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BEARINGLESS SLIP RING ASSEMBLY

Filed March 7, 1967

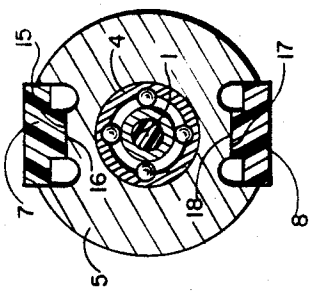


FIG. 2
PRIOR ART

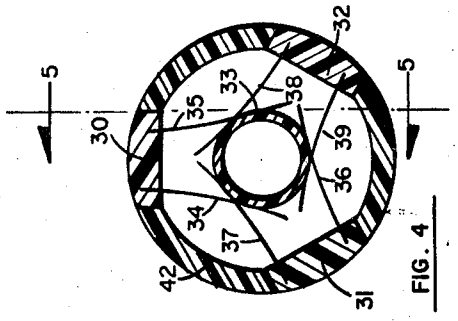


FIG. 4

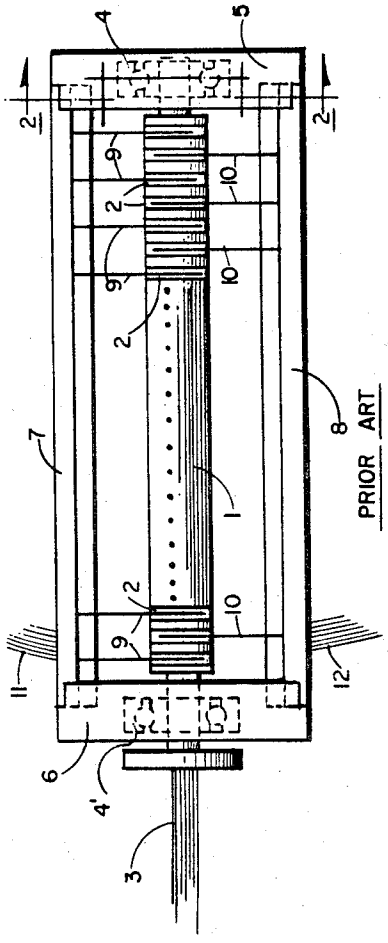


FIG 1
PRIOR ART

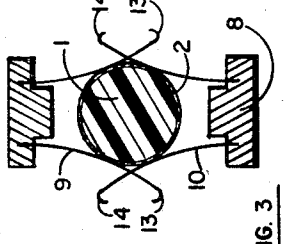


FIG. 3
PRIOR ART

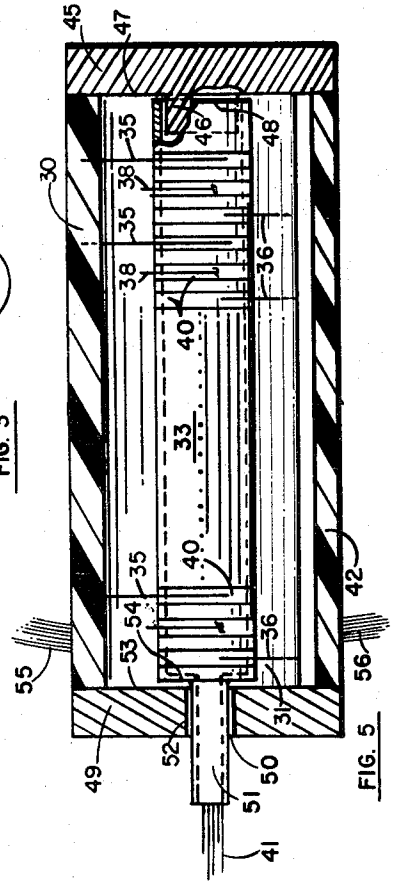


FIG. 5

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BEARINGLESS SLIP RING ASSEMBLY

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ABSTRACT OF THE DISCLOSURE

A combination slip ring and bearing assembly for rotary shafts in which three rotor-brush block sections are located at 120° intervals around the rotary shaft. Each brush block section includes at least one pair of wiper wires which contact the rotary shaft on opposite sides thereof. In this manner there are wiper contact points at 60° intervals and the need for a conventional bearing is eliminated.

