

Dec. 9, 1941.

C. G. JONES

2,265,288

ELECTRIC GENERATOR

Filed Nov. 17, 1938

3 Sheets-Sheet 1

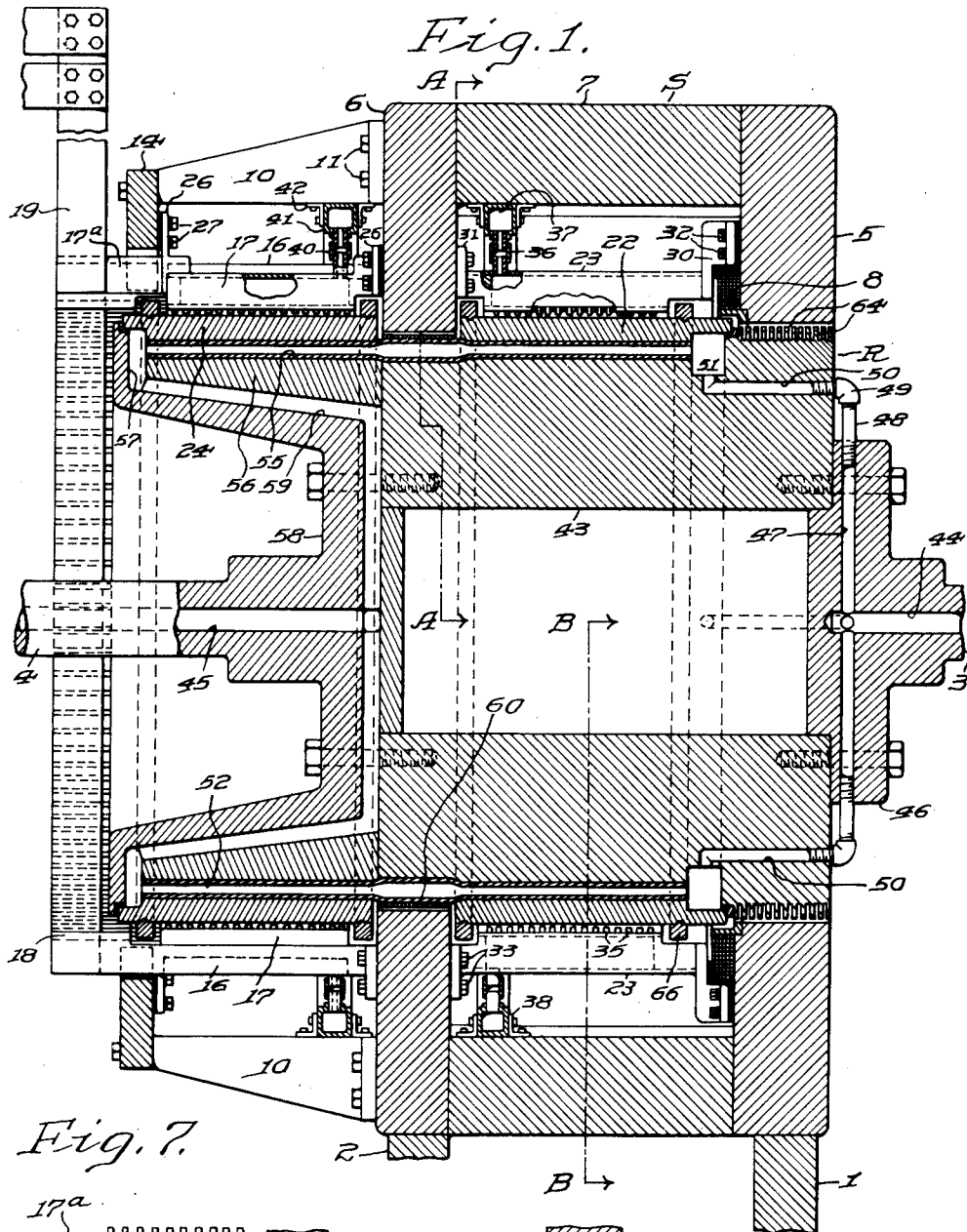
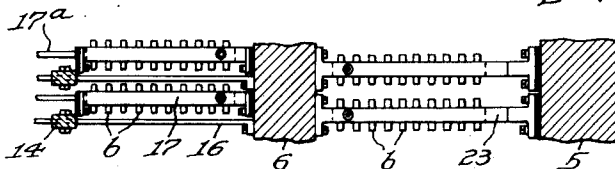


Fig. 7.



