

Nov. 21, 1967

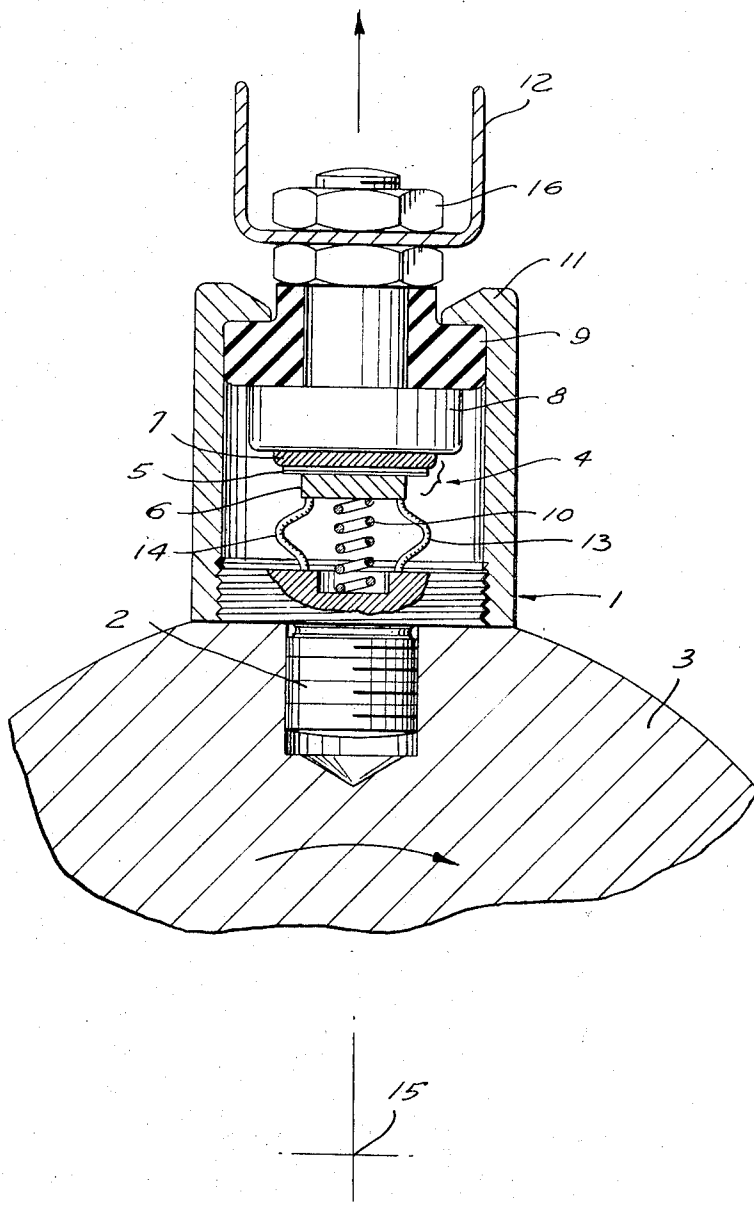
B. STORSAND
DYNAMO-ELECTRIC MACHINE CARRYING RADIALLY
MOUNTED RECTIFIERS

3,354,330

Filed Oct. 29, 1965

4 Sheets-Sheet 1

