United States Patent

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[54] **BRUSH LIFTING GEAR FOR ELECTRICAL MACHINES**
4 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **310/240**
[51] **Int. Cl.** **H01r 39/42**
[50] **Field of Search** .... 310/240, 167, 246, 244, 542, 36—39

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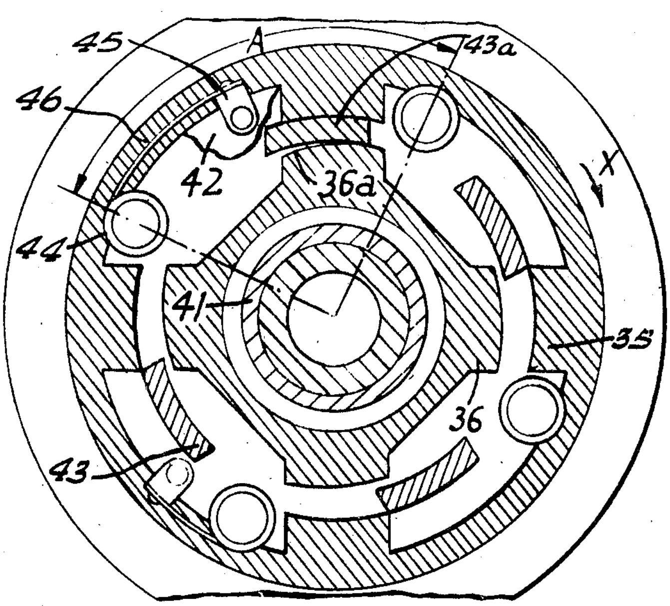
ABSTRACT: A rotary solenoid operable to lift the brushes off the commutator of an electrical machine is disclosed. The solenoid has radially inner and outer stationary pole pieces and an armature movable into the airgap between the pole pieces. The armature is provided with an auxiliary portion which bridges the airgap when the remainder of the armature has entered the airgap. The inner pole piece is shaped by a single angular machined cut.