WITNESS

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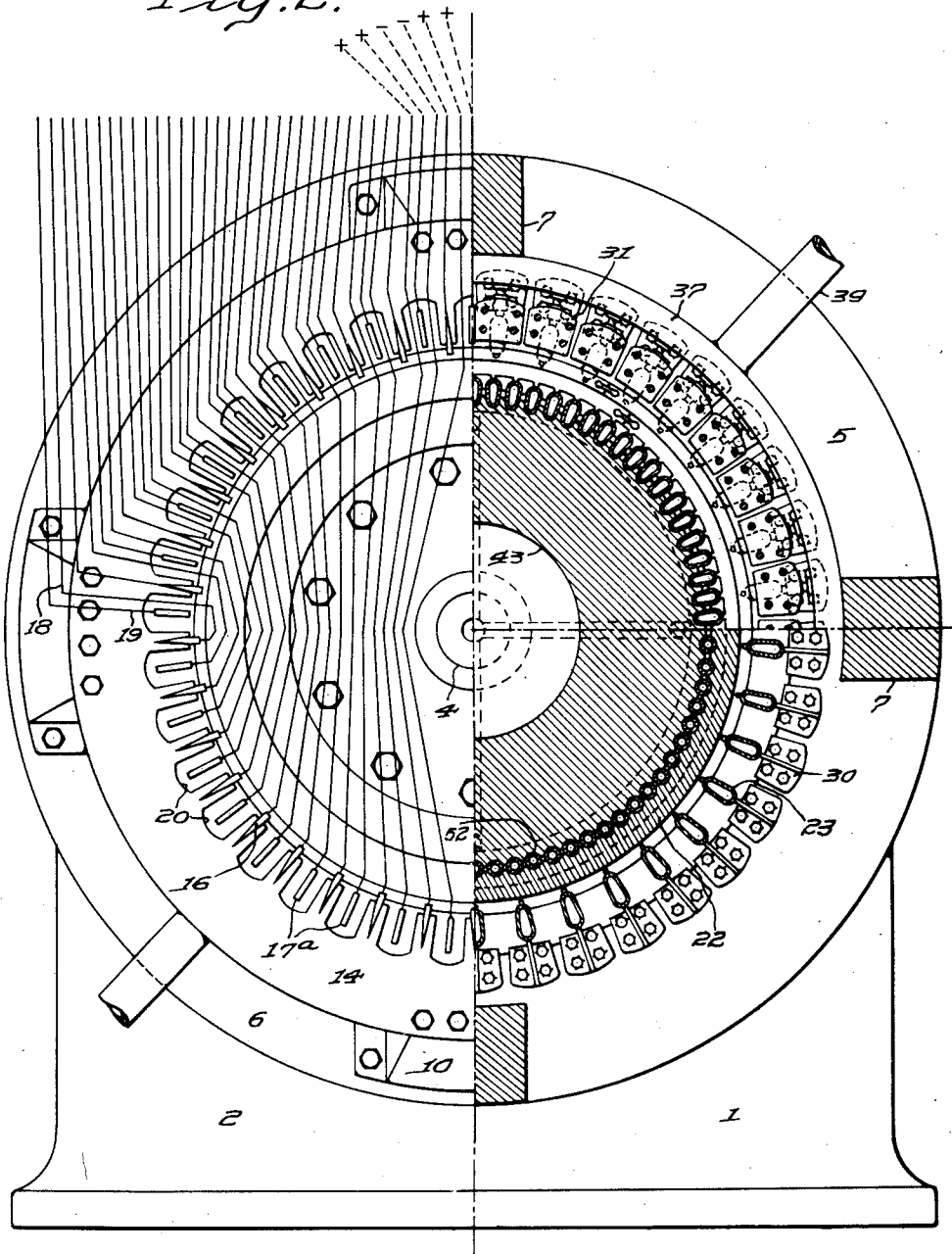
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3 Sheets-Sheet 2

Fig. 2.