BACKGROUND OF THE INVENTION

(1) Field of the invention

The present invention relates to slip ring assemblies for rotary shafts and, more particularly, to a novel brush block arrangement for supporting a slip ring rotor without using conventional bearings.

(2) Description of the prior art

In numerous types of systems, it is necessary to transmit information in the form of an electrical signal from a stationary member to a member which has unlimited rotational freedom. For this purpose, it is usual to provide a slip ring assembly which includes a stationary element which is connected to the stationary member and a rotary element which is connected to the rotating member. The rotary element, or shaft, is typically constructed of an electrically non-conductive plastic with a plurality of electrically conductive bands located thereon. The electrical signals to be transmitted are provided over a plurality of conducting wires through the center of the rotary shaft to the conductive bands. A slip ring assembly is provided on the stationary element, including a plurality of electrically conductive wiper wires which contact the electrically conductive bands on the rotary shaft. In this manner, the signals on the electrically conductive bands of the rotary shaft are transmitted to the wiper wires from which an output may be derived.

In the construction of such slip ring assemblies, it is usual to provide a ball bearing arrangement at each end thereof to provide the rotary shaft with complete rotational freedom. In this manner, a relatively stable construction is provided, one in which the rotary shaft is restrained from motion in a direction perpendicular to its longitudinal axis. In other words, the longitudinal axis of the rotary shaft is held fixed by the stationary bearings to prevent radial motion.

The construction of a slip ring assembly with such a bearing arrangement creates several problems. The rotary shaft is a cylindrical member made of an electrically non-conductive material with a plurality of spaced electrically conductive bands which are electrically insulated from each other. The slip ring assembly consists of a plurality of thin electrical wiper wires which are fixedly mounted with respect to the rotary shaft in such a manner as to tangentially contact the rotary shaft. With such an arrangement, the force with which the wiper wires contact the rotary shaft is critical. Typically, the force is on the order of several grams. If the force of the wiper wires on

the rotary shaft is less than that required, there will exist the possibility that the wires will lose contact with the shaft. If this occurs, a foreign substance can become lodged between the wipers and the shaft to create a permanent loss of contact between the two members. Even if permanent loss of contact does not occur, the electrical resistance between the shaft and the wipers increases and the noise level similarly increases. If the force between the wiper wires and the rotary shaft is greater than that required, there are other problems. Excessive wear of the wipers and conductive sections together with increased friction between the two members results leading to early failure of the assembly. In addition, there may be polymerization of the wiper-shaft assembly. In other words, the excessive friction between the two sliding members may cause material from one of the members to become deposited on the other.

Numerous techniques have been formulated heretofore to eliminate these problems but none have been completely successful. Because of th criticality of the force with which the wipers contact the rotary shaft, it is usual to make the wiper assemblies with a high degree of accuracy. Typically, each wiper wire is hand-fitted into the brush block assembly. This is a very time consuming process and one which is expensive. Another proposed solution is the use of a floating bearing. In other words, one which has limited freedom with respect to its housing. This too, however, is very expensive and difficult to design and manufacture with very small slip ring assemblies.

SUMMARY OF THE INVENTION

According to the present invention, these numerous problems of prior art systems are in large measure overcome. By providing the rotary shaft with a unique brush block arrangement, conventional bearings may be completely eliminated. According to the present invention, the rotor is a hollow, lightweight, electrically non-conductive, molded plastic part. Instead of the usual two brush block assemblies on diametrically opposed sides of the rotary shaft, there is provided three brush blocks which are located at 120° intervals around the rotary shaft. Each brush block assembly includes at least one pair of wiper wires which contact the rotary shaft tangentially, on opposite sides thereof. Therefore, there are wiper contact points at approximately 60° intervals. In this manner, the wiper wires themselves, acting as spring arms, may be used to support the rotary shaft radially, and there is no need to use a conventional ball bearing. By eliminating the bearing, the first clear advantage is the elimination of its cost. But a far more important advantage is the elimination of the problem of centering the rotary shaft with respect to the wiper wires. Since there are no bearings to constrain the rotary shaft, it is free to move radially. In this manner, the rotary shaft is self-centering and can assume a rotational position in which relatively all of the forces on the wiper wires are equalized. Equalization of the forces with which the wipers contact the rotary shaft increases the life of the slip ring assembly. Limit stops are also provided to prevent extreme motions of the rotary shaft in a radial direction and additional limit stops are employed to prevent any axial thrust loads on the shaft.

