United States Patent

McNab

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[45] **Aug. 1, 1972**

[54] **CURRENT TRANSFER IN HOMOPOLAR MACHINES**

[72] Inventor: **Ian Roderick McNab,** Fossway, England

[73] Assignee: **International Research & Development Company Limited,** Fossway, England

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Aug. 27, 1969 England.....42,638/69

[52] **U.S. Cl.**.....**310/178,** 310/178

[51] **Int. Cl.**.....**H02k 31/00**

[58] **Field of Search**.....310/178, 219, 232, 237, 243, 310/268

[56] **References Cited**

UNITED STATES PATENTS

3,191,082	6/1962	Csillag	310/219
2,828,431	3/1958	Klaudy	310/178
3,546,508	12/1970	Harvey	310/178
2,786,155	3/1957	Sellers	310/219
2,832,909	4/1958	Brill	310/219
3,211,936	10/1965	Harvey	310/178

Primary Examiner—J. D. Miller
Assistant Examiner—R. Skudy
Attorney—Kemon, Palmer & Estabrook

[57] **ABSTRACT**

Current transfer in a homopolar dynamo-electric machine is effected by liquid metal which is caused to flow from the periphery of the rotor by centrifugal action and impinges on a stationary trough which provides a current transfer surface and serves to collect the liquid metal, which can then be re-circulated to the rotor. The liquid metal can emerge from a porous pad to engage with brushes in the trough but in a preferred construction is sprayed from annular distribution trough which projects from the periphery of the rotor into the collecting trough.