WITNESS

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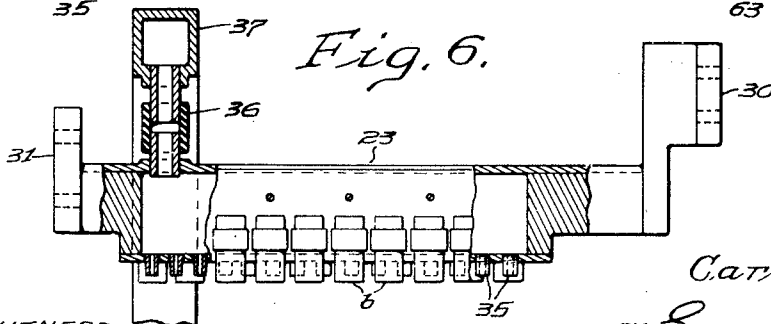
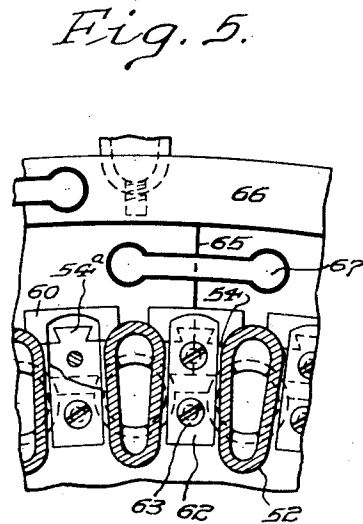
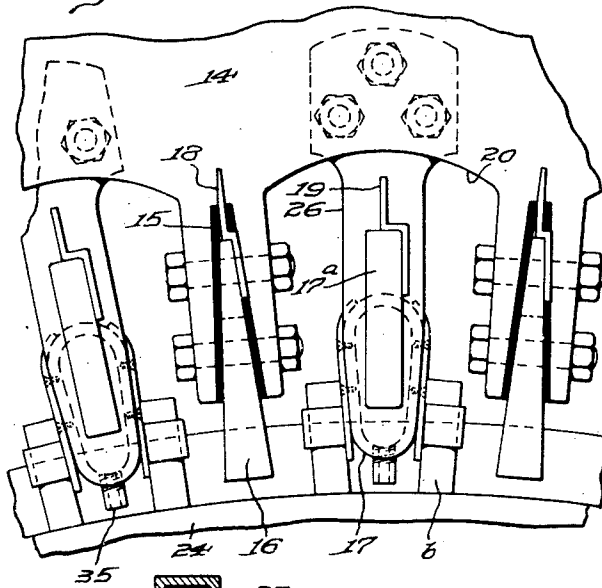
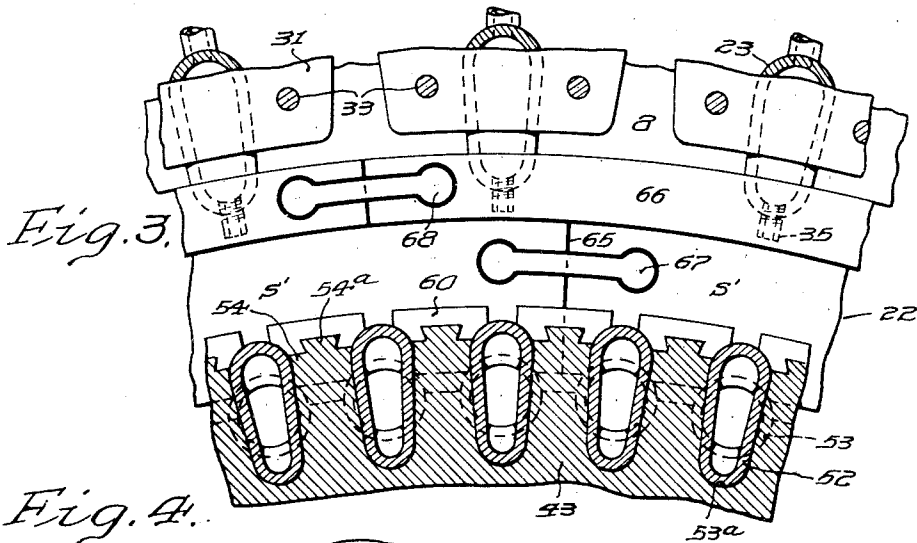
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ELECTRIC GENERATOR

Filed Nov. 17, 1938

3 Sheets-Sheet 3



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ELECTRIC GENERATOR

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Application November 17, 1938, Serial No. 240,929

13 Claims. (Cl. 171-212)

This invention relates to electric generators and especially to unipolar or homopolar generators adapted for developing very large currents at low voltages, for example currents in the neighborhood of 100,000 amperes or more at about 4 to 7 volts, such as are used in resistance welding of longitudinal seams in pipe blanks and the like.