OBJECTS OF THE INVENTION

It is therefore, an object of the present invention to provide a slip ring assembly for a rotary shaft that does not require a support bearing.

It is a further object of the present invention to provide a slip ring assembly for a rotary shaft which permits limited freedom of motion of said shaft in a radial direction.

It is a still further object of the present invention to provide a novel brush block arrangement for a rotary shaft which permits self-centering of said shaft.

It is another object of the present invention to provide a slip ring assembly for a rotary shaft which permits limited freedom of motion of said shaft in an axial direction.

Still other objects, features, and attendant advantages of the present invention will become apparent to those skilled in the art from a reading of the following detailed description of a preferred embodiment constructed in accordance therewith taken in conjunction with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic view of a prior art slip ring assembly;

FIGURE 2 is a cross-sectional view of the slip ring assembly of FIGURE 1 showing the manner in which the rotor brush block sections are attached to the assembly;

FIGURE 3 is a cross-sectional view of the slip ring assembly of FIGURE 2 showing the manner in which the wiper wires are formed so as to apply the proper force to the rotary shaft;

FIGURE 4 is a view of the slip ring assembly of the present invention; and

FIGURE 5 is another view of the slip ring assembly of the present invention showing schematically the use of limit stops.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and, more particularly, to FIGURE 1 thereof, there is shown a typical prior art slip ring assembly. Such an assembly consists of a rotary shaft **1** made of a non-conductive material, typically of plastic, with a plurality of electrically conductive annular bands **2** spaced along its longitudinal axis. A plurality of leads **3** are placed through rotor **1** so as to contact electrically conductive bands **2** from within. In other words, a separate lead will be attached to a different one of the electrically conductive bands **2**. Located at each end of rotary shaft **1** is a bearing configuration **4** and **4'** for supoprting rotary shaft **1** with unlimited rotational freedom. Bearing sections **4** and **4'** fixedly connect rotary shaft **1** to housing end portions **5** and **6**, respectively, which are connected together by means, not shown, to provide a unitary apparatus. Supported by end portions **5** and **6** are a pair of brush block sections **7** and **8** which support a plurality of thin, wiper wires **9** and **10**, respectively. Wiper wires **9** are fixedly connected to brush block section **7** and are in contact with alternate electrically conductive bands **2** of rotary shaft **1**. Similarly, wiper wires **10** are fixedly connected to brush block section **8** and contact alternate electrically conductive bands **2** of shaft **1**. Each of wipers **9** is electrically connected to a different one of a plurality of electrical leads **11** which may be made integral with brush block section **7**. In a like manner, each of wiper wires **10** is electrically connected to a different one of a plurality of electrical leads **12** which may be made integral with brush block section **8**.

The manner in which such a slip ring assembly may be assembled will be better understood with reference to FIGURE 2 which shows a cross-sectional view of the slip ring assembly of FIGURE 1 taken along lines **2—2** thereof and FIGURE 3 which shows a schematic representation of the shape of the wiper wires thereof. Initially, end plates **5** and **6** are constructed and attached by means, such as metal rods, not shown, and rotary shaft **1** is connected to end sections **5** and **6** by ball bearing arrangements **4** and **4'**. Wiper wires **9** and **10** are then constructed and placed within brush block sections **7** and **8**. Brush block sections **7** and **8** are then fitted into cutout sections in end portions **5** and **6** provided for the purpose. In other words, as shown in FIGURE 1, brush block **7** is lowered onto rotary shaft **1** whereas brush block section **8** is lifted into contact with shaft **1**.