7 Claims, 9 Drawing Figures

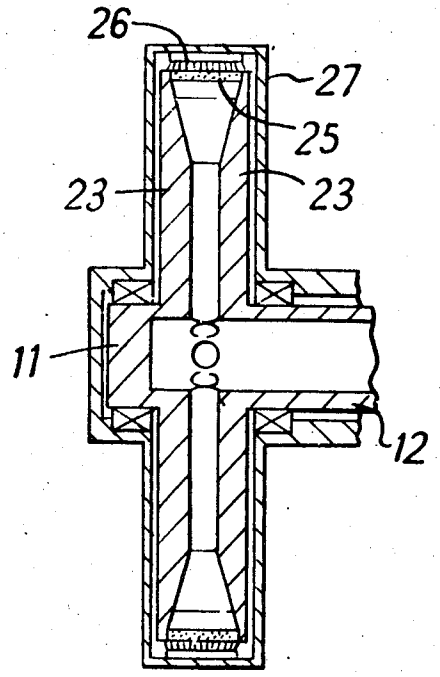


FIG. 1

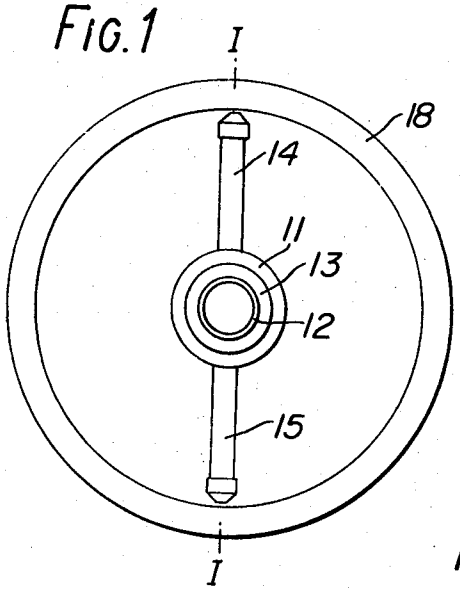


FIG. 2

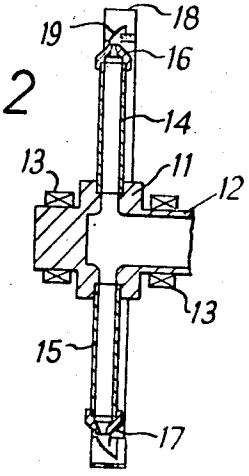


FIG. 5

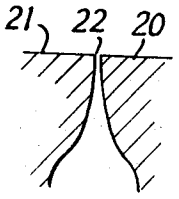


FIG. 3

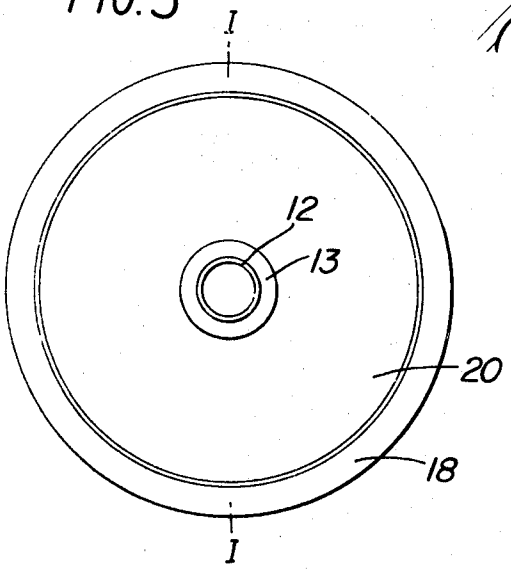


FIG. 4

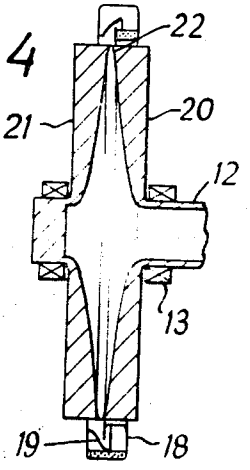


FIG. 6

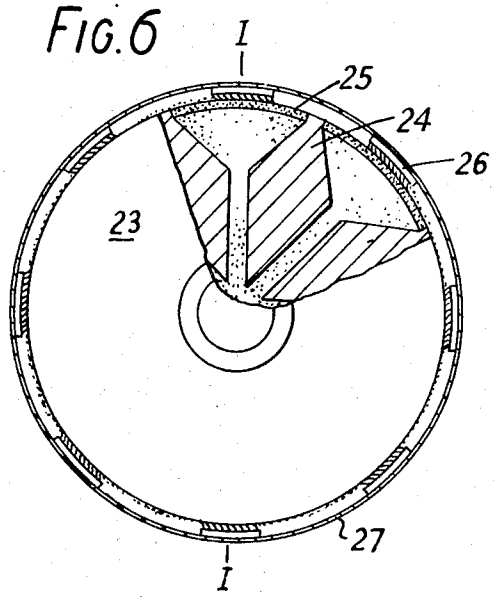


FIG. 7

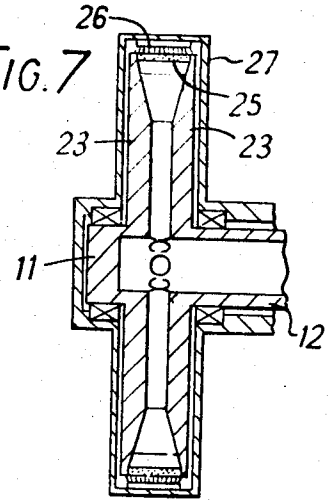
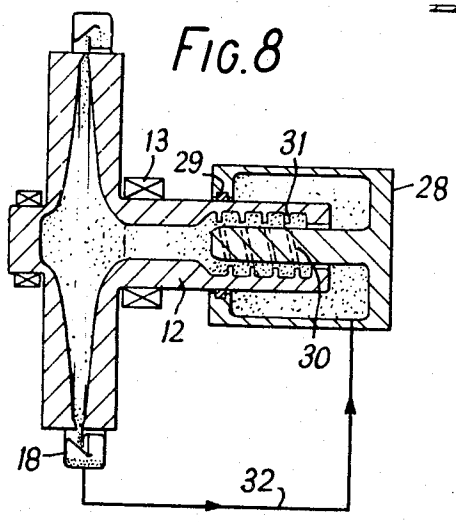


FIG. 8



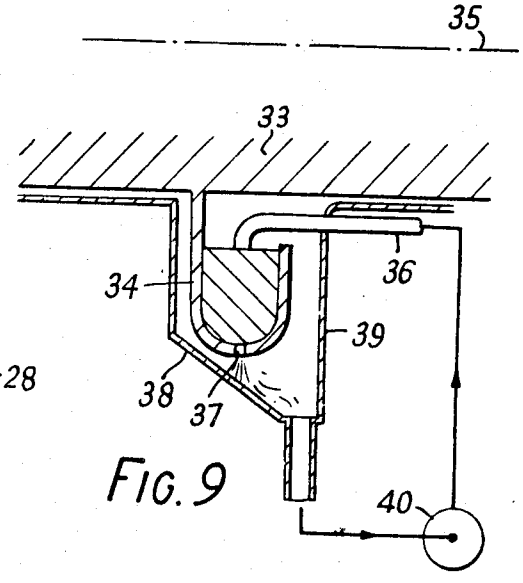


FIG. 9

CURRENT TRANSFER IN HOMOPOLAR MACHINES

This invention relates to current transfer means for homopolar electro-dynamic machines.