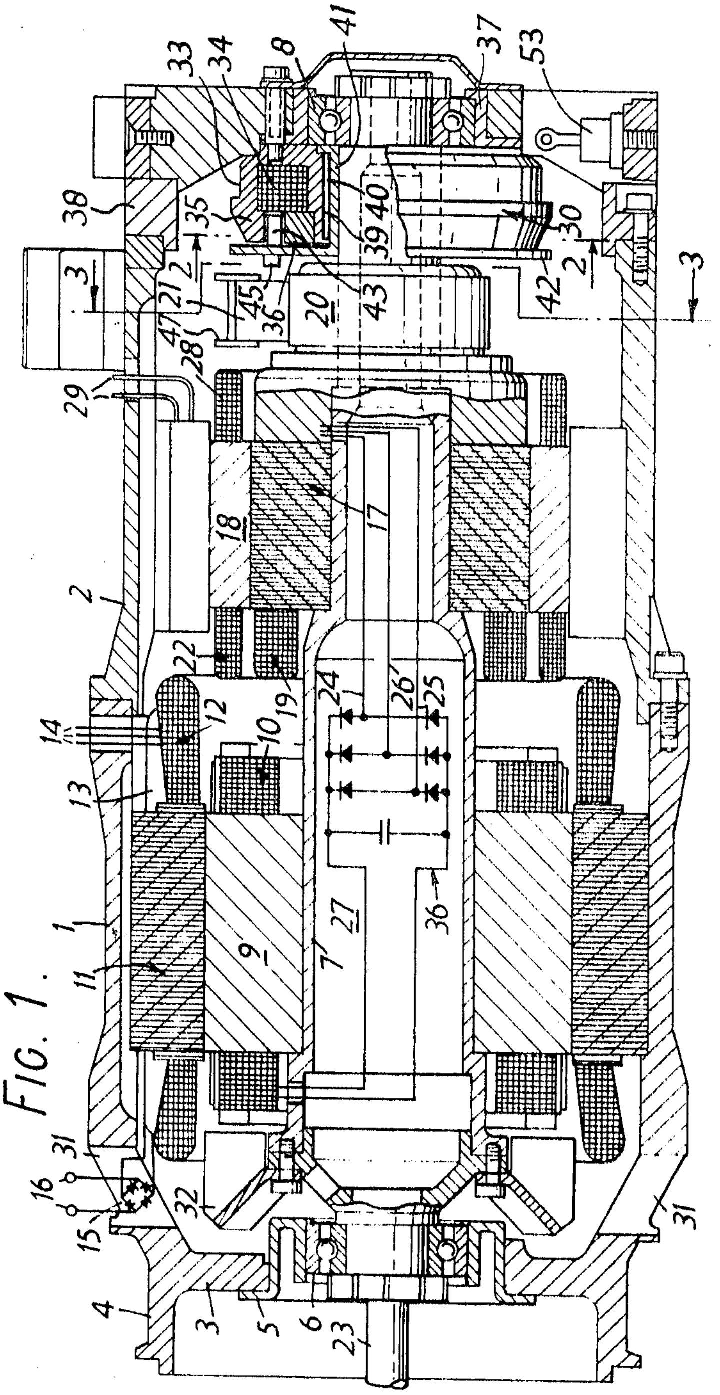


FIG. 1.

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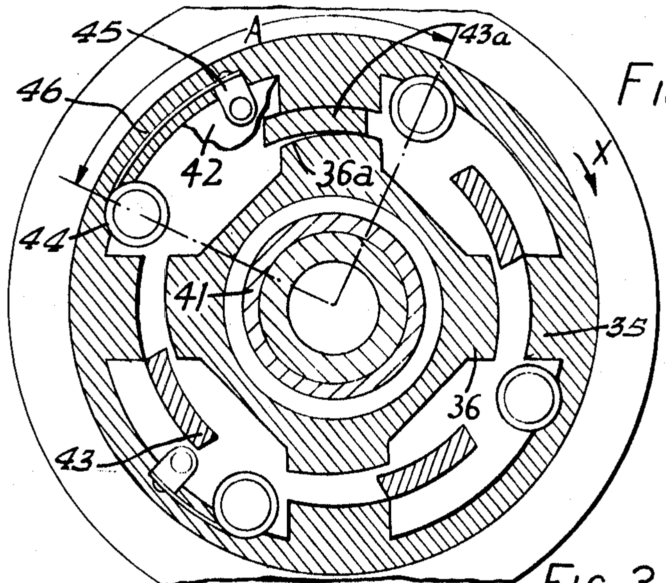
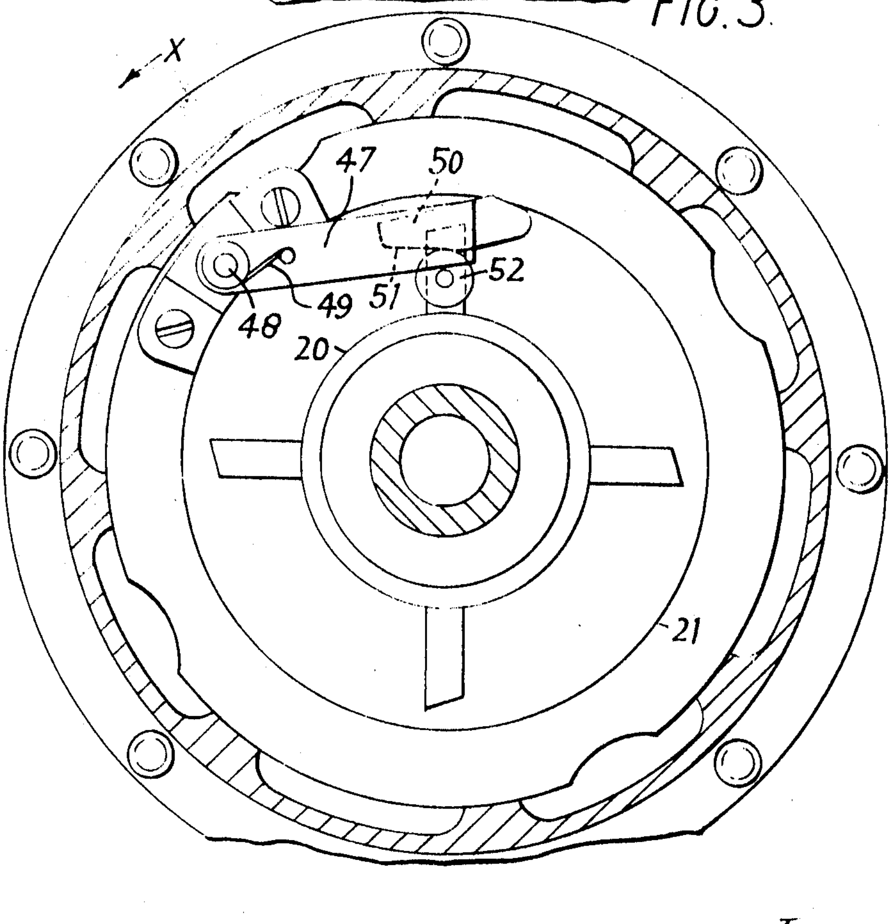


