A power generator assembly supplying electronic (sensors, wireless transmitter) mounted at 16c includes a rotating part 16a and a non-rotating part 16b, the rotating part including multiple generator units 18a-18d, each unit including coil 20, two permanent magnets 22a, 22b and respective pole shoes/pole surfaces 24a-24b facing radially outward, the non-rotating part 16b including an arc-shaped ferromagnetic saddle adaptor 26 arranged with a radial distance to the pole surfaces 24a-24b, configured to close a magnetic circuit passing via the pole shoes 22a-22b through the coil in a rotational position where the saddle adaptor 26 overlaps with the pole shoes 22a-22b. The rotating part 16a further comprises at least one additional permanent magnet 28a-28b arranged in proximity to one of said pole shoes of one of said multiple generator units 18a-18d, wherein the at least one additional permanent magnet 28a-28b is configured to avoid magnetic flux leakage and/or cross talk between magnetic flux circuits pertaining to adjacent generator units 18a-18d in the magnetic open position. In the magnetic closed position, fig 3a (not shown), the distance between magnetic poles 28a-28b and the saddle adaptor is greater than that of the poles 22a-22b avoiding flux loss to the poles 28a-28b.
Title

Power Generator Assembly for Rotating Applications

5 Background of the Invention

Power generator assemblies including a rotating part and a non-rotating part are widely known. A stator as a non-rotating part is then usually configured such that it encompasses the rotor as a rotating part completely.

10 One type of generator assembly is a so-called variable reluctance generator wherein a magnetic circuit powered by a permanent magnet and passing through a coil is periodically opened and closed. The AC voltage induced in the coil as a result of the oscillating magnetic field may be used to generate energy or to drive other devices.

20 In some applications, the room for a stator encompassing the rotor may be limited and be available only on one side. For example in train bogies with saddle type suspension, it may be possible to arrange additional structures on or in a saddle adapter, whereas structures arranged below the axle may be excluded for security reasons and extreme environmental conditions.

Summary of the Invention

25 The invention seeks to provide a versatile generator assembly suitable for use in situations where an amount or a quality of available space in different radial directions of a rotating part is inhomogeneous.

The invention relates to a power generator assembly including a rotating part and a non-rotating part, in particular to a power generator assembly for use in a train axlebox, wherein the rotating part is configured to be mounted on an end cap.

30 It is proposed that the rotating part includes at least one generator unit. The generator unit is preferably of modular type and includes at least one coil, at least one permanent magnet and two pole shoes having pole surfaces facing radially
outward. The non-rotating part includes an arc-shaped saddle adaptor of ferromagnetic material arranged with a radial gap to the pole surfaces. The saddle adaptor is configured to close a magnetic circuit passing via the pole shoes through the coil at least one first rotational position where the saddle adaptor overlaps with the pole shoes of the generator unit, wherein the magnetic circuit is at least partially opened if the saddle adaptor does not overlap or does not overlap completely with both of the pole shoes.

The configuration described above works based on a variable reluctance generator principle in that the oscillating magnetic field of the magnetic circuit being periodically opened and closed induces an oscillating voltage in the coil of the generator unit. This oscillating voltage can be used for driving electronic devices arranged on the rotating part as desired without external power supply.

In the context of the invention, the expression arc-shaped means that the saddle adaptor does not extend over the entire circumference but only over a certain fraction thereof, wherein that fraction differs from both 0° and 360° by at least the angular length of the generator unit, i.e. the distance between the middle points or the outer edges of the pole surfaces.

In particular, the circumferential lengths of the generator unit and of the saddle adaptor are such that at least one second rotational position exists where the saddle adaptor does not overlap with the pole shoes of the generator unit. In this configuration, the magnetic circuit should be open and the magnetic flux substantially zero. The magnetic flux therefore changes from minimum to maximum when the rotating part rotates from the second rotational position to the first rotational position and vice versa.

In a preferred embodiment of the invention, the rotating part is configured to be mounted on an end cap configured to hold a bearing of a train axle and the saddle adaptor is configured to be mounted on a train bogie side frame.

Further, it is proposed that the generator devices comprises multiple, preferably substantially identical generator units each having at least one coil, at least one
permanent magnet and two pole shoes arranged in a row. This modular structure increases the versatility of the device. Additional units can be added to increase the output power if required.

According to a further aspect of the invention, it is proposed that the rotating part comprises at least one additional permanent magnet arranged in proximity to a pole shoe, wherein the additional permanent magnet is configured to avoid magnetic flux leakage and/or cross talk between magnetic flux circuits pertaining to adjacent generator units. The additional permanent magnets may in particular be configured to absorb the magnetic flux generated by the permanent magnets in the generator units in the configuration where the magnetic circuit passing through the coils is supposed to be open, i.e. when the saddle adaptor does not overlap with the pole shoes.