One of the factors limiting the power density obtained from homopolar machines is the method by which current is transferred from moving to static surfaces. Most conventional machines employ solid copper/carbon brushes which generally limit the surface speeds to about 10,000 ft per minute and current densities to about 200 amp/sq.in. This limits the angular speed of the rotor and thus limits the voltage generated. A high power output therefore necessitates a high current density and a large contact surface. In general, machines of this nature employing solid brushes are limited to outputs of about 30,000 amps and 10 volts at 3,000 r.p.m. and, although larger diameter machines operating at lower speeds would permit an increase in output, they are mainly impracticable.

Many ways of overcoming difficulties in current collection are known, involving the use of liquid metals e.g., sodium, sodium/potassium alloy, mercury, mercury amalgams and other low melting point alloys. These methods entail the interposing of liquid metal between the rotor and the means for current collection and include methods involving discreet or sheet jets of liquid metal directed onto the rotor surface from a stationary nozzle and may also involve the use of porous metal pads through which the liquid metal is pumped.

According to the present invention there is provided a homopolar dynamo-electric machine having current transfer means comprising a stationary current collection surface or surfaces surrounding the periphery of the rotor, an opening or openings at the periphery of the rotor, and means for introducing liquid metal to a region radially inwards of the periphery of the rotor which communicates with the said opening or openings so that upon rotation of the rotor the action of centrifugal force will create a substantially radial pressure head in the liquid metal and cause it to issue through the said opening or openings to impinge upon the current collection surface or surfaces.

In one embodiment the rotor comprises a simple double or multiple tube arrangement with jets having a circular cross-section.

In a further embodiment the liquid metal issues from a substantially continuous circumferential slot formed in the outer periphery of the rotor to produce a sheet jet of liquid.

In a further embodiment the liquid metal flows through passages or discreet or sheet jets onto a continuous porous ring or a series of porous pads located on the outer periphery of the rotor.

In a further embodiment a pumping system is employed which utilizes the rotation of the rotor to pump the liquid metal into the inner region of the rotor.

In yet another embodiment the rotor has an annular distribution trough around its periphery which is open on its radially inward side to allow for the introduction of the liquid metal from a stationary supply pipe or pipes and has the opening or openings formed in its radially outward side. The distribution trough can lie within a collecting trough one of whose surfaces forms the current collection surface and the liquid metal can be pumped from the collecting trough back to the supply pipe or pipes.

The rotor can be constructed of electrically insulating material and the liquid metal will then serve as the rotor conductors in which the current is generated. Preferably however the rotor is electrically conducting and the liquid metal serves primarily for current transfer at the periphery of the rotor.

The invention will now be described in more detail with reference to the accompanying drawings, in which:

FIG. **1** is an end elevation of a homopolar generator in accordance with the invention;

FIG. **2** is a section on I—I of the embodiment shown in FIG. **1**;

FIG. **3** is an elevation of a further embodiment of the invention;

FIG. **4** is a section on I—I of the embodiment shown on FIG. **3**;

FIG. **5** shows an alternative configuration of the peripheral slot shown in FIG. **4** on a larger scale;

FIG. **6** is an elevation of a further embodiment of the invention with part cut away;

FIG. **7** is a section on I—I of the embodiment shown in FIG. **6**;

FIG. **8** is a section of a complete machine showing a further feature; and

FIG. **9** is a partial cross-section of a further embodiment of the invention.

FIGS. **1** and **2** show the rotor assembly and current collection arrangement for a homopolar generator. For simplicity the field coils and stator are not shown.

The rotor comprises a composite hollow hub **11** and shaft **12** which are journalled between bearings **13**. Two tubes **14** and **15** are securely attached to the hub and are fitted with conical nozzles **16** and **17**. A stationary circumferential trough **18** surrounds and is spaced away from the tubes **14** and **15**. The trough **18** has a deflecting inner surface **19** leading to the inside of the trough. The trough **18** also forms one current collecting member the other being a conventional brush sliding on the surface of the rotor shaft **12**.

The hollow shaft **12** and hub **11** of the rotor are filled with liquid metal by any form of low pressure pump (not shown).

