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DYNAMOELECTRIC MACHINE

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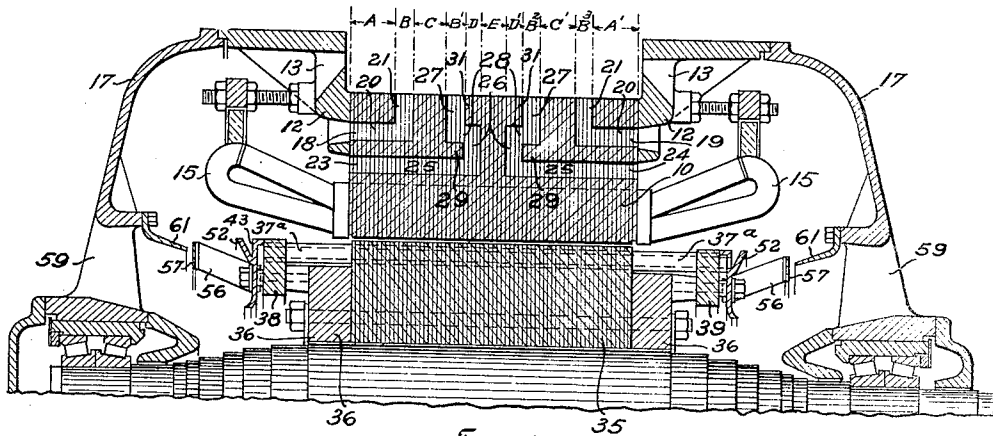


Fig. 1

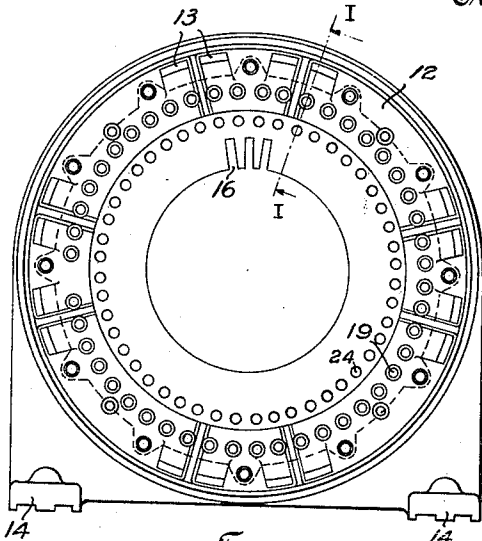


Fig. 2

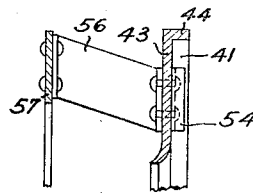


Fig. 5

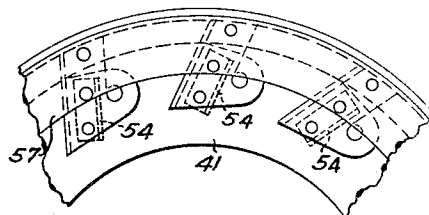


Fig. 6

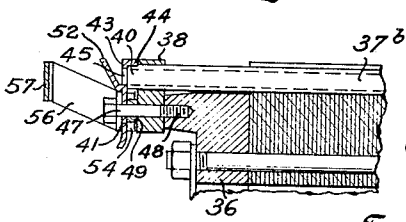


Fig. 3

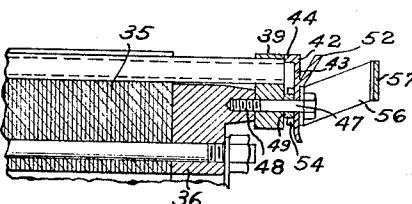


Fig. 4

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UNITED STATES PATENT OFFICE

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DYNAMO-ELECTRIC MACHINE

Application filed November 19, 1928. Serial No. 320,268.

This invention relates in general to dynamo-electric machine construction, and has more particular relation to features of design and construction concerned with securing effective ventilation and cooling of the machine during operation.