Because of the necessity of having a predetermined force between wiper wires **9** and **10** and rotary shaft **1**, the spacing between each pair of wiper wires is less than the diameter of rotary shaft **1**. This may be seen in FIGURE 3. With such a construction, when wiper wires **9** are lowered onto rotary shaft **1** they will spread a predetermined amount to establish the required force on shaft **1**. In order to insure that wiper wires **9** and **10** will spread without damaging conductive sections **2** of rotor **1**, each of wiper wires **9** and **10** is provided with a curl section **13** and **14**, respectively. In this manner, when rotor brush block section **7** is lowered onto rotary shaft **1**, wiper wires **9** will bend outwardly without the points of the wipers scratching the surface of rotary shaft **1**.

Brush block **7** is lowered until surface **15** at the lowermost part thereof contacts surface **16** of end portion **5**. Similarly, brush block section **8** is raised until surface **17** at the uppermost part thereof contacts surface **18** of end portion **5**. Surfaces **15**, **16**, **17** and **18** must be finely machined and accurately positioned so that the force of wiper wires **9** and **10** on rotary shaft **1** is proper. It can be seen from FIGURE 3 that the further brush block section **7** is lowered with respect to rotary shaft **1** the further wiper wires **9** will be spread and a greater force will be exerted between wipers **9** and rotor **1**.

The disadvantages which are inherent in a slip ring assembly as shown with respect to FIGURES 1 through 3, may now be apparent. Rotary shaft **1** is fixed axially and radially with respect to end portions **5** and **6** by bearings **4** and **4'**. In the construction of brush block sections **7** and **8**, each of wipers **9** and **10** must be accurately placed within the assembly so that the curl portions **13** and **14** are all pointed outwardly. Brush block assembly **7** and **8** must be placed within end portions **5** and **6** in such a manner as to accurately locate surfaces **15**, **16**, **17** and **18**. Even discounting the expense and difficulty of assembly, the final product has obvious disadvantages. It is difficult or impossible to control the force with which each individual wiper wire **9** and **10** contacts rotary shaft **1**. As a result, if any wiper wire is misplaced, and becomes inoperative, the whole slip ring assembly is rendered useless.

The unique features of the present invention will now be described with reference to FIGURE 4 which shows a cross-sectional view of a novel rotor-brush block assembly. Instead of using a pair of brush block sections as shown in FIGURES 1 through 3, there is provided three brush block sections **30**, **31** and **32** which are located at 120° intervals around rotary shaft **33**. Each of brush block sections **30–32** includes at least one pair of wiper wires, **34** and **35** in the case of section **30**, **36** and **37** in the case of section **31**, and **38** and **39** in the case of section **32**. The pair of wiper wires on each brush block section contact the rotary shaft tangentially on opposite sides thereof. Since the spacing of brush block sections **30–32** is at 120° intervals, there is provided a wiper contact point at approximately 60° intervals. In this manner, wiper wires **34–39** may themselves be used to support rotary shaft **33** and there is no need to use a conventional bearing assembly.

Wiper wires **34–39** are effective to support rotary shaft **33** radially and to provide limited motion for shaft **33**. However, in order to prevent large radial excursions or to prevent axial thrust loads, additional apparatus must be provided. This additional structure, together with the manner in which the slip ring assembly may be constructed, will be more fully understood with reference to FIGURE 5 which shows a schematic view of a complete slip ring assembly taken along lines **5—5** of FIGURE 4. With reference to FIGURE 5, rotary shaft **33** is a hollow, lightweight, electrically non-conductive molded plastic part. Rotary shaft **33** may be made, for example, of polysulphone, a thermo-plastic, which can be injection molded to produce a strong composition which machines well.

Rotary shaft **33** has a plurality of electrically conductive bands **40** spaced along its longitudinal axis. A plurality of leads **41** may be placed through the center of shaft

33 so that a different one of the leads contacts a different one of the electrically conductive bands 40 from within. Brush block sections 30, 31 and 32 are supported by a cylindrical, hollow housing 42.