FIG. 2

FIG. 3



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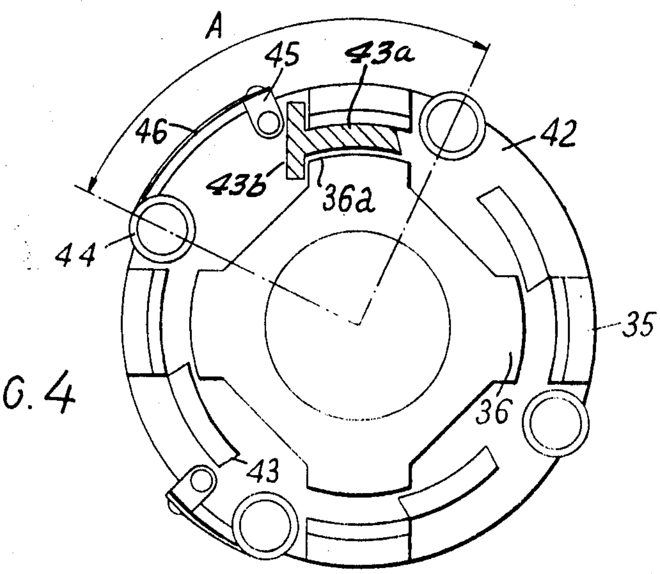

FIG. 4

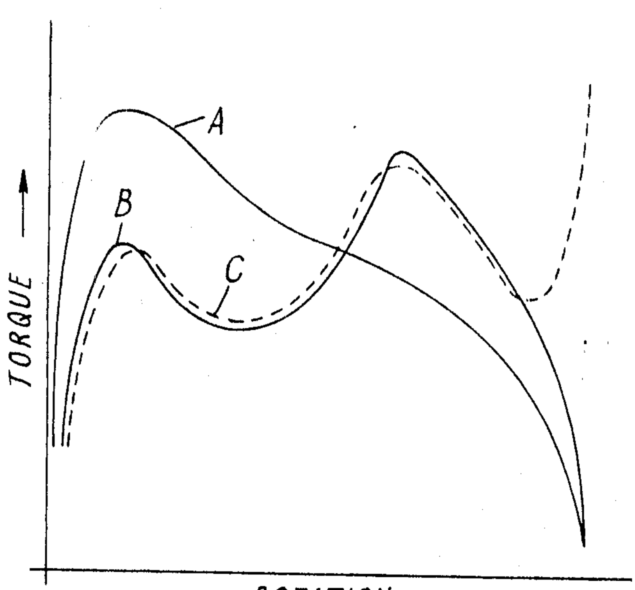

FIG. 5

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BRUSH LIFTING GEAR FOR ELECTRICAL MACHINES

This invention relates to brush lifting gear for electrical machines and in particular to brush lifting gear as disclosed in copending patent application Ser. No. 820,124.

