and, in phantom lines, in the working position. This structure provides spring force to bias the brush toward both the slip ring and the brush holder.

FIG. 7 shows, in elevation, a profile view of the structure shown in FIG. 4. As can be seen, the fingers **118** are maintaining the brush **116** in contact with the slip ring **10**. To insure against the loss of electrical contact between the brush **116** and the brush holder **128**, the fingers **118** are shown as being wide and, therefore, capable of carrying all the current between the brush holder **128** and brush **116**.

I claim:

1. A stationary-to-rotary electrical current conducting device comprising:

a slip ring for connection to a shaft;

at least one arcuate brush having a first surface adapted to engage said slip ring;

resilient retention means operative to engage a second surface of said brush to bias said brush substantially radially toward said slip ring;

holding means for retaining said arcuate brush; and

stop means associated with said holding means operative to permit limited movement of said brush with said slip ring;

said stop means operative upon rotation of said slip ring relative to said holding means to abut an end of said arcuate brush and in cooperation with said resilient retention means to cause said brush to attempt to rotate about the stop means as relative rotation of said slip ring causes, as by friction, said brush to bear against said stop means.

2. The device claimed in claim **1** wherein said brush subtends an arc of said slip ring of less than 180°.

3. The device claimed in claim **2** wherein said brush subtends an arc of said slip ring of greater than 30°.

4. The device claimed in claim **1** wherein said stop means is a tab protruding from said holding means.

5. The device claimed in claim **1** using a grounded return including further a diode with its cathode connected to the brush and its anode connected to the return.

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RICHARD E. MOORE, Primary Examiner