FIG. 1



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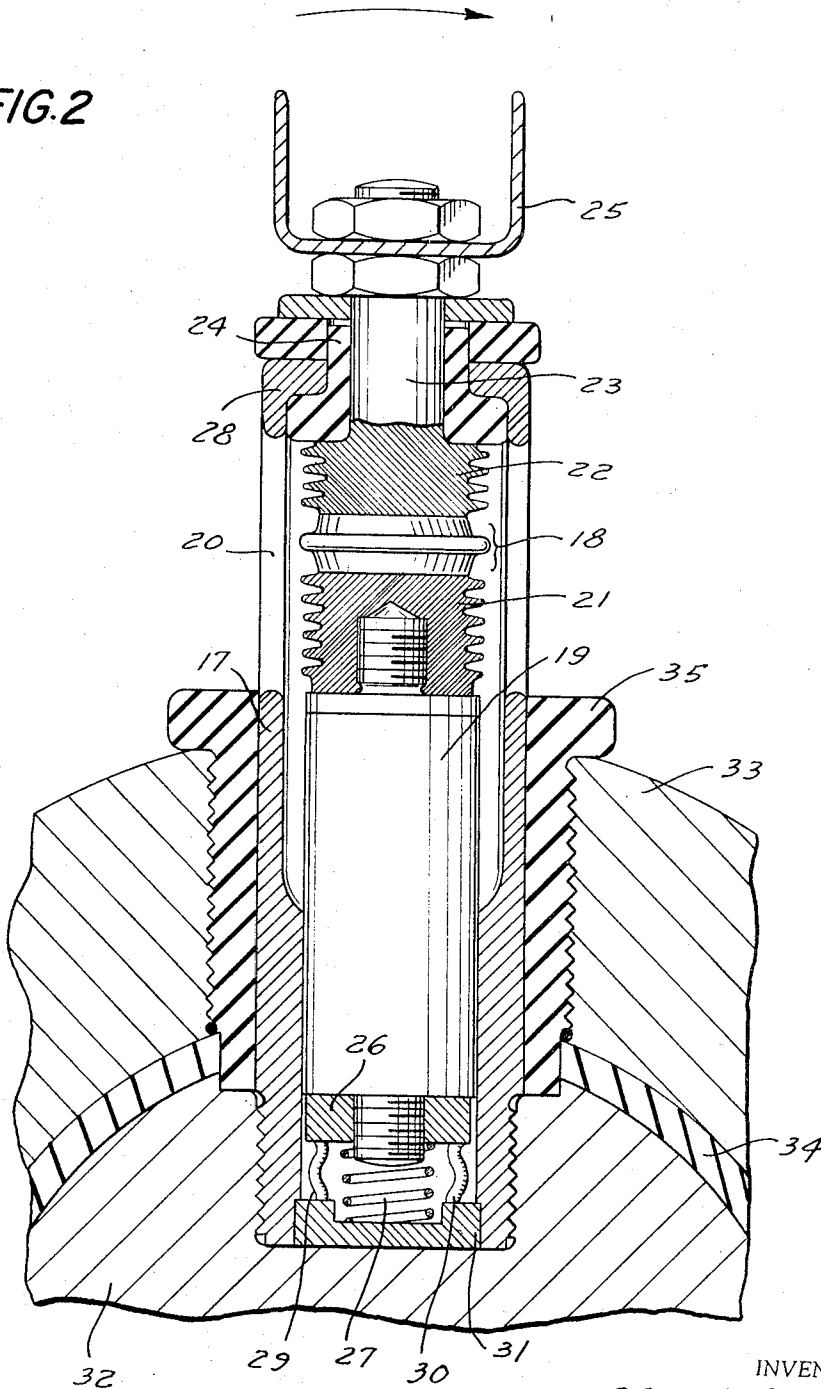
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FIG. 2