Although in this art it is of extreme economic importance that the time lag of the generator be kept at a minimum, in homopolar generators heretofore suggested the time lag has been excessive while the large currents produced, relatively high operating temperatures, and other factors cause rapid deterioration of the collector rings and adjacent parts through which the current passes; current collectors in such generators have moreover been so constructed and arranged that excessive accumulative compounding of the current results from the current unbalance between different parts of the collectors lying in the same axial plane.

It is therefore an object of the invention to provide an improved homopolar generator adapted for the production of high amperage, low voltage welding currents and in which the time lag attending current changes is maintained at a minimum enabling maximum production of satisfactory welds and obviating the use of switches in the load circuit with their attendant disadvantages.

Another object is to provide improved means for cooling the generator parts whereby their temperature is maintained substantially normal and their rapid deterioration as a result of excessive working temperatures is eliminated.

A further object is to provide means for maintaining the zone adjacent the collector rings and brushes of a generator free from the fine particles of metal produced by the friction between these parts whereby the life of the generator is prolonged and the well-being of the men working in its vicinity during its operation is materially enhanced through elimination of the danger of their inhaling such particles, which are produced principally as a fine, almost impalpable powder commonly referred to as "brush dust."

A still further object is to provide in a generator, mechanism for inducing a flow of air in the vicinity of the brushes and collector rings in such manner as to bring about adequate and uniform cooling of these parts and concurrent effective removal of metal dust produced by the

friction between them without allowing it to escape into the surrounding atmosphere.

Another object is to provide a fluid cooling system for a generator armature, collector rings and associated parts whereby their temperatures may be maintained sufficiently low to minimize rapid deterioration and promote most efficient operation.

Still another object is to provide a generator in which the extremities of all terminal leads of either polarity lie in a common plane normal to the axis of the generator armature and axially spaced from the generator itself with all leads of each polarity of exactly the same length and all leads of either polarity regularly spaced circumferentially in the said plane and thus arranged in uniform inductive relation whereby the conductors carrying current between the generator and the load may be connected with the several terminal leads and fully interleaved as to opposite polarities so as to minimize the inductive effect.

A further object is to minimize accumulative compounding of the current in a homopolar generator by utilizing a collector of segmental construction with resultant material reduction of the current unbalance usual between circumferentially spaced portions of the solid collectors heretofore employed.

Other objects, purposes and advantages of the invention will hereinafter more fully appear or will be understood from the following description and accompanying drawings in which:

Fig. 1 is an axial section of a generator constructed in accordance with the invention with certain parts shown in elevation;

Fig. 2 is an end view of the generator in which the upper and lower right hand quadrants are broken away into section on the lines A—A and B—B respectively in Fig. 1;

Fig. 3 is an enlarged fragmentary detail of that part of Fig. 2 on the line A—A;

Fig. 4 is an enlarged fragmentary detail of the upper left hand quadrant of Fig. 2, that is, an enlarged fragmentary end view of the generator;

Fig. 5 is a similar detail of the armature portion of the rotor of the generator with the conductors shown in section;

Fig. 6 is an enlarged view of one of the brush arms apart from the generator; and

Fig. 7 is a fragmentary horizontal section on a slightly smaller scale than Fig. 1 showing a planar development of certain parts of the generator.

In the several figures, except Figs. 4 and 6, the

brushes are omitted for the sake of clearness, and in all, like characters are used to designate the same parts.

Referring first generally to the drawings, the generator stator S is supported from pedestals 1, 2 while the rotor R is supported for rotation within the stator from stub shafts 3, 4 journaled in suitable bearings (not shown). The stator S comprises a pair of rings 5, 6 formed of magnetic metal and suitably secured together preferably by four bars 7 extending parallel to the rotor axis and spaced 90° apart. An exciting coil 8 is carried by ring 5 to create a magnetic flux of high density in the stator when the coil is energized in accordance with usual practice. End brackets 10 are secured to the outer face of ring 6 as by cap screws 11; they are also preferably spaced 90° apart and support certain of the terminal leads and other parts of the generator from an end ring 14 bolted to their outer extremities. This ring, which with its supporting brackets 10 is preferably of non-magnetic material, is provided with a plurality of uniformly spaced slots 15 for the reception of terminal leads 16, while terminal leads 17a, carrying current of opposite polarity, project from brush arms 17 through openings 20 alternating with slots 15 in the ring. The terminal leads 16 and 17a have brazed or bolted to them current conductors 18, 19 respectively for conveying current between the generator and the load, these conductors extending in substantial parallelism in the same plane transversely of the generator axis; the conductors connected below the horizontal plane of the axis are thus interleaved with those connected above said plane, as shown in Fig. 2, so that beyond the generator each conductor of either polarity, excepting of course those on the extreme outside of the entire bank of conductors, extends between a pair of similar conductors, one of which is of like polarity while the other is of opposite polarity. Consequently as the current fluxes in the leads are in opposition to each other they tend to neutralize, thus avoiding the building up of a voltage in opposition to the main voltage, while their location at one end of the generator facilitates their connection to the load bus bars. Moreover within the generator itself the terminal leads 16 and brush arms 17 are also fully interleaved, and the loss of generator efficiency through induction is thus reduced to a minimum.