One feature of the present invention is particularly concerned with facility for securing desired and effective ventilation of interior core portions of an element of a dynamo-electric machine, particularly the stator element thereof, through the use of ventilating passages or ducts through the core which insure the passage of cooling air other than through the air-gap of the machine, these ventilating passages opening both axially and radially and being so designed that the radial portions thereof are formed through the removal of the required material of the core laminæ without unduly reducing the mechanical strength of the individual laminæ or the core structure formed therefrom. Another feature of the present invention is concerned with the use of conductors of a hollow or tubular character disposed in slots of a core member of a dynamo-electric machine, particularly the rotor element thereof, and portions associated with these tubular conductors for suitably directing and insuring the passage of effective ventilating currents of air through the conductors. And the provisions for directing the air through the hollow conductors may be so associated with end connecting elements for the hollow conductors through the core as to insure removal of heat from the end connecting elements.

It is an object of the present invention to provide a dynamo-electric machine of improved design and construction embodying provisions for ventilating interior portions of either or both stator and rotor elements of the machine.

It is a further object of the present invention to provide a dynamo-electric machine of improved design and construction embodying an interiorly ventilated laminated core structure provided with ventilating ducts having a component in a radial direction and of such formation as to insure a

high degree of mechanical strength of the individual laminæ and the assembled core structure while insuring suitable ventilating or cooling effects.

It is a further object of the present invention to provide a dynamo-electric machine of improved design and construction embodying hollow conductor members associated with a core element, along with provisions for insuring the passage of cooling or ventilating currents of air in contact with the conductors so as to provide increased capacity in the matter of dissipation of heat.

These and other objects and advantages are attained by the present invention, various novel features of which will be apparent from the description and drawings forming a part of this application, disclosing an embodiment of the invention, and will be more particularly set forth in the claims hereinafter.

In the drawings:

Fig. 1 is a broken sectional elevation, in the plane of the line I—I of Fig. 2, of a dynamo-electric machine embodying features of the present invention.

Fig. 2 is an end view, with parts broken away, of the machine of Fig. 1.

Fig. 3 is an enlarged fragmentary sectional elevation of the rotor of the machine of Fig. 1.

Fig. 4 is a plan view of a detail of Figs. 1 and 3.

Figs. 5 and 6 are enlarged sectional and side elevations, respectively, of a detail of Figs. 1 and 3.

There is disclosed in the drawings, as to an embodiment of the present invention, a dynamo-electric machine of the induction motor type having a secondary provided with a squirrel-cage winding. The stator of the motor is of the open or riveted frame type wherein the outer periphery of the stator core 10 is exposed to the air, this core being made up of annular laminæ clamped together in a conventional manner between radially extending portions of end heads 12, as by bolts extending through the end heads and peripheral enlargements of the laminæ, the end heads extending substantially be-

yond the normal periphery of the laminæ and having at their outer edges axially outward extensions and being provided with spaced apertures 13 leading from the space within the axial extensions to the space radially outside of the core laminæ, these end heads also being provided with base or foot portions 14. Spaced strengthening ribs may be provided between the outer face of the radial portion of the end heads 12 and the inner side of the axial extension therefrom, as indicated. A winding 15 is disposed in slots 16 at the inner periphery of the stator core and the end turns of this winding extend axially into the spaces within the outer axial flanges on the end heads, suitable conventional means being provided to anchor the end turns and other portions of the winding in desired operative position with respect to the end heads of stator core. End bells or housings 17 are provided for enclosing the ends of the stator and rotor of the machine, these end bells being provided with the usual centrally located bearing housings in which the bearings for the rotor shaft are mounted, and there being provided an aperture or apertures of suitable size outside of the bearing housing to permit the entrance of the required amount of air for passage through and cooling of the machine during operation.

The stator core is shown as being provided with four ventilating ducts, each having an axially extending passage or portion and a substantially radially extending passage communicating with the axially inner end of the axially extending passage of the duct and communicating with the outer air outside the periphery of the core. Two of these ducts 18 and 19 are similar and symmetrically arranged about the center line of the core, the axially extending portions 20 of these ducts opening through the end heads 12 and communicating at their inner ends with the radial portions or passages 21. A second pair of ventilating ducts 23 and 24 are similar one to another and are symmetrically positioned about the center line of the core. Each of these latter ducts includes an axially extending passage 25 and a generally radial portion communicating with the inner end of the axial passage opening through the end laminæ or the relatively stiff tooth support thereof, and including two offset radially extending portions 26 and 27 communicating with each other through an axial connecting passage 28, whose axial dimension may be as desired, and may well be only such as is afforded through immediate communication through the adjacent side wall portions at the radially outer end of the passage 26 and the radially inner end of the passage 27. The outer passage 27 opens through the periphery of the core.