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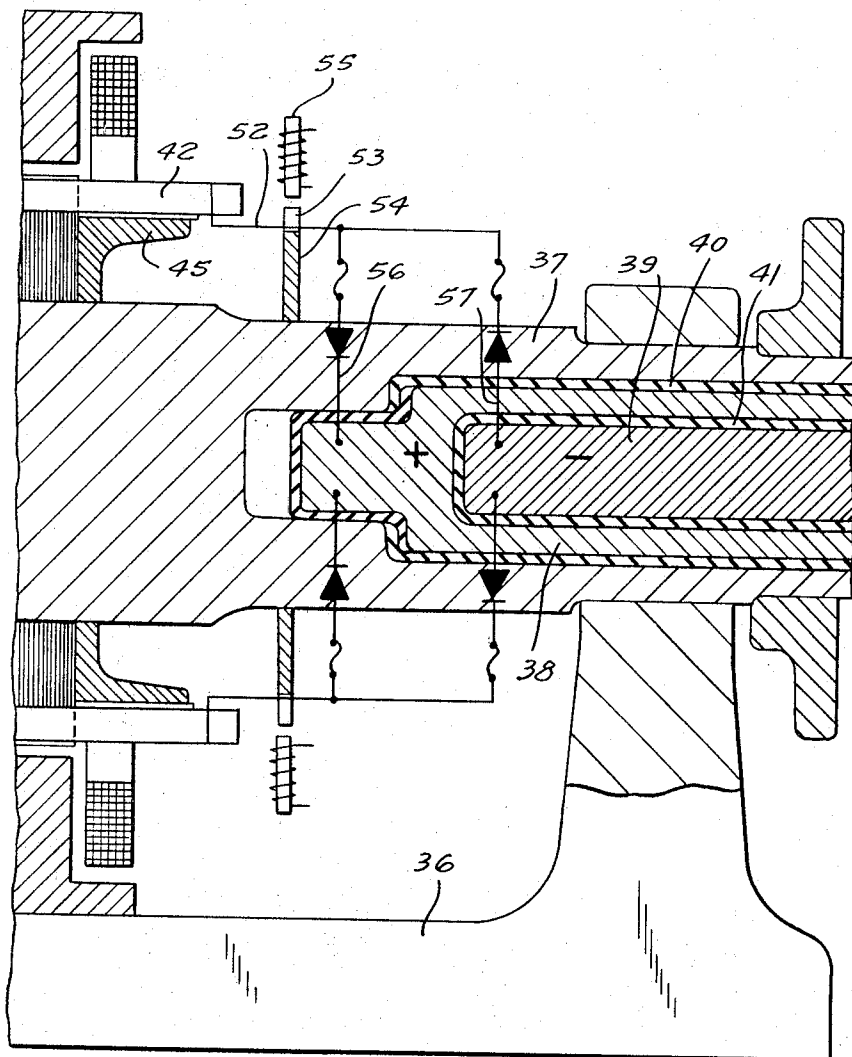
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FIG. 3



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Nov. 21, 1967

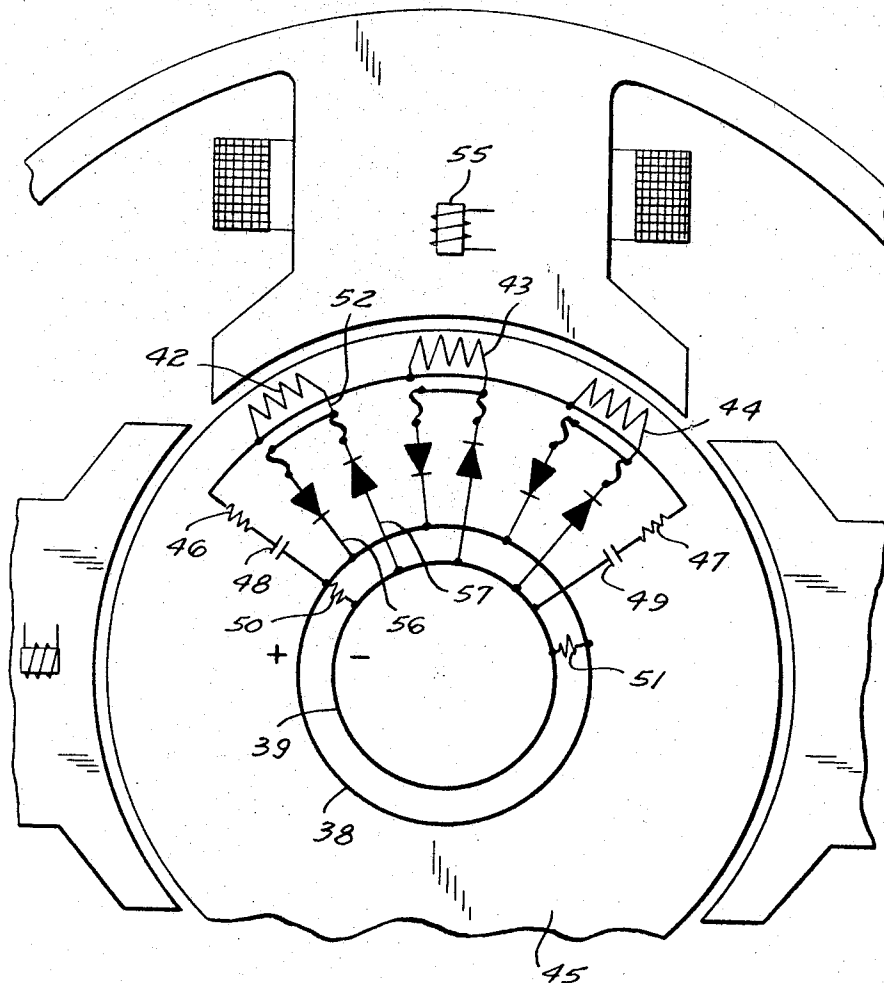
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FIG. 4