In that copending application, brush lifting gear for lifting brushes off an electrical machine commutator was disclosed comprising a brush lifting element biased into a brush lifting position by spring means, and a rotary solenoid arrangement having a rotor and a stator, the rotor being coupled to the brush lifting element whereby to oppose the action of the spring means when the solenoid is electrically energized so as to move into a position in which it holds the brushes in engagement with the commutator.

The stator may provide at least one pair of radially displaced pole pieces and the rotor may comprise an armature member arranged to move angularly into the gap between them as the solenoid is energized. In accordance with one aspect of the present invention, at least one of the pole pieces is shaped by a single angular cut so that the gap between the poles decreases as the armature member moves inwardly thereof.

According to another aspect of the invention, the rotor carries an auxiliary pole piece operative, only when the rotor is substantially in the said position, to cooperate with the stator to provide a low magnetic reluctance path between rotor and stator.

The low magnetic reluctance path augments the "hold-on" force of the solenoid.

Brush lifting gear embodying the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings in which:

FIG. 1 is an elevation in axial section of a combined alternator-generator and starter-exciter unit as described in copending application Ser. No. 816,710 and incorporating brush lifting gear as disclosed in copending application Ser. No. 820,124.

FIG. 2 is a cross section on line 2–2 of FIG. 1, the sector A being shown in the brush-engaged position and the remainder of the Figure being shown in the brush-lifted position;

FIG. 3 is a cross section substantially on line 3–3 of FIG. 1;

FIG. 4 shows the cross section of FIG. 2 incorporating a modification of the unit, the modified unit embodying the present invention; and

FIG. 5 shows a graph of torque against angular rotation for the rotary solenoid using various pole piece configurations.

Referring now to the drawing, the arrangement comprises a two-part housing 1, 2 in which two rotor systems 9 and 17, carried by a common shaft 7, are rotatable within a stator-iron structure 11 and a field structure 18 respectively. The winding 19 on the rotor 17 has connections to a commutator 20 which is arranged, when the rotor is running as a motor armature for starting an engine coupled to the shaft 7 by a stub shaft 23, cooperates with a set of brushes 21 only one of which is shown, and brush-lifting gear 30 is provided for lifting the brushes 21 off the commutator except when the motor 17, 18 is energized for starting the engine and its rotor speed is below a predetermined value lying between the speeds respectively corresponding to the self-sustaining speed and the normal running speed of the engine. The construction so far mentioned is described in more detail in copending application Ser. No. 816,710 but the brush-lifting gear will now be described in more detail with reference to the accompanying drawings.