The desired formation of the ventilating

ducts described may be secured through the use of core laminæ having apertures punched therein of such form and so relatively positioned as to constitute ten groups of perforated laminæ, these groups, from left to right in Fig. 1, being indicated as A, B, C, B', D, D', B², C', B³ and A', and an additional centrally disposed group E of unapertured laminæ. The laminæ of the groups A and A' are similarly formed or apertured, as is also the case with the laminæ of the groups B, B', B² and B³, the laminæ of the groups C and C' and the laminæ of the groups D and D'. From this it will be apparent that the core is made up of laminæ of five different designs as to the character of the apertures or slots formed therein for the production of the desired ventilating air passages.

The several axial passages of the ducts 18, 19, 23 and 24 are formed by alined apertures, shown as circular, in the laminæ of the several groups, except D, D', E, constituting the core. And the radial passages 21 of the ducts 18 and 19 and the radial passages 27 of the ducts 23 and 24 are formed by perforations or slots of generally rectangular form, in groups B and B³ and groups B' and B², respectively, of a width approximately equal to the diameter of the circular apertures forming the axial passages 21 and 25, with the radially inner ends of these perforations, preferably of semi-circular shape where the passages communicate with the axial passages 18 and any axial passage that may exist at the connection of passages 26 and 27. The radial passages 26 of the ducts 23 and 24 are formed by alined elongated perforations in the laminæ of groups D and D', preferably formed with semi-circular ends where the passages 26 communicate with the axial passages 25 and any axial passage that may exist at the connection 28. Through the described combination of perforated laminæ, the radial passages 21 of ducts 18 and 19 and passages 26 and 27 of ducts 23 and 24 are formed of rectangular cross-section and of substantially the same cross-sectional area as the axial passages 18, 19, 23 and 24 of circular cross-section. The right angular portions of the ducts 18 and 19 and the generally right angular portions of the ducts 23 and 24, with the offset radial portions produced by imperforate portions 29 of the laminæ of groups B' and B² and the imperforate portions 31 of the laminæ of groups D and D', insure that cooling air passes over an extended surface of the interior core portions forming the boundaries of these passages, thus facilitating removal of heat from the core. Where the conditions as to operating temperatures and expense dictate it, the ducts 18 and 19 may be omitted, the corresponding laminæ then being formed similar to those of groups C and C'.

Further, through the provision of a staggered effect as to the radial passages 26 and 27 of the ventilating ducts 23 and 24, it is possible to provide the desired discharge from the axial passages 25 and through the outer periphery of the laminae, while avoiding slotting or perforating the laminae of the groups B', D, D' and B² to such an extent as to almost sever, and in any case very substantially weaken, these laminae, thus making them difficult to handle during the assembling of the rotor core; for it will be apparent that the radially inner edge of the axial passages 25 of the ventilating ducts 23 and 24 are quite close to the bottom, or radially outer side, of the winding slots 16 of the core, the positioning of the axial passages 25 reasonably close to the winding slots being desirable in order to facilitate dissipation of heat from the points at which the greater amount of the heat is generated, that is, immediately adjacent the winding itself. And through the imperforate portions 29 of the laminae of the groups B' and B² and the imperforate portions 31 of the laminae of the groups D and D', in addition to insuring suitable mechanical strength of the laminae, there are provided zig-zag ventilating ducts having relatively great surface area for contact by the circulating and cooling air currents.

The rotor core 35 is shown in the form of a group of annular laminae clamped together between end heads 36 and secured in position upon the rotor shaft. The core is provided with the usual peripheral slots, preferably of the partially closed type, tubular conductor bars, one set of alternate bars being indicated at 37^a and the other set at 37^b, being inserted within these slots and having portions projecting beyond the core and end heads 36 and through the usual conductive end-connecting rings 38, 39, the ends of these tubular conductors being preferably soldered or otherwise rigidly mechanically and electrically connected to the end rings.