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3,354,330

DYNAMO-ELECTRIC MACHINE CARRYING RADIALLY MOUNTED RECTIFIERS

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8 Claims. (Cl. 310—68)

This invention relates generally to dynamo-electric machines, and has particular reference to an arrangement in which semiconductor rectifiers are mounted upon the rotating shaft of such a machine.

In dynamo machines of massive size, the use of such rectifiers, mounted on and rotating with the rotor of the machine, is of value in avoiding the necessity for providing and servicing slip-rings and commutators.

Basically, the rectifiers and their respective safety fuses can be installed either radially or axially, i.e., either at right angles or parallel to the axis of the dynamo machine. Combinations of these orientations, i.e., inclined arrangements of the rectifiers are also possible. In some cases, especially in connection with high-speed machines, a radial arrangement of rectifiers and accompanying safety fuses has numerous advantages from the standpoint of space requirements, accessibility, ease of replacement, good cooling, and simplicity of electrical connections.

The radial arrangement gives rise to a problem, however, because of the fact that semiconductor rectifiers currently available are not suited to withstand the large centrifugal forces that develop. Neither the semiconductor nor the customarily employed ceramic or glass insulation can with adequate safety withstand large tensile stresses in the direction of the rectifier axis.

A radial arrangement of semiconductor rectifiers is known, in which the rectifiers are mounted on the inner surface of a ring-shaped carrier secured to the shaft of the dynamo machine and adapted to absorb the centrifugal forces that are developed. This arrangement suffers from the disadvantage that access to the rectifiers is difficult. Moreover, this solution to the problem is not usually suitable for high-speed machines because of space limitations.

It is an object of the invention to provide a radially oriented arrangement of semiconductor rectifiers which does not have these shortcomings. In accordance with the invention, the semiconductor and insulation elements of the rectifier are mounted within a hollow metallic body in such a way that the centrifugal forces subject them chiefly to compressive stresses while the hollow body is subjected chiefly to tensile stresses.

In practicing the invention, it is advantageous to make the shaft of the dynamo machine hollow, and to form the positive and negative direct-current bus-bars as concentric elements within the shaft. The hollow housings that carry the rectifiers can then be passed through the hollow shaft and screwed or otherwise secured to either the positive or negative bus-bar, as the case may be, depending upon the polarity of the rectifier involved. It is also desirable that each rectifier and its accompanying safety fuse be mounted together within a common housing.

In installations of the type described, it is known that the excitation current can be determined by stationary measuring windings so arranged that voltages are induced which are proportional to the current to be measured. However, this does not allow supervision of individual rectifiers and safety fuses during operation of the machine. But by means of this invention such supervision is made possible in an advantageous manner: the measuring windings are arranged in a special way which

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allows the current flowing in each individual rectifier circuit to be determined, and if any rectifier has stopped functioning, a measurement of the induced voltages with the aid of an oscillograph gives an immediate indication of that fact. A summation of the amplified voltage impulses by means of a summation transformer gives a ready indication of the total excitation current.

In the accompanying drawings, several embodiments of the invention are depicted.

FIG. 1 is an illustrative cross-sectional view of a rectifier unit;

FIG. 2 is a similar view of a combined rectifier and safety fuse unit;

FIG. 3 is a partially schematic representation of a dynamo-electric machine embodying the features of the invention; and

FIG. 4 is a schematic representation corresponding to FIG. 2, showing only a single pole by way of example.