In order to avoid leakage of magnetic flux to a pole shoe of a neighbouring unit, the direction of the magnetization of the permanent magnet in adjacent generator units is preferably opposite, i.e. the flux in adjacent pole shoes is oriented in the same direction.

If necessary, the rotating part comprises at least one counterweight unit configured to compensate for imbalances created by the at least one generator unit.

The counterweight unit may itself comprise at least one generator unit having at least one coil, at least one permanent magnet and two pole shoes having pole surfaces facing radially outward. For example, the rotating part of the power generating assembly may comprise a first generator device, having one generator unit or two or more circumferentially adjacent generator units, and comprise a second generator device, having one generator unit or two or more circumferentially adjacent generator units, whereby the second generator device is arranged at an angular interval from the first generator device, which interval is selected to rotationally balance the rotating part.
As will be understood, the mass of and location of further components of the rotating part are taken into account when determining the angular position of the counterweight unit.

According to a further aspect of the invention, it is proposed that the saddle adaptor includes a main body part and at least one additional piece configured to increase the surface area of the saddle adaptor and/or decrease the air gap provided between the saddle adaptor and the pole shoes. In the case of a train axlebox, the main body may be integrated in the saddle or saddle adapter of a saddle type train bogie suspension.

In one example, the at least one additional piece comprises a toothed radially inner surface, such that a varying radial gap is provided between the saddle adaptor and the pole shoes. This has the advantage of increasing flux change. In a further example, the radially inner surface of the saddle adapter is directly provided with such a toothed profile.

The invention further proposes that the rotating part includes power harvesting electronics configured to accumulate AC power generated by the oscillating magnetic field passing through the coils.

Further, it is proposed that the rotating part includes at least one condition monitoring sensor and a wireless transmitter configured to be driven by power generated by the at least one generator unit. The condition monitoring sensor may be a temperature sensor, a vibration sensor or other type of sensor for monitoring an operating parameter of interest.

The invention further proposes that the rotating part comprises means for monitoring an output signal from the at least one generator unit. Suitably, the generated voltage signal is monitored. The signal is necessarily cyclical in nature and may thus be used to determine rotational speed of the rotating part and, in the case of a train axle, the linear distance travelled.
Signal amplitude may also be monitored. The amplitude varies depending on the radial gap between the pole shoes and the radially inner surface of the saddle adaptor and on a degree of axial overlap between the pole shoes and said surface.

In the case of a train axle comprising a first and a second power generator assembly according to the invention at first and second ends of the axle respectively, the monitored voltage signal from the first and second assemblies may advantageously be compared with each other. If, for example, both signals exhibit a similar change in voltage, this may be used to detect a sideways movement of a train bogie that comprises the axle.

A yet further aspect of the invention relates to a train bogie including a power generator assembly according to the invention.

The above embodiments of the invention as well as the appended claims and figures show multiple characterizing features of the invention in specific combinations. The skilled person will easily be able to consider further combinations or sub-combinations of these features in order to adapt the invention as defined in the claims to his specific needs.

**Brief Description of the Figures**

Fig. 1 is a schematic view of an end part of a train axle equipped with a power generator assembly according to the invention;

Figs. 2a and 2b are schematic illustrations of the principle of operation of the power generator assembly according to the invention; and

Fig. 3a and 3b are schematic illustrations of the effect of additional magnets in the power generator assembly according to the invention.

**Detailed Description of the Embodiments**

Fig. 1 is a schematic view of an end part of a train axle, wherein outer rings 10a, 10b of a double row tapered roller bearing configured to mount the axle 12 in the saddle type adapter of a train bogie are visible.
An end cap 14 is fastened to an end face of the axle 12 by means of three bolts and preloads a split inner ring of the bearing in an axial direction. A rotating part 16a of a power generator assembly 16 according to the invention is provided on an outer rim of the end cap 14. The outer rim of the end cap 14 is substantially divided in two halves. One section 16c houses the electronics and the other half includes multiple generator units 18a - 18d. Four generator units 18a - 18d are provided in the embodiment illustrated.

The power generator assembly 16 includes the rotating part 16a and a non-rotating part 16b. The generator units 18a - 18d are of modular type and essentially identical in configuration. Each of the generator units 18a – 18d includes one coil 20, two permanent magnets 22a, 22b and two pole shoes having pole surfaces 24a, 24b facing radially outward each. In the embodiment illustrated, the pole shoes are formed by the permanent magnets 22a, 22b.