The mechanism supplying current to conductors 18, 19, now to be fully described, is divided by the active pole 6 of the stator and the rotor armature into two separate zones, each relating primarily to current of one polarity, the right hand zone (Fig. 1) between the stator rings or pole pieces 5, 6 including one, preferably segmental, collector 22 with its associated brush arms 23 and brushes b (Fig. 6) normally attached thereto in any convenient way, while the other, or left hand, zone, separated from the first by the stator ring 6, includes end brackets 10, ring 14, the other collector 24, which may also be segmental, and terminal leads 16 which are electrically connected with brush arms 23 in the first zone. The left hand zone also contains brush arms 17 and similar brushes b (Fig. 4) engaging collector 24, all of opposite polarity to terminal leads 16; the latter are thus fully interleaved with brush arms 17 in this zone to minimize inductive effect and enhance the efficiency of the generator. The brush arms 17 are bolted or otherwise suitably secured to but in-

sulated from the outer face of stator ring 6 on brackets 25 supporting their inner ends, while their opposite ends, in the form of the solid rectangular terminal leads 17a, extend through the openings 20 in ring 14 beyond brackets 26. These brackets support the adjacent ends of the brush arms 17 and terminal leads 17a from ring 14 and are secured thereto by cap screws 27, suitable insulation being interposed between brackets 26 and ring 14.

In the right hand zone in Fig. 1 the stator supports brush arms 23 from brackets 30, 31 which may be brazed or otherwise fixed to the ends of the brush arms; brackets 30 are secured to the inner face of stator ring 5 by cap screws 32 but are insulated therefrom, and similar screws 33 hold brackets 31 fixed to the inner face of stator ring 6 but without the interposition of insulation.

Brush arms 17 and 23 are generally similar, preferably of hollow or tubular construction and somewhat pear-shaped in cross section and are disposed in spaced relation about the respective adjacent collectors 24, 22 with the narrower edges of the arms nearest to their surfaces. Each brush arm has a plurality of spaced holes along its inner edge which are preferably provided with short tubular nozzles 35 threaded thereinto extending from the arm toward the adjacent collector surfaces and terminating just short of them. The interiors of brush arms 23 are connected through rubber or other insulating tubes 36 with a manifold 37 carried by but insulated from bars 7 adjacent the active pole or ring 6 of the stator, the manifold being supported on brackets 38 bolted or otherwise secured to the respective parts. The manifold, which may be divided into segments, is in turn connected through a suitable conduit or conduits 39 to a vacuum pump or other mechanism for maintaining reduced pressure at the nozzle openings sufficient to insure a fairly strong suction through the nozzles from adjacent the collector surface and its vicinity. The brush arms 17 are similarly connected to the same suction system through insulating tubes 40 and manifold 41 supported on angle brackets 42 carried by but insulated from end brackets 10.

The air stream set up adjacent the collector surfaces by the suction system drawing air into nozzles 35 in the several brush arms entrains any metal dust produced by friction between the brushes and collectors which is thus drawn into the suction system for disposal in any suitable innocuous way. The air withdrawn by the suction system may of course be cleaned to precipitate the metal particles before discharging it into the atmosphere at a remote point, but such cleaning forms no part of the invention and no means for carrying it out are shown. The flow of air, in addition to removing the dust, also exercises a marked cooling effect upon the collectors and brushes, and assists in maintaining them at proper temperature, while as the air in the zone of influence of the nozzles is being constantly evacuated and replaced with other air moving in from the exterior of the machine, the creation of air pockets and zones of unequal pressure because of the irregular conformation of the machine parts which often occurs when high pressure air is blown against them in an effort to remove the dust by simply scattering it into the room where the generator is housed, as in some prior constructions, is avoided.