The brush-lifting gear comprises a rotary solenoid having a ring-shaped U-section stator 33 facing the armature 17, and which accommodates a winding 34. At the open end of the U its outer wall is subdivided to form a number of pole pieces 35 each faced by an inner pole piece 36 connected to the radially inner wall of the U-section annular body 33. This structure is supported at 37 in a stationary housing body 38 and has a bore 39 whose wall is radially spaced from the shaft 7. Rotatably supported in this bore 39 is a sleeve 41 having a flange 42 which carries magnetizable armature pole piece plates 43 which project into the space between the pole pieces 35 and the pole pieces 36. The radial thickness of the pole pieces 43 is less than the minimum radial width of this space so as to leave an airgap at both inner and outer faces of each pole piece when the pole piece has moved to its maximum depth into the space. As shown in FIG. 2 spiral strip springs 44, (omitted from FIG. 1 for the sake of clarity) each fixed between the stationary housing body 38 and a block 45 secured to the flange 42, urge the flange plate 42 to the angular position in which its armature pole pieces 43 are in the position shown outside the sector *a*. Brushes 21 are mounted in brush-holder arms 47 which as shown in FIG. 3 are pivotally mounted at 48, and the arms 47 are urged by springs 49 to apply the brushes 21 to the commutator 20. Each arm 47 has a cam block 50 (omitted from FIG. 1 for the sake of clarity) having an inclined surface 51, and four lifting rollers 52 (also omitted from FIG. 1) are carried on the flange plate 42. When, at the end of a starting operation, the plate 42 moves to displace its pole pieces from the position 43*a*, shown in sector A of FIG. 2, to the position 43, each arm 47 is engaged by one of the rollers 52 which engages the surface 51 and thereby lifts the arm 47 so as to lift the brush 21 from the armature 20. When the engine is to be started, and before a voltage is applied to the starter motor via brushes 21, the winding 34 is energized, and the resulting magnetic flux causes the flange 42 to be rotated. The pole pieces 43 move from their normal position illustrated in FIG. 2 outside sector A to the position 43*a* causing the flange 42 to rotate in the direction of the arrow X, thereby moving the rollers 52 along the cam surfaces 51 and allowing the springs 49 to apply the brushes 21 to the commutator 20. When the engine has fired and reached a self-sustaining speed, a speed-responsive switch 53 as shown in FIG. 1 cuts off the starter current and the energization of the winding 34. The springs 44 return the flange 42 to its position shown outside sector A of FIG. 2, and the rollers 52 cooperate with the cam surfaces 51 of the blocks 50 as shown in FIG. 3 to raise the brushes clear of the commutator. A fuller description of the brush lifting gear is given in our copending application Ser. No. 320,124.

Since the torque of the springs 44 increases with movement of the disc from the brushes-lifted position to the brushes-applied position, it is desirable to ensure that the torque of the rotary solenoid follows a somewhat similar law and at least does not unduly decrease during the brush-application movement. Therefore, the mutually facing surfaces of the pole pieces 43 and the pole pieces of the annular body 35 are angularly displaced in the circumferential direction in such a manner that the gap at least at one of the radially inner and outer surfaces of the pole pieces 43 becomes narrower as these pole pieces enter into the space between the inner and outer pole pieces 35 and 36 of the solenoid stator body 33, as shown in FIG. 2 at the radially outer surface 36*a* of the pole pieces 36.

The variation in airgap may be achieved by shaping each of the inner stator pole pieces 36 by a single angular machined cut. FIG. 5 shows at A the torque/angular rotation characteristic of the rotary solenoid before pole shaping takes place, and at B shows the torque/angular rotation characteristic when the inner pole pieces are shaped as aforementioned. Although curve B is not a continuously graded torque curve it is an improvement on curve A in that it results in a reduction of the initial torque and an increase in torque over the later stages of angular travel.

In the modification shown in FIG. 4, the pole pieces 43*a* are each provided with an auxiliary pole piece 43*b* (only one shown). Each auxiliary pole piece 43*b* is so arranged to form a low reluctance path between the two stator pole pieces 35 and 36 when the brushes are applied to the commutator 20 after energization of the solenoid.

The auxiliary pole pieces 43*b* may advantageously be provided with thin strips of nonmagnetic material (not shown) so as to ensure a minimum flux gap between the pole pieces 43*b* and respective pairs of stator pole pieces when the solenoid is energized. The provision of this minimum flux gap ensures that the pole pieces **43*b*** become "unstuck" from respective pairs of stator pole pieces when the solenoid is deenergized.

The provision of the auxiliary pole pieces **43*b*** are of particular advantage in systems where the solenoid is energized by the same source which energizes the electrical starting motor. Under starting conditions after the solenoid has been energized and the brushes applied to the commutator, the starter motor draws a high current which, for example, may be of the order of 1000 amps. This high current usually results in a large voltage drop across the terminals of the solenoid which can for example be from a potential of 48 volts to a potential as low as 6 volts.