One end of each of these tubular conductor bars is machined to lie flush with the axially outer face of one of the end rings, and the other end of the bar projects slightly beyond the outer face of the other end ring, this projecting portion being indicated at 40. As indicated, one set 37^a of alternate conductor bars have one end flush with the outer face of end ring 38, and the opposite end of the bars of this group have the portion 40 projecting beyond the outer face of end ring 39.

Axially outside of the end rings 38 and 39 are disposed annular shroud or casing members 41, 42, respectively, these shrouds being of substantially similar construction and including a radial side wall portion 43 spaced from the outer face of the end ring,

to an extent corresponding to the length of the projecting portion 40 of the bar, and an outer flange-like portion 44 which lies flush against the outer face of the end ring and preferably machined portions at the outer end of the projecting portions 40 of one group of the tubular conductor bars. The radial walls 43 of the shrouds 41, 42 are provided with apertures 45 of substantially the same size as the bore of the tubular conductor bars, these apertures being in alignment with the bores of alternate conductor bars at each end of the core, and the ends of the conductor bars fitting closely against the wall of the radial portions of the shrouds about the apertures 45.

With the above arrangement, alternate conductor bars have one end thereof flush with the outer face of one end ring, with their bores opening to the space within the chamber formed by this end ring and the annular shroud associated therewith; and the other end of each conductor of this group is so disposed as to have its bore communicating with an aperture 45 in the radial wall 43 of the shroud at the other end of the rotor. Through the provision of machined surfaces at the outer sides of the projecting portions 40 of the conductor bars, a relatively close fit may be provided between the axial flanges at the outer periphery of the shrouds and the end rings so as to insure substantially fluid-tight chambers open at their radially inner sides and from which there is communication, through the bores of alternate bars, to the opposite end of the rotor.

The annular shrouds 41 and 42 may be held in position by means of bolts 47 with their heads disposed at the outer side of each shroud and passing therethrough and through the adjacent end ring and threaded into spaced axially projecting portions 48 upon the end head 36, with a spacer 49 between the inner face of the radial portion of the shroud and the outer face of the corresponding end ring to insure the desired positioning of the radially inner edge of the shroud. The radially inner edge of the radial wall 43 of the shrouds 41, 42 may be provided with an outwardly extending guiding or directing lip to facilitate the entrance of air to the space or chamber within the shrouds, and an outwardly inclined deflecting or guiding flange 52 may be provided axially outside of the apertured parts of the radial side wall of the shroud to insure that air discharged from the tubular conductor bars communicating with the apertures 45 is given an axially outward directional component after it leaves the discharge ends of the bores of the conductor bars.

In order to permit the circulation of cooling air currents through the tubular conductor bars, fan blades 54 are provided, the

same being attached to the inner face of the radial wall of each shroud, these fan blades being suitably shaped to insure the supply of an ample volume of cooling air under suitable pressure to and through the conductor bars during the operation of the machine.

Mounted on each end of the rotor at the axially outer side thereof is a series of fan vanes 56, the same being preferably mounted on the outer side of the radial walls of the shrouds 41, 42, these fan vanes having integral attaching flanges lying against the outer side of these radial walls on the shrouds, and the vanes or blades being preferably held in position by rivets passing through this radial portion of the shroud and through the flange portions of the fan blades 54 at the inner side of the shrouds, the inner and outer sets of fan blades 54 and 56, respectively, being thus capable of being assembled on the shrouds at the same time, as will be more apparent from Figs. 5 and 6.

Each set of fan vanes 56 may have their outer ends secured to a shroud or guiding rim 57 of such size and so positioned as to secure the desired inflow of air to the fan and its discharge therefrom in the desired direction.

Openings 59 in the end bells 17 serve as inlets for cooling air drawn into the machine, a guiding or deflecting rim or flange 61 being attached to the inner wall of the end bell about the inlet opening 59 there-through, as indicated, and serving, particularly in conjunction with the outer rim 57 of the fan vanes 56, to insure the passage of cooling air from outside the motor casing to the inlet side of the rotor fan vanes.

