

PATENT SPECIFICATION

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(54) ROTATABLE MAGNET SUPPORT STRUCTURE

(71) We, SUNDSTRAND CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 4751 Harrison Avenue, Rockford, Illinois 61101, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:— The invention relates to rotatable magnet support structures of general use in the field of dynamoelectric machines.

15 In many dynamoelectric machines, such as self-excited synchronous generators used in aircraft, a permanent magnet generator is utilized as a source of excitation current and includes a circular permanent magnet

20 secured to the machine's shaft. However, a number of problems have been encountered in securing a permanent magnet to a rotating shaft, due primarily to the nature of the materials used for the permanent magnet.

25 For example, the materials used for the permanent magnets, such as ALNICO VI (Trade Mark), tend to be brittle and in many cases have various metallurgical defects including excessive porosity. One

30 approach to this problem has been to attach the magnet to the shaft by means of circumferential clamping. However, clamping the magnet to the shaft by this method tends to place excessive stress on the magnet,

35 resulting in fractures during the operation of the machine. Another approach has been to use an adhesive material to secure the magnet to the shaft. One disadvantage of this approach results from the temperature-sensitive nature of the adhesive, wherein the

40 adhesive properties tend to fail at elevated temperatures, thus allowing the magnet to become disengaged from the shaft. In many applications this is a serious consideration,

45 since generators, and aircraft generators in

particular, quite often are required to function in high temperature environments. Perhaps one of the greatest problems with the adhesive method of attachment results from the differing thermal expansion rate of 50 the steel shaft material and the permanent magnet material. For example, if the magnetic material has a coefficient of expansion greater than the material of the shaft, at high temperatures the magnetic material 55 would tend to expand away from the shaft, thereby placing excessive strains on the adhesive material. On the other hand, if the magnetic material has a coefficient of expansion less than the shaft material, the 60 shaft would expand at a greater rate than the magnetic material at higher temperatures, thus placing unacceptable tensile stress on the magnet, thereby significantly increasing the probability of fracturing the 65 magnetic material.

The invention accordingly provides an annular permanent magnet and a rotatable support structure therefor, the support structure comprising a rotatable shaft having 70 an integral enlarged portion formed with a cylindrical surface of lesser diameter than the internal diameter of the magnet and with a shoulder upstanding from one end of the cylindrical surface, a ring formed with a 75 cylindrical surface of diameter equal to that of the cylindrical surface of the enlarged portion and with a shoulder upstanding from one end of the cylindrical surface, means for securing the ring to the enlarged 80 portion with the cylindrical surfaces in abutment whereby the shoulders restrain axial movement of the magnet, a flexible material interposed between the cylindrical surfaces and the magnet, and a member 85 engaging the magnet and one of the ring and the enlarged portion to prevent rotation of the magnet with respect to the shaft.

The invention is hereinafter particularly described, by way of example only, with 90

reference to the drawings of which:

Figure 1 is a sectional perspective view of a first structure for retaining a permanent magnet on a shaft; and

5 Figure 2 is a sectional perspective view of a second structure for retaining a permanent magnet on a shaft.

10 In FIG. 1 of the drawings is illustrated a first embodiment of the invention. Rotatable inside a dynamoelectric machine is a shaft 10 which supports an annular circular permanent magnet 12. The permanent magnet 12 is typically used as a portion of a permanent magnet generator in a self-
15 excited dynamoelectric machine such as a synchronous generator. The shaft 10 includes a circular integral support portion 14 which in turn includes an outer circular support surface 16 on its outer diameter and an
20 annular shoulder portion 18 to prevent the magnet 12 from moving axially to the right. Secured to the support member 14 is a shouldered ring 20 which includes an outer support surface 21 and an annular shoulder
25 portion 22 that prevents the magnet from sliding axially to the left along the surface 21. Thus, the shoulders 18 and 22 cooperate to axially retain the magnet 12 on the support surface 16. The shoulders 18 and 22
30 are spaced by contact of the end of the ring 20 with the end surface 23 of the support 14. In this particular embodiment of the invention, the shoulder ring 20 is secured to the support portion 14 of the shaft 10 by
35 means of a plurality of fastening devices, as represented by bolts 24, 25 and lock-nut 26. As illustrated, the surface 16 and the surface 21 afford support for the magnet 12, but it
40 should be understood that the support may be afforded primarily by surface 16 rather than ring 20.

In the first embodiment of the invention as illustrated in FIG. 1, the magnet 12 is prevented from rotating with respect to the
45 shaft 10 by means of a pin 28. The pin 28 is inserted into a hole or receptacle 29 in the shouldered ring 20, preferably by means of a press fit. The inner surface of the magnet 12 is configured with a slot 30 which is
50 slightly larger in width than the diameter of the pin 28 and serves to engage the magnet 12 with the pin 28.