In operation the rotor is driven by mechanical means to rotate and cut the lines of force produced by stationary field windings, not shown, located on both sides of the rotating tubes. In accordance with a well known principle a d.c. current is produced and will be transferred to the trough **18** through the liquid metal issuing at high velocity from the conical nozzles **16** and **17** of the rotor. The liquid metal impinges upon the collector trough **18**, being then deflected into the interior of the trough by the inner surface **19**. The excess liquid falls to the bottom of the trough and is Pumped back into the interior of the rotor by the low pressure pump.

FIGS. **3** and **4** show a further embodiment in which the rotor is formed in two halves **20** and **21**, joined together by internal webs to form a hollow interior through which the liquid metal passes. The outer periphery of the rotor has a continuous gap or slot **22** around its circumference from which will issue a continuous sheet jet of high velocity liquid metal in the same manner as described above.

FIG. **5** shows an alternative form of the slot nozzle **22** formed by the rotor halves **20** and **21** by means of which the velocity of the sheet jet may be increased.

In the embodiment shown in FIGS. 6 and 7 the rotor comprises a pair of circular plates 23 held apart by discontinuous webs 24.

The outer periphery of the rotor is formed of a series of arcuate segments 25 made of porous material such as sintered metal or carbon foam which are securely fixed to end walls defined by the plates 23 and the webs 24.

In this embodiment a series of conventional brushes 26 are used to collect current from the rotor. The brushes 26 are fixed to the inside of a continuous stationary collecting trough 27 which surrounds the rotor and shaft assembly.

FIG. 8 shows a further embodiment having a closed cycle pumping system for pumping the liquid metal from a reservoir 28 sealed to the end of the shaft 12 by rotary seals 29. The reservoir 28 is of circular cross-section and has a plain central spigot 30 on which the shaft 12 rotates. The inside of the shaft 12 is formed with an Archimedean spiral 31 which pumps the liquid metal from the reservoir into the interior of the rotor. The collector trough 18 is connected by a conduit 32 to return the liquid metal to the reservoir. It will however be necessary to introduce some form of isolator into the connection between the trough 18 and the reservoir 28 to prevent short circuiting of the machine. This could take the form of a mesh grating which will break the liquid metal into droplets, thus presenting a discontinuity in the current path.

In the embodiment of FIG. 9 the periphery of a rotor 33 carries an annular trough 34 which is open on its radially inward side towards the axis 35 about which the rotor rotates. A stationary supply or inlet pipe 36 feeds liquid metal to the trough and this liquid metal emerges from openings 37 to impinge on a current collection surface 38 forming part of an annular trough 39 which surrounds the distribution trough 34 and serves to collect the liquid metal which is then returned by a pump 40 to the inlet pipe 36. In a modification of this construction the trough 34 is disposed in a recess in the periphery of the rotor and the collecting trough 39 can be similar to the trough 18 used in other embodiments.

Further embodiments of this invention may comprise combinations of features of the embodiments described. Also the embodiment described in FIG. 1, may comprise more than two tubes, or the rotor may be a solid disc having a series of radial passages to allow the liquid metal to flow from the interior of the rotor to the outer periphery.

I claim:

1. In a homopolar dynamo-electric machine, current transfer means comprising stationary brush means arranged around the periphery of the rotor, at least one opening in the rotor at the periphery thereof, a porous pad covering said opening, means for introducing liquid metal to the rotor in a region radially inwards of the periphery, at least one rotor passage connecting said region to said opening, whereby upon rotation of the rotor, the liquid metal is caused by centrifugal forces to flow generally radially through the passage and issue through said porous pad to contact said stationary brush means.

2. Current transfer means as claimed in claim 1 comprising an annular trough surrounding the periphery of the rotor for the collection of the liquid metal, said brush means forming part of said trough.

3. A homopolar machine as claimed in claim 1 wherein the rotor has an annular distribution trough open on its radially inward side, said opening being formed in the radially outward side of said distribution trough and said means for introducing liquid metal comprising at least one stationary supply pipe feeding into the radially inward side of said trough.

4. A homopolar machine as claimed in claim 3 having an annular collection trough surrounding the periphery of the rotor to receive said liquid metal, the current collection surface forming part of said collection trough.

5. A homopolar machine as claimed in claim 4 in which the distribution trough is located within the collection trough.

6. A homopolar machine as claimed in claim 5 having a pump for drawing liquid metal from the collection trough and feeding it to the supply pipe.

7. A homopolar machine as claimed in claim 1 in which the said region into which liquid metal is introduced is a central region of the rotor and the rotor is formed to act as a pump for pumping the liquid metal to the said central region.

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