The housing 1 (FIG. 1) is shown screwed into the direct-current coaxially mounted bus-bar 3 by means of a threaded pin or stud 2. The bus-bar has been shown in the form of an element of substantially circular cross-section. The housing 1 may also be of cylindrical cross-section. Within the housing there is a semiconductor rectifier 4 consisting of a semiconductor body 5 with alloyed terminal plates 6 and 7. The rectifier can be of either polarity. It is connected to the head of a stud 8 which extends outwardly through an insulator 9. A compression spring 10 is arranged within the housing to press the semiconductor assembly outwardly so that the outer face of the insulator 9 presses against an intumed flange 11 on the housing 1. The stud 8 serves not only as a conductor of waste heat from the rectifier to the outside of the housing, but also establishes an electrical connection between the rectifier and the connection terminal 12. The latter embodies a cross-section enabling it to serve as a cooling fin; it establishes electrical connection with the rotor winding. The flexible wires 13 and 14 connect the other side of the rectifier electrically to the bus-bar 3.

FIG. 1 shows that during rotation of the assembly around the axis of rotation 15, the rectifier 4 and the insulator 9 are subjected in the radial direction only to compression, whereas the radially extending side wall of the housing 1 is subjected only to tension. For purposes of repair or replacement, the housing 1 can be readily disconnected from the direct current bus-bar 3 by first loosening the nut 16 to permit withdrawal of the connector 12, then unscrewing the pin 2.

In FIG. 2, the housing 17 fulfills a function similar to that of housing 1. It contains a laminated semiconductor rectifier unit 18 and an accompanying safety fuse 19. The housing 17 may be substantially cylindrical. It has a part which projects radially beyond the peripheral surface of shaft 33, and is provided with lateral openings 20 to facilitate cooling. The rectifier 18 is located between finned conductive cooling bodies 21 and 22. The body 22 is formed with an elongated part 33 which extends through an insulator 24. The part 23 serves to establish an electrical connection between the rectifier 18 and the connection terminal 25. As in the case of the element 12 of FIG. 1, the connector 25 has a cross-section adapting it to serve as a cooling fin. Electrical connection is made between the connector 25 and a rotor winding.

The safety fuse 19 is connected at one end, as by screw threads, to the cooling body 21. At its opposite end it is connected, also by screw threads if desired, to a conductive block 26. The entire assembly, including the block 26, the fuse 19, the rectifier 18, the cooling bodies 21 and 22, and the insulator 24, is pressed outwardly by a compression spring 27 so that the insulator 24 presses

outwardly against an inturned flange or shoulder on the housing 17.

The flexible wires 29 and 30 establish electrical connection between the block 26, hence the safety fuse 19, and the contact block 31 defining the bottom of the housing 17. The housing 17 is screw-threaded, or otherwise secured to, and the direct-current bus-bar 32 which has been shown in the form of an element of circular cross-section.

The element 32 is concentrically mounted within the hollow shaft 33 of the rotor, and is separated from the shaft 33 by a sheath or layer of insulation 34. The housing 17 is insulated from the shaft 33 by an insulating sleeve 35 which surrounds the housing 17 and is screwed or otherwise secured to the hollow shaft 33. Thus the rectifier housing is adapted to be readily inserted into and removed from engagement with the bus-bar 32 through a radial opening in the hollow shaft 33.

Rotation of the rotor shaft 33 carries with it the bus-bar 32, the housing 17, and the parts associated with it. During rotation, the rectifier 18 is subjected only to compressive forces, the side wall of the housing 17 only to tensile stress.

FIG. 3 shows a dynamo machine 36 embodying a hollow rotor shaft 37, and two mutually insulated coaxially mounted bus-bars 38, 39 concentric to each other and to the rotor shaft 37. The bus-bar 38 is of one plurality, e.g., positive. It is itself of hollow character and accommodates the bus-bar 39 which is of opposite polarity, i.e., negative. A sheath or layer of insulation 40 separates the bus-bar 38 from the hollow shaft 37, and a similar layer of insulation 41 is interposed between the elements 38 and 39.