The non-rotating part 16b includes an arc-shaped saddle adaptor 26 of ferromagnetic material, in particular iron, arranged with a radial gap to the pole surfaces 24a, 24b on a saddle of a saddle-type suspension in a railway bogie.

The saddle adaptor is configured to close a magnetic circuit passing via the pole shoes 22a, 22b through the coil in a rotational position where the saddle adaptor 26 overlaps with the pole shoes 22a, 22b of the generator unit 18a – 18d, wherein the magnetic circuit is at least partially opened if the saddle adaptor 26 does not overlap or does not overlap completely with both of the pole shoes 22a, 22b.

The principle is illustrated in Figs. 2a and 2b, wherein the saddle adaptor 26 and the generator units 18a - 18d are illustrated without curvature for the sake of simplicity. Fig. 2a illustrates the case where the saddle adaptor 26 overlaps with the pole shoes 22a, 22b of the generator unit. The magnetic circuit is then closed and a strong magnetic flux passes the coil. In the situation illustrated in Fig. 2a, the saddle adaptor 26 does not overlap with the pole shoes 22a, 22b of the
generator unit. The magnetic circuit is then opened and substantially no magnetic flux passes the coil.

When the axle is rotating, the saddle adaptor 26 periodically passes the generator unit 18a such that the magnetic flux will be periodically varying. The oscillating magnetic field of the magnetic circuit being periodically opened and closed induces an oscillating voltage in the coil of the generator unit. This oscillating voltage can be then used for driving electronic devices arranged in the electronics section 16c of the assembly as desired without external power supply.

The circumferential lengths of the generator unit 18a and of the saddle adaptor 26 are such that at least one rotational position exists where the saddle adaptor 26 does not overlap with the pole shoes 22a, 22b of the generator unit. Specifically, the circumferential length of the saddle adaptor 26 is a multiple of the circumferential length and the pitch of the generator units 18a - 18d such that these are closed in a first rotational position and open in a second rotational position (Fig. 1).

In the embodiment illustrated in Fig. 1 and Figs 3a and 3b, the rotating part 16a comprises additional permanent magnets 28a, 28b arranged in proximity to the pole shoes 22a, 22b, wherein the additional permanent magnets 28a, 28b are configured to avoid magnetic flux leakage and/or cross talk between magnetic flux circuits pertaining to adjacent generator units 18a - 18d. This is described in further detail below.

The direction of the magnetization of the permanent magnet in adjacent generator units 18a - 18d is opposite such that the fluxes originating from the pole shoes 22a, 22b in the open configuration will be repelled. This leads to a leakage in the sense that a fraction of the flux out of one of the pole shoes 22a, 22b will be guided back to the other pole shoe of the same unit as illustrated with a dashed line in Fig. 2a.

The additional permanent magnets 28a, 28b are provided in proximity to the pole shoes 22a, 22b, i.e. at a distance smaller than the distance to the other pole shoe
pertaining to the same unit. The flux will therefore be absorbed by the additional magnets 28a, 28b as illustrated in Fig. 3b.

The radially outer surfaces of the additional permanent magnets 28a, 28b are arranged with a large air gap to the saddle adaptor 26. In the closed configuration illustrated in Fig. 3a, the air gap will avoid that flux is lost to the additional permanent magnets 28a, 28b because the magnetic resistance of the flow path via the saddle adaptor 26 is much smaller. In other embodiments of the invention, the additional permanent magnets 28a, 28b may be mounted close to the rim of the end cap 14 and/or radially underneath the pole shoes 22a, 22b.

It is to be noted that the arrows in the permanent magnets 22a, 22b, 28a, 28b indicate their direction of magnetization, respectively. Further, it is noted the magnetic circuits illustrated in Fig. 3b are closed on their respective bottom sides via the rim of the end cap 14 on which they are mounted.

Further embodiments of the invention include cases where the rotating part comprises at least one counterweight unit configured to compensate for imbalances created by the at least one generator unit, where the saddle adaptor 26 includes a main body part and at least one additional piece configured to increase the surface area of the saddle adaptor 26 and/or decrease the air gap provided between the saddle adaptor 26 and the pole shoes 22a, 22b.