In order to prevent compressive stresses on the magnet 12, which could lead to failures due to fracturing, the distance between the shoulders 18 and 22 is greater than the axial width of the magnet 12 for all anticipated operating temperatures. This is to ensure that there are no axial compressive
55 forces acting on the magnet 12 due to thermal expansion of the shoulders 18 and 22 which might tend to cause fracturing of the magnetic material. By the same token, the support portion and retaining ring 20 are
60 configured so that the diameter of the sup-

porting surfaces 16 and 21 will always be at least slightly less than the inside diameter of the magnet 12 for any anticipated operating temperatures. This is to prevent thermally induced expansion of the shaft from applying a tensile stress to the magnet 12.

In order to prevent vibration and excessive movement of the magnet 12 on the shaft 10, a flexible material 32 is interposed between the inside diameter of the magnet 12
75 and the supporting surfaces 16 and 21 and between the ends of the magnet and the shoulders 18 and 22. The flexible material 32 occupies the radial and axial clearance between the supporting surfaces and the
80 permanent magnet 12. The distances between the supporting surfaces and the magnet 12 are exaggerated slightly in FIGS. 1 and 2 for clarity of illustration. A wide variety of materials are suitable for the flexible
85 material 32, including various rubber compounds or even an O-ring, but the preferred material is the trademarked LOC-TITE material or other materials that conform to United States Military Specifications Mil-
90 R-46082-A or Mil-S-22473-D. Preferably, the flexible material 32 will have a temperature expansion characteristic such that the flexible material 32 will in effect absorb
95 temperature expansion of the shaft 10 or the magnet 12 and at the same time remain in contact with the shaft and the magnet during any anticipated temperature or rotational operating conditions.

100 A second embodiment of the invention is illustrated in FIG. 2. This embodiment differs from the one shown in FIG. 1 principally in the manner in which the magnet 12 is prevented from rotating with respect to
105 the shaft 10. Instead of the pin 28 secured to the shoulder ring 20 as in FIG. 1, the magnet 12 is prevented from rotating with respect to the shaft 10 by means of a key 34 which is inserted in a keyway slot 36
110 configured out of the permanent magnet 12 and a keyway slot 38 configured out of the support portion 14.

WHAT WE CLAIM IS:

1. An annular permanent magnet and a
115 rotatable support structure therefor, the support structure comprising a rotatable shaft having an integral enlarged portion formed with a cylindrical surface of lesser diameter than the internal diameter of the
120 magnet and with a shoulder upstanding from one end of the cylindrical surface, a ring formed with a cylindrical surface of diameter equal to that of the cylindrical surface of the enlarged portion and with a
125 shoulder upstanding from one end of the cylindrical surface, means for securing the ring to the enlarged portion with the cylindrical surfaces in abutment whereby the
130 shoulders restrain axial movement of the



reference to the drawings of which:

Figure 1 is a sectional perspective view of a first structure for retaining a permanent magnet on a shaft; and

5 Figure 2 is a sectional perspective view of a second structure for retaining a permanent magnet on a shaft.

In FIG. 1 of the drawings is illustrated a first embodiment of the invention. Rotatable inside a dynamoelectric machine is a shaft 10 which supports an annular circular permanent magnet 12. The permanent magnet 12 is typically used as a portion of a permanent magnet generator in a self-excited dynamoelectric machine such as a synchronous generator. The shaft 10 includes a circular integral support portion 14 which in turn includes an outer circular support surface 16 on its outer diameter and an annular shoulder portion 18 to prevent the magnet 12 from moving axially to the right. Secured to the support member 14 is a shouldered ring 20 which includes an outer support surface 21 and an annular shoulder portion 22 that prevents the magnet from sliding axially to the left along the surface 21. Thus, the shoulders 18 and 22 cooperate to axially retain the magnet 12 on the support surface 16. The shoulders 18 and 22 are spaced by contact of the end of the ring 20 with the end surface 23 of the support 14. In this particular embodiment of the invention, the shoulder ring 20 is secured to the support portion 14 of the shaft 10 by means of a plurality of fastening devices, as represented by bolts 24, 25 and lock-nut 26. As illustrated, the surface 16 and the surface 21 afford support for the magnet 12, but it should be understood that the support may be afforded primarily by surface 16 rather than ring 20.

In the first embodiment of the invention as illustrated in FIG. 1, the magnet 12 is prevented from rotating with respect to the shaft 10 by means of a pin 28. The pin 28 is inserted into a hole or receptacle 29 in the shouldered ring 20, preferably by means of a press fit. The inner surface of the magnet 12 is configured with a slot 30 which is slightly larger in width than the diameter of the pin 28 and serves to engage the magnet 12 with the pin 28.