Housings of the character shown in FIG. 2, containing rectifiers of positive polarity, are screwed into the bus-bar 38, as indicated schematically at 56. Similar housings, containing rectifiers of negative polarity are similar screwed into the bus-bar 39, as indicated at 57. Each housing accommodates a rectifier and an accompanying safety fuse.

In FIG. 4 the bus-bars 38, 39 are shown schematically in a direction transverse to the representation of FIG. 3. This figure shows how each pair of rectifier units is associated electrically with one of the rotor windings. For illustrative purposes three windings 42, 43 and 44, associated with a pole of the rotor 45, have been shown.

It will be noted that a three-phase bridge circuit exists. Damping resistors 46, 47 along with capacitances 48 and 49, suppress in known manner the excess voltages resulting from the commutation of the rectifier currents. These loss resistances and capacitances can be mounted in radially installed housings similar to those herein described in connection with the rectifiers and safety fuses.

Over-voltage suppressors 50, 51 are preferably interposed, electrically, between the bus-bars 38, 39.

A special feature of the invention is indicated in FIGS. 3 and 4. A lead wire 52 has been shown, by way of example, extending between a rotor winding (e.g., winding 42) and a branch of the rectifying circuitry. The wire 52 passes through a cut-out 53 on the periphery of a disk 54 composed of magnetic material. Stationary measuring windings 55 are mounted adjacent to the disk periphery. When the machine operates, the movement of the lead wire 52 past the windings 55 induces a voltage which is proportional to the current flowing in the wire 52. The same is true of all the other lead wires corresponding to the wire 52. Hence the currents flowing in the individual circuits can be sensed and determined, and the non-

functioning of any particular rectifier set can be readily detected.

What is claimed is:

1. In a dynamo-electric machine, a rotor having windings, a hollow rotor shaft, a bus-bar concentrically secured within said shaft in coaxial insulated relation thereto, a rectifier housing extending through said hollow shaft and mounted on said bus-bar in radial disposition, said hollow shaft having a radial opening through which said housing may be inserted and withdrawn with respect to the bus-bar, the mounting of the housing being such that it may be readily inserted and removed, a semi-conductor rectifier within said housing, and means electrically connecting said rectifier in interposed relation between a rotor winding and said bus-bar.

2. An arrangement as defined in claim 1, in which said housing has a radially extending side wall with an inturned shoulder, the rectifier being so mounted within the housing that it presses outwardly against said shoulder when rotation of the rotor shaft generates centrifugal force, whereby said housing wall is subjected mainly to tensile stress while the housed rectifier is subjected mainly to compression.

3. An arrangement as defined in claim 2, in which said inturned shoulder is at the outer end of the housing, and in which the housing contains a spring which constantly presses the rectifier against said shoulder.

4. In a dynamo-electric machine, a rotor having windings, a rotor shaft, two bus-bars secured to said shaft in coaxial insulated relation to each other and to said shaft, rectifier housings mounted on said bus-bar respectively in radial disposition, a semi-conductor rectifier in each housing, and means electrically connecting said rectifiers in interposed relation between a rotor winding and said bus-bars respectively, said rectifiers being of opposite polarity and being electrically connected to opposite ends of said winding respectively.

5. An arrangement as defined in claim 4, in which said rotor shaft is hollow and at least one of said bus-bars is hollow, said bus-bars being concentrically secured within said shaft with one bus-bar concentrically mounted within the other, said housings extending through said hollow shaft.

6. An arrangement as defined in claim 2, in which a safety fuse for the rectifier is also mounted within said housing.

7. An arrangement as defined in claim 1, in which the housing has a part which projects radially beyond the peripheral surface of the rotor shaft, and in which said projecting part is provided with openings to facilitate cooling of the interior of the housing.

8. An arrangement as defined in claim 1, in which the machine is provided with stationary measuring windings in concentric relation to the rotor, and in which the electrical connector from the rectifier to the rotor winding is positioned to move past said stationary windings, whereby a voltage is induced in the latter windings proportional to the current flowing through the rectifier.

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