Since rotary shaft 33 is not supported by housing 42 with conventional bearings it is possible to first construct brush block assemblies 30–32 integrally with housing 42. In other words, after wiper wires 34–39 are constructed and set in assemblies 30–32, the assemblies may be placed in a fixture which will hold them in their proper orientation. A plastic material may then be poured into the fixture in such a manner as to form circular, hollow housing 42 which will both provide a housing for the slip ring assembly and simultaneously bond the brush block assemblies 30–32 in place.

With the entire stator assembly arranged in place, the rotor may be inserted. This may be accomplished in any convenient manner. An overly simplified approach may be to extend a plurality of thin, rigid rods through the stator assembly, in between the pairs of wiper wires. The rods may then be moved radially until they contact and spread wiper wires 34–39. Rotary shaft 33 may then be inserted through the center of the stator assembly without contacting wipers 34–39 which are held in a spread position. After shaft 33 is properly located, the rods may be removed permitting each pair of wipers, in turn, to contact its selected electrically conductive band 40. In manner, it is not necessary to provide wiper wires 34–39 with curled sections as shown in FIGURE 3 since the rods serve the purpose of properly spreading each pair of wiper wires.

After rotary shaft 33 is properly located within housing section 42, with wiper wires 34–39 in contact with electrically conductive bands 40, it is necessary to provide limit stops to prevent extreme radial motion of shaft 33 and to provide limit stops for any axial thrust loads. For this purpose, an end portion 45 may be attached to housing 42. End portion 45 may be arranged with a cylindrical protuberance 46 which will fit within the hollow section of rotary shaft 33. The diameter of protuberance 46 may be a few thousandths of an inch smaller than the inside diameter of rotary shaft 33. In this manner, protuberance 46 will provide a first limit stop against extensive radial motion of shaft 33. In addition, surface 47 of end portion 45 will be located a few thousandths of an inch away from the end 48 of rotary shaft 33. In this manner, surface 47 provides a first limit stop for any axial thrust loads on rotary shaft 33 to the right as shown in FIGURE 5.

A second pair of limit stops must be provided for the left end of rotary shaft 33. With reference to FIGURE 5, there is schematically shown a second end portion 49 which may be attached to housing 42 after rotary shaft 33 is properly positioned. End portion 49 may be arranged with a circular cut-out section 50 whose diameter is a few thousandths of an inch greater than the outside diameter of shaft portion 51 of rotary element 33. In this manner, surface 52 of end portion 49 provides a second limit stop for radial motion of rotary shaft 33. In addition, surface 53 of end portion 49 is spaced a few thousandths of an inch from surface 54 of rotary shaft 33. In this manner, a second limit stop is provided for axial thrust loads of shaft 33 to the left as shown in FIGURE 5.

From FIGURES 4 and 5, it may be seen that the pairs of wiper wires 34, 35 contact every third electrically conductive band 40 along rotary shaft 33. (Wiper wires 34 are not seen in FIGURE 5 since they are hidden behind wiper wires 35.) In a similar fashion, wiper wire pairs 36, 37 and 38, 39 will also contact every third electrically conductive portion 40 of rotary shaft 33.

Each pair of wipers 34, 35 is electrically connected to a different one of a plurality of electrical leads 55 which may be made integral with brush block section 30. In a like manner, each pair of wipers 36, 37 and 38, 39 is electrically connected to a different one of a plurality of electrical leads 56 and 57, respectively, which may be made integral with brush block sections 31 and 32.

It is, therefore, seen that in accordance with the present invention there is provided a novel slip ring rotor-brush block assembly which completely eliminates the necessity for conventional bearings. The elimination of these bearings has the obvious advantage of eliminating their cost. But the far more important advantage is the elimination of the problem of centering rotary shaft 33 with respect to wiper wires 34–39. Since there are no bearings to constrain rotary shaft 33, it is free to move radially. In this manner, rotary shaft 33 is self-centering and is capable of assuming a rotational position in which relatively all of the forces on wiper wires 34–39 are equal. Equalization of the forces with which wiper wires 34–39 contact rotary shaft 33 drastically increases the life of the entire slip ring assembly.