Desirably the suction nozzles on the brush

vicinity of the collector surfaces, are so arranged longitudinally of the arms and circumferentially of the generator with relation to the main exhaust ducts of their manifolds as to maintain a substantially uniform flow of air adjacent all the brushes and collectors. To this end the nozzles nearest the points at which manifolds 37 and 41 are connected to the exhaust system may be smaller and/or more widely spaced than those more remote therefrom; in lieu of nozzles, the arms may be provided with suitably proportioned longitudinal slots.

The rotor R to which reference has been made is revolved within the stator at a suitable speed by a driving motor or other prime mover (not shown) connected with it through one of the stub shafts 3, 4 at its ends, preferably shaft 3, at the end opposite that at which conductors 18, 19 are connected. The rotor comprises a hollow generally cylindrical metal body 43 from which for rotation with it the collectors 22, 24 as well as the conductors which cut the lines of the stator magnetic flux created adjacent the stator pole 6 by the exciting coil 8 to generate the current, are supported as in the rotors of homopolar generators heretofore in use.

In accordance with my invention, however, the rotor embodies certain improvements and novel features contributing materially to the advantages to be derived from practice of the invention, including my improved cooling system for maintaining the rotor at a desired operating temperature. For this purpose the stub shafts 3, 4 are provided with axial bores 44, 45 and connected at their outer ends (not shown) with a fluid source and a drain respectively so that during their rotation in their bearings, a flow of water or other coolant through these bores and through the rotor can be maintained. Thus the bore 44 in stub shaft 3 which supports the rotor body from an end plate 46 is connected at its inner end with radial passages 47 in the plate 46 which are in turn connected through tubular conduits 48, L-fittings 49 and bores 50 parallel to the rotor axis with an annular passage 51 formed through cooperation of a groove in the rotor body and the adjacent end of the collector ring 22 overlying this groove. Communicating with this passage are a plurality of tubular conduits 52, preferably lengths of copper tubing, extending toward the opposite end of the generator parallel to the rotor axis in circumferentially spaced grooves 53 in the surface of the rotor body beneath the collector 22. Within the collector 22 these conduits are cylindrical, but as they serve as flux cutting conductors adjacent the active stator pole or ring 6, they are flattened where they pass through the area of its influence and are held in narrow grooves 53a in this area between teeth 54 integral with the rotor body. Beyond the rotor teeth the conduits or conductors 52 are again of hollow cylindrical form, lie in grooves 55 in an extension 56 secured to and projecting beyond the end of the rotor body within what has been termed the left hand zone of the generator, and terminate in an annular passage 57 defined by the extension 56, an end cap 58 and the collector 24. In extension 56 are also a plurality of grooves 59 forming with the end cap 58 fluid ducts connecting passage 57 with bore 45 of stub shaft 4, which is desirably integral with end cap 58, whereby the rotor cooling fluid is discharged from the generator. Extension 56, similarly to ring 14 and its brackets 10, is preferably made of

being cut by stray flux with resultant production of a counter voltage to the load voltage.

Each of the rotor teeth 54 comprises an oppositely undercut tip 54a adapted to receive a plurality of sheet metal stampings 60, preferably suitably insulated from each other, which are consecutively slipped endwise over tips 54a after the conductors are placed in adjacent grooves 53a, the inner corners of the stampings overlying and conforming to the surfaces of the conductors. After assembly the stampings are clamped in position by caps 62 and screws 63 so as to firmly hold them in position and prevent displacement of the conductors under the influence of centrifugal force during generator operation, the teeth 54, tips 54a, stampings 60 and flattened parts of the conductors lying in grooves 53a thus forming the generator armature.

There are of course minor or incidental eddy currents induced in various parts of the generator due to the magnetic flux produced in the stator by the exciting coil and the movement through this flux of various electrically conductive rotor parts; with a view to forming a barrier to the flow of these eddy currents parallel with the axis of the rotor adjacent its outer surface where it is in close proximity to the inactive pole 5 of the stator, the rotor is preferably provided with a plurality of relatively deep slots 64 cut in its outer surface in planes normal to its axis in that portion of the rotor which is aligned with the said pole while passage 51 is desirably made of considerable radial depth so as to cooperate with the slots for this purpose.