In order to prevent compressive stresses on the magnet 12, which could lead to failures due to fracturing, the distance between the shoulders 18 and 22 is greater than the axial width of the magnet 12 for all anticipated operating temperatures. This is to ensure that there are no axial compressive forces acting on the magnet 12 due to thermal expansion of the shoulders 18 and 22 which might tend to cause fracturing of the magnetic material. By the same token, the support portion and retaining ring 20 are configured so that the diameter of the sup-

porting surfaces 16 and 21 will always be at least slightly less than the inside diameter of the magnet 12 for any anticipated operating temperatures. This is to prevent thermally induced expansion of the shaft from applying a tensile stress to the magnet 12.

In order to prevent vibration and excessive movement of the magnet 12 on the shaft 10, a flexible material 32 is interposed between the inside diameter of the magnet 12 and the supporting surfaces 16 and 21 and between the ends of the magnet and the shoulders 18 and 22. The flexible material 32 occupies the radial and axial clearance between the supporting surfaces and the permanent magnet 12. The distances between the supporting surfaces and the magnet 12 are exaggerated slightly in FIGS. 1 and 2 for clarity of illustration. A wide variety of materials are suitable for the flexible material 32, including various rubber compounds or even an O-ring, but the preferred material is the trademarked LOC-TITE material or other materials that conform to United States Military Specifications MIL-R-46082-A or MIL-S-22473-D. Preferably, the flexible material 32 will have a temperature expansion characteristic such that the flexible material 32 will in effect absorb temperature expansion of the shaft 10 or the magnet without applying excessive stress to the magnet 12 and at the same time remain in contact with the shaft and the magnet during any anticipated temperature or rotational operating conditions.

A second embodiment of the invention is illustrated in FIG. 2. This embodiment differs from the one shown in FIG. 1 principally in the manner in which the magnet 12 is prevented from rotating with respect to the shaft 10. Instead of the pin 28 secured to the shoulder ring 20 as in FIG. 1, the magnet 12 is prevented from rotating with respect to the shaft 10 by means of a key 34 which is inserted in a keyway slot 36 configured out of the permanent magnet 12 and a keyway slot 38 configured out of the support portion 14.

WHAT WE CLAIM IS:

1. An annular permanent magnet and a rotatable support structure therefor, the support structure comprising a rotatable shaft having an integral enlarged portion formed with a cylindrical surface of lesser diameter than the internal diameter of the magnet and with a shoulder upstanding from one end of the cylindrical surface, a ring formed with a cylindrical surface of diameter equal to that of the cylindrical surface of the enlarged portion and with a shoulder upstanding from one end of the cylindrical surface, means for securing the ring to the enlarged portion with the cylindrical surfaces in abutment whereby the shoulders restrain axial movement of the

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magnet, a flexible material interposed between the cylindrical surfaces and the magnet, and a member engaging the magnet and one of the ring and the enlarged portion to prevent rotation of the magnet with respect to the shaft.

2. An annular permanent magnet and a rotatable support structure therefor according to claim 1 wherein the member preventing rotation of the magnet with respect to the shaft is a pin and the ring is configured with at least one recess for receiving one end of the pin.

3. An annular permanent magnet and a rotatable support structure therefor according to claim 2 wherein the pin is secured in the recess as a press fit.

4. An annular permanent magnet and a rotatable support structure therefore according to claim 1 wherein the cylindrical surface of the enlarged portion of the rotatable shaft and the interior surface of the magnet are configured with keyway slots and the member preventing rotation of the magnet with respect to the shaft is a key which engages each of the slots.

5. An annular permanent magnet and a rotatable support structure therefor according to any preceding claim wherein the diameter of the cylindrical surface of the enlarged portion of the rotatable shaft is less than the internal diameter of the magnet for

all anticipated operating temperatures.

6. An annular permanent magnet and a rotatable support structure therefor according to claim 5 wherein the distance between the shoulder of the enlarged portion of the rotatable shaft and the shoulder of the ring is greater than the axial width of the magnet for all anticipated operating temperatures.

7. An annular permanent magnet and a rotatable support structure therefor according to any preceding claim having a flexible material interposed between the shoulders and the magnet.

8. An annular permanent magnet and a rotatable support structure therefor according to any preceding claim wherein the means for securing the ring to the enlarged portion of the rotatable shaft comprises a plurality of bolt and nut assemblies spaced around the ring and the enlarged portion of the rotatable shaft.

9. An annular permanent magnet and a support structure therefor substantially as particularly described herein with reference to either Figure 1 or Figure 2 of the drawings.

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