The auxiliary pole pieces **43*b*** augment the "holding" force of the solenoid and resist any tendency for the biasing springs **46** to overcome the action of the solenoid during this period of voltage reduction.

At C FIG. **5** shows the torque/rotation relationship for the modified construction shown in FIG. **4** the inner pole pieces being shaped by a single angular machined cut. It will be seen that the curve is substantially the same as curve B but rises to a high torque in the final brush applied position in contrast with curve B which falls to low torque in this position.

Suitable stop means, not shown, are preferably provided for limiting the movement of the flange plate **42** in the direction of the arrow X under the action of the solenoid winding **34** and also to limit its movement in the opposite direction under the action of the springs **44**, and it will be observed that the latter limit is so chosen that that end of each armature pole pieces **43** which is leading during movement in the direction X is much closer to the nearest pair of pole pieces **35** and **36** than the opposite end of the same pole pieces is to its next adjacent pair of pole pieces **35** and **36**. This will ensure that a large torque in the desired direction is produced when the winding **34** is first energized.

I claim:

a. In an electrical machine having a stator, a rotor, a commutator and at least one pair of commutator brushes, brush lifting gear comprising,

brush engaging means mounted on said stator and engaging said brushes, said means being displaceable to move said brushes into and out of contact with said commutator,

a rotary solenoid mounted on said stator and energizable to displace said brush engaging means, said rotary solenoid comprising

radially inner and outer pole pieces rigid with said stator and defining an airgap,

a coil supported on said stator and energizable to generate a magnetic flux across said airgap, and

an armature coupled to said brush engaging member and rotatably supported on said stator so as to be movable into said airgap in response to energization of said coil, said armature being substantially in balance about its axis of rotation and including an auxiliary portion which bridges said airgap to form a low reluctance path across said airgap when the remainder of the armature has entered the airgap, thereby rendering the solenoid insensitive to subsequent fluctuations in the energization level of the coil.

2. Brush lifting gear according to claim **1** wherein one said pole piece is shaped by a single angular machined cut so that said airgap converges along the direction of motion of said armature into the airgap so as to cause the torque of the solenoid to generally increase as the armature progressively enters the airgap.

3. In an electrical machine having a stator, a rotor, a commutator and at least one pair of commutator brushes, brush lifting gear comprising,

brush engaging means mounted on said stator and engaging said brushes, said means being displaceable to move said brushes into and out of contact with said commutator,

a rotary solenoid mounted on said stator and energizable to displace said brush engaging means, said rotary solenoid comprising

radially inner and outer pole pieces rigid with said stator and defining an airgap,

a coil supported on said stator and energizable to generate a magnetic flux across said airgap, and

an armature coupled to said brush engaging member and rotatably supported on said stator so as to be movable into said airgap in response to energization of said coil, said armature including

an auxiliary portion which bridges said airgap to form a low reluctance path across said airgap when the remainder of the armature has entered the airgap, thereby rendering the solenoid insensitive to subsequent fluctuations in the energization level of the coil, and

a thin nonmagnetic liner mounted on said armature to prevent said armature from contacting the pole pieces when it bridges the pole pieces.

4. In an electrical machine having a stator, a rotor, a commutator and at least one pair of commutator brushes, brush lifting gear comprising,

brush engaging means mounted on said stator and engaging said brushes, said means being displaceable to move said brushes into and out of contact with said commutator,

a rotary solenoid mounted on said stator and energizable to displace said brush engaging means, said rotary solenoid comprising

radially inner and outer pole pieces rigid with said stator and defining an airgap,

a coil supported on said stator and energizable to generate a magnetic flux across said airgap, and

an armature coupled to said brush engaging member and rotatably supported on said stator so as to be substantially in balance about its axis of rotation and to be movable into said airgap in response to energization of said coil,

one said pole piece being shaped by a single angular machined cut so that said airgap converges along the direction of motion of said armature into the airgap so as to cause the torque of the solenoid to generally increase as the armature progressively enters the airgap.