Moreover, to reduce the time lag of the generator in reaching full load current and to minimize accumulative compounding of the load voltage which I have found occurs in generators of this class embodying solid collector rings, I make at least one collector ring of segmental construction with the segments suitably insulated from each other as this tends to obstruct the circumferential flow of currents in the ring which, if present, induces the objectional results to which I have referred. To this end and incidentally to facilitate assembly, collector ring 22 lying within the flux field is desirably formed of at least three segments s' which may be insulated from each other by the thin film 65 of copper oxide which normally forms on copper surfaces on exposure to air, particularly in the presence of heat, as this amount of insulation is normally sufficient to prevent material flow of current from one collector segment to another but, if desired, more substantial insulation may be provided between them. The other collector ring 24 may also, as shown, be made in the same way but as this ring lies substantially outside the flux field the advantages incident thereto may not be considered as offsetting the added cost of construction over a solid ring.

The collector segments of course are not insulated from conductors 52, against which they desirably exert considerable pressure to insure good electrical contact and heat exchange relation as well as to hold the conductors rigidly in position in grooves 53 and 55. This pressure of the collector segments is materially supplemented by shrink rings 66 which are also formed in segments and insulated from the collectors, and steel locks 67, 68 of the character heretofore more or less in general use for preventing bursting of fly wheels may be used for fastening the col-

ments together, those used for the collectors at least being insulated to prevent bridging of the insulation between adjacent segments.

The normal tendency of the current generated in the vicinity of active pole 6 of the stator through the cutting of magnetic lines by the flattened parts of conductors 52 in the armature portion of the rotor is to flow near the outer surface of the latter and so through the conductors to one collector, thence through the communicating brushes, brush arms and buses to the load from which it returns through the corresponding parts of opposite polarity, but under certain conditions to positively insure this desired current flow it may be deemed advisable to provide suitable insulation between the cylindrical portions of the conductors and the rotor body.

While I have herein described one embodiment of my invention with some particularity, it will be understood that I do not desire or intend to limit or confine myself thereto in any way as changes and modifications in the form, structure, and relationship of the several parts of the generator and in their mode of operation will readily occur to those skilled in the art and may be made if desired without departing from the spirit and scope of the invention as defined in the appended claims.

Having thus described my invention, I claim and desire to protect by Letters Patent of the United States:

1. In a homopolar generator, a rotor comprising axially spaced collector rings, an armature disposed therebetween, an annular stator pole radially spaced from the armature, a set of brush arms extending from the pole parallel to the rotor axis adjacent each collector ring, the arms in one set each having a conductor connected therewith, and a plurality of conductors interleaved with the brush arms in said set and having electrical connection with the other set of brush arms, all said conductors terminating in a common plane normal to the rotor axis and axially spaced from the stator pole.

2. In a generator, a rotor comprising axially spaced collector rings and an armature disposed therebetween, a stator pole surrounding and radially spaced from the armature, brush arms secured to the pole and extending in opposite directions therefrom parallel with the rotor axis adjacent the rings, the brush arms extending in one direction being insulated from the pole, a terminal lead extending from the pole between each pair of the last mentioned brush arms and in a like direction and having electrical connection with the brush arms extending in the opposite direction, and current conductors respectively interconnected with said terminal leads and the last mentioned brush arms extending from the generator in substantial parallelism with a radial plane of the rotor in a plane normal to its axis.

3. In a generator, a rotor comprising a substantially cylindrical body having on its outer surface a plurality of longitudinal grooves and an annular groove communicating therewith adjacent one end, tubular conductors disposed in the longitudinal grooves having end connections with the annular groove, a collector ring carried by the rotor having electrical connection with the conductors and overlying the annular groove, and means for supplying a fluid coolant to the

ductors during rotation of the rotor.

4. In a generator, a rotor comprising a substantially cylindrical body having on its outer surface a plurality of circumferentially spaced longitudinal grooves and an annular groove adjacent one of its ends, a tubular conductor disposed in each longitudinal groove communicating with the annular groove, each of said conductors extending beyond the opposite end of the body, a longitudinally grooved extension secured to said end adapted to receive the conductors and having an annular groove communicating with the adjacent conductor ends, means respectively overlying said annular grooves to thereby form annular passages, and means for supplying a fluid coolant to one and removing said coolant from the other of said passages during rotation of the rotor to thereby induce a flow of the coolant through the conductors.

5. In a generator a stator affording a circumferentially substantially uniform magnetic field, a rotor coaxial with the field comprising a plurality of circumferentially spaced hollow conductors extending parallel to the rotor axis, a segmental collector ring overlying the conductors and clamping them to the rotor, said rotor having an annular groove adjacent one of its ends communicating with said conductors and forming with the collector ring an annular passage, and means for supplying a coolant to said passage, the rotor having between the passage and its adjacent end a plurality of circumferential slots cooperative with said passage to obstruct the flow of current adjacent said end in substantial parallelism with the rotor axis.