While the invention has been described with respect to a preferred physical embodiment constructed in accordance therewith, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. For example, even though a slip ring assembly has been disclosed which includes three brush block sections located at 120° intervals, it will be apparent to those skilled in the art that other arrangements are possible with two, three, four or more brush block sections. In addition, the wiper wires need not be arranged in pairs although this is the preferred physical construction. Accordingly, it is to be understood that the invention is not to be limited by the specific illustrative embodiment disclosed but only by the scope of the appended claims.

We claim:

1. In combination:
   a member having a longitudinal axis;
   means for floatingly mounting said member to permit limited radial motion thereof; and
   means for supporting said member for rotation about said longitudinal axis, said means comprising:
      a plurality of spring arms supported to contact said member tangentially at different positions around said longitudinal axis.

2. The combination of claim 1 wherein said plurality of spring arms are arranged in pairs to contact said member on opposite sides thereof and wherein said pairs are spaced along the longitudinal axis of said member,

3. The combination of claim 1 wherein said member is a rotary shaft and wherein said means for supporting said member comprises:
   a plurality of brush block assemblies spaced from said rotary shaft and substantially parallel thereto;
   each of said brush block assemblies supporting at least one pair of spring arms arranged to contact said rotary shaft on substantially opposite sides thereof.

4. The combination of claim 3 wherein said brush block assemblies are spaced at 120° intervals around said rotary shaft whereby there is a spring arm contact point at substantially 60° intervals.

5. The combination of claim 3 wherein said rotary shaft comprises:
   an electrically non-conductive body portion; and
   a plurality of electrically conductive sections located on said body portion, each of said pairs of spring arms contacting a different one of said electrically conductive sections.

6. The combination of claim 5 wherein said rotary shaft is hollow and wherein a plurality of electrical leads are located within the hollow portion of said shaft so as to contact said electrically conductive sections from within.

7. The combination of claim 1 wherein said plurality of spring arms are spaced along the longitudinal axis of said member whereby said spring arms permit limited freedom of motion of said member and wherein said means for floatingly mounting said member to permit limited radial motion thereof comprises:

means for preventing extensive radial motion of said member.

8. The combination of claim **7** wherein said means for floatingly mounting said member to permit limited radial motion thereof further comprises:

means for preventing axial motion of said member.

9. In combination:

a cylindrical member;

means for floatingly mounting said member to permit limited radial motion thereof; and

means for supporting said member with unlimited rotational freedom, said means comprising:

a plurality of stationary members; and

a plurality of electrically conductive wiper wires supported by said stationary members to contact said cylindrical member tangentially, each of said wire contacting said cylindrical member at a different position around the circumference thereof.

10. The combination of claim **9** wherein each of said stationary members supports a pair of substantially parallel wiper wires which contact said cylindrical member on opposite sides thereof.

11. The combination of claim **9** wherein said stationary members are spaced at 120° intervals around the circumference of said cylindrical member.

12. The combination of claim **9** wherein said cylindrical member comprises:

an electrically non-conductive body portion; and

a plurality of electrically conductive bands spaced along the circumference of said body portion, said wiper wires contacting said electrically conductive bands whereby an electrical circuit is formed between said wires and said bands.

13. The combination of claim **12** wherein each of said

stationary members supports a plurality of pairs of substantially parallel wiper wires, the wipers of each pair contacting said cylindrical member on opposite sides thereof and wherein said stationary members are spaced at 120° intervals around the circumference of said cylindrical member, the pairs of wiper wires on each stationary member alternately contacting every third conductive band whereby said wiper wires support said cylindrical member with limited radial motion.

14. The combination of claim **13** wherein said means for floatingly mounting said member to permit limited radial motion thereof further comprises:

means for preventing extensive radial motion of said cylindrical member; and

means for preventing axial motion of said cylindrical member.

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