The electronics section 16c of the rotating part 16a includes power harvesting electronics configured to accumulate AC power generated by the oscillating magnetic field passing through the coils and at least one condition monitoring sensor such as a temperature sensor, an acoustic emission sensor or a vibration sensor for measuring operating parameters of the bearing and/or of the axle. Further, the electronics section includes a wireless transmitter configured to be driven by power generated by the generator units 18a – 18d.
Claims

1. Power generator assembly including a rotating part (16a) and a non-rotating part (16b),
   characterized in that
   the rotating part (16a) includes multiple generator units (18a – 18d),
   wherein each generator unit includes at least one coil (20), at least one
   permanent magnet (22a, 22b) and two pole shoes having pole surfaces
   (24a, 24b) facing radially outward, wherein the non-rotating part (16b) in-
   cludes an arc-shaped saddle adaptor (26) of ferromagnetic material ar-
   ranged with a radial distance to the pole surfaces (24a, 24b), wherein the
   saddle adaptor (26) is configured to close a magnetic circuit passing via
   the pole shoes (22a, 22b) through the coil in a rotational position where
   the saddle adaptor (26) overlaps with the pole shoes (22a, 22b) of the
   generator unit (18a – 18d), wherein the rotating part (16a) comprises at
   least one additional permanent magnet (28a, 28b) arranged in proximity
   to one of said pole shoes of one of said multiple generator units (18a -
   18d), wherein the at least one additional permanent magnet (28a, 28b) is
   configured to avoid magnetic flux leakage and/or cross talk between
   magnetic flux circuits pertaining to adjacent generator units (18a - 18d).

2. Power generator assembly according to claim 1,
   characterized in that
   the direction of the magnetization of the at least one permanent magnet
   (22a, 22b) in a first one of the multiple generator units (18a - 18d) is op-
   posite to the direction of the magnetization of the at least one permanent
   magnet (22a, 22b) in a second one of the multiple generator units (18a -
   18d), the second one of the multiple generator units (18a - 18d) being lo-
   cated adjacent to the first one of the multiple generator units (18a - 18d).

3. Power generator assembly according to claim 1 or 2,
   characterized in that
   the circumferential lengths of the multiple generator units (18a – 18d) and
of the saddle adaptor (26) are such that at least one rotational position exists where the saddle adaptor (26) does not overlap with the pole shoes (22a, 22b) of a generator unit (18a – 18d).

4. Power generator assembly according to one of the preceding claims, characterized in that
the rotating part (16a) is configured to be mounted on an end cap (14) configured to hold a bearing of a train axle (12) and the saddle adaptor (26) is configured to be mounted on a railway bogie side frame.

5. Power generator assembly according to one of the preceding claims, characterized in that
the rotating part (16a) comprises at least one counterweight unit configured to compensate for imbalances created by the multiple generator units.

6. Power generator assembly according to claim 5, characterized in that
the counterweight unit comprises a further generator unit having at least one permanent magnet (22a, 22b) and two pole shoes, the further generator unit being arranged at an angular interval to the multiple generator units (18a – 18d).

7. Power generator assembly according to one of the preceding claims, characterized in that
the saddle adaptor (26) includes a main body part and at least one additional piece configured to increase the surface area of the saddle adaptor (26) and/or decrease the air gap provided between the saddle adaptor (26) and the pole shoes.

8. Power generator assembly according to one of the preceding claims, characterized in that
a radially inner surface of the saddle adaptor (26), which faces the pole shoes, has a toothed profile such that varying radial gap exists between
the pole surfaces (24a, 24b) and saddle adapter.

9. Power generator assembly according to one of the preceding claims, characterized in that
the rotating part (16a) includes power harvesting electronics configured to accumulate AC power generated by the oscillating magnetic field passing through the coils (20).

10. Power generator assembly according to one of the preceding claims, characterized in that
the rotating part (16a) includes at least one condition monitoring sensor and a wireless transmitter configured to be driven by power generated by the generator unit.

11. Power generator assembly according to one of the preceding claims, characterized in that
the rotating part (16a) includes means for monitoring an output signal from the multiple generator units (18a – 18d).

12. Power generator assembly according to claim 11, further comprising means for processing the monitored signal in order to determine at least the rotational speed of the rotating part (16a).

13. Railway bogie side frame including a power generator assembly according to one of the preceding claims.

14. Railway bogie side frame according to claim 13, comprising an axle (12) with a first end and a second end which are respectively provided with a first and a second power generator assembly according to claim 11, further comprising means for comparing a first output signal from the first assembly with a second output signal from the second assembly, for detecting a sideways movement of the bogie side frame.
Application No: GB1502096.9

Claims searched: 1-14

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC:

H2A

Worldwide search of patent documents classified in the following areas of the IPC:

H02K

The following online and other databases have been used in the preparation of this search report:

ONLINE: WP1, EPODOC

International Classification:

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