6. In a generator comprising axially spaced annular stator poles and a rotor coaxial therewith and comprising a plurality of tubular conductors extending parallel to the rotor axis adjacent one of the poles, collector rings axially oppositely spaced from said pole having electrical connection with the conductors, the rotor having axially spaced annular grooves forming with the rings annular passages communicating with the conductors and a series of circumferential slots between one passage and the adjacent end of the rotor in proximity to the other pole cooperative with said passage to obstruct the flow of eddy currents in the rotor adjacent said end, and means for maintaining a flow of coolant from one of said annular passages to the other.

7. In a homopolar generator, an annular stator pole, a rotor coaxial therewith having circumferentially spaced outwardly directed teeth each comprising an undercut tip, hollow conductors disposed between the teeth and extending outwardly beyond the bodies thereof, a series of plates surrounding the tip of each tooth and engaging the adjacent conductors to hold the latter in position and means for preventing endwise displacement of the plates from the tooth.

8. A homopolar generator comprising a stator having an annular pole, collector rings coaxial with and axially spaced in opposite directions from said pole, flux-cutting conductors interconnecting the rings and movable therewith about the stator axis, a plurality of circumferentially spaced brush arms secured to and having electrical connection with said pole adjacent one of the collector rings, a plurality of circumferentially spaced conductors extending from and having electrical connection with said pole adjacent the other collector ring, and brush arms electrically insulated from and secured to said pole

mentioned conductors adjacent the second collector ring.

9. In a generator, a stator affording a circumferential substantially uniform magnetic field, a rotor coaxial with the field comprising a plurality of flux-cutting conductors and axially spaced collector rings of mutually opposite polarity interconnected through said conductors, brush arms extending parallel to the rotor axis adjacent the collector rings in opposite directions, terminal leads interposed between adjacent brush arms extending in one of said directions and having electrical connection with the brush arms extending in the other direction, and load conductors respectively interconnected with said leads and the adjacent brush arms, each load conductor extending outwardly from the generator in substantial parallelism with a radial plane of the rotor and in a plane normal to its axis between a pair of load conductors of opposite polarity.

10. In a generator, a stator affording a circumferentially substantially uniform magnetic field, a rotor coaxial with the field comprising a plurality of flux-cutting conductors, axially spaced collector rings of mutually opposite polarity interconnected through said conductors, brush arms extending parallel to the rotor axis adjacent each collector ring, those adjacent one ring being circumferentially offset with respect to those adjacent the other ring, a terminal lead interposed between each pair of brush arms adjacent one ring having electrical connection with the brush arms adjacent the other ring, and load conductors respectively interconnected with each of said leads and with the adjacent brush arms extending outwardly from the generator in substantial parallelism with a radial plane of the rotor and in substantially the same plane normal to said axis, the conductors of each polarity respectively lying adjacent and between a pair of load conductors of opposite polarity.

11. In a homopolar generator, a stator, a rotor coaxial therewith comprising axially spaced col-

ity, a plurality of magnetic armature elements between the rings and a plurality of circumferentially spaced tubular flux-cutting conductors underlying each ring and extending therebetween, those portions of the conductors underlying the rings being cylindrical and their intermediate portions between the rings extending for a greater distance radially of the rotor than circumferentially thereof.

12. A generator comprising a magnetic flux producing substantially annular stator pole, a plurality of conductors movable through the flux about a common axis, current collecting means electrically interconnected with the conductors at points disposed respectively on opposite sides of the plane of said pole, current conveying leads interconnected with each collecting means and extending in circumferentially spaced relation substantially parallel to said axis to a common plane normal to said axis and axially spaced from the zone containing all of said collecting means and load carrying leads extending from the generator in said plane respectively interconnected at circumferentially spaced points with the first leads.

13. In a homopolar generator, a rotor comprising axially spaced collector rings and an armature including flux-cutting conductors interconnecting the rings, an annular stator pole coaxial with and radially spaced from the armature, sets of brush arms extending from the pole parallel to the rotor axis respectively adjacent the collector rings, a conductor interposed between and extending parallel to each pair of adjacent brush arms in one set in substantial circumferential alignment therewith and having electrical connection with the other set of brush arms and load conductors disposed in a plane normal to the rotor axis respectively connected to said interposed conductors and said adjacent brush arms proximate their extremities remote from the stator pole and collector rings.

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