During operation of the machine, air enters through the opening 59 in each end bell and the associated deflector 61, the major portion of the air being passed through the main ventilating fans 56, with a portion thereof slightly deflected by the outer side of the flange 52, and being discharged radially outward therefrom into the space between the end bell and the stator core and about the end turns of the stator winding 15. A smaller portion of the incoming air is drawn by the fan vanes 54 into the chambers formed by the shrouds 41, 42 with the rotor end rings 38, sufficient pressure being developed to readily force this air through the tubular conductors 37 communicating with the chambers formed by the shrouds, to the opposite ends of the conductors, when the air is discharged through the openings 45 and deflected by the guiding flange 52 in the general direction of the air discharged by the main fan blades 56. The inclined flanges 52 serve to protect the discharge ends of the tubular conductors from impact head due to the fan vanes 56, and they also serve to insure that

the air discharged from these conductors escapes without whistling or siren effect. A further portion of the incoming air is drawn by the axially extending portions of the tubular conductors 37^a, 37^b, between the spaced projections 48 on the end heads 36 and between the end heads and the end rings 38, this air passing over and serving to cool the surface of these extending portions of the conductors and being discharged against and about the end turns of the stator winding.

The air passing from the several fan elements associated with the rotor is discharged to the surrounding atmosphere through several paths, the major portion of this air passing through the pairs of ventilating ducts 18, 19 and 23, 24, through the core in an axial and then in a radially outward direction to the outside atmosphere; and a second portion of this air is discharged through the apertures 13 located in the radial extensions of the stator end head members 12 to the space outside of the stator core.

If the flow of air through all of the tubular conductor bars of the core were in the same direction, a single inlet shroud chamber would suffice, with the discharge through the opposite end of all the bars; but better and more uniform and efficient cooling effects during the operation of the motor may be secured with the specific arrangement described hereinabove wherein the cooling air is caused to circulate in both directions through the conductor bars.

The construction described hereinabove permits building up the core with smooth finish laminations and undesirable effects caused by air ducts opening into the air-gap may be avoided. And the arrangement is such, particularly by reason of the passage of the cooling air in contact with or immediately adjacent the hotter parts of the core and windings, as provides a machine capable of operation under heavy load with a considerable reduction in heat losses. Through the utilization of features of the present invention, there is attained a comparatively simple and inexpensive design and construction of ventilated core for electrical apparatus, and there may likewise be attained a comparatively simple and inexpensive design and construction of dynamo-electric machine, of particular utility as an induction motor, and one capable of operation under heavy load with minimum heat losses.

It should be understood that the invention claimed is not limited to the exact details of construction shown and described herein, for various modifications will occur to persons skilled in the art, and it is contemplated that the invention cover such modifications.

It is claimed and desired to secure by Letters Patent:

1. A core for electrical apparatus, comprising a group of assembled laminæ having a ventilating duct therethrough, said ventilating duct including two communicating passages formed through the assemblage of said laminæ with perforations through adjacent laminæ in communication with each other, one of said passages extending in the direction of the planes of the laminæ and the other passage extending in a direction at right angles to the first passage, the passage extending in the direction of the planes of the laminæ having an offset portion and formed by perforated portions of a group of said laminæ whose perforations do not extend from the periphery of the core throughout the full depth of the passage in the direction of the planes of said laminæ. 70
2. A core for electrical apparatus, comprising a group of assembled laminæ provided with a ventilating duct therethrough and including a portion extending in the general direction of the planes of the laminæ, said portion of the duct being formed through the assemblage of a group of said laminæ with perforations through adjacent laminæ in communication with each other but with the perforations of said group of laminæ extending throughout less than the full depth of said passage in the direction of the planes of said laminæ. 75
3. A core element for a dynamo-electric machine, comprising a group of assembled laminæ lying in radial planes and provided with a through ventilating duct including a portion extending in a radial direction, said portion being formed by the assemblage of said laminæ having through perforations in communication with each other and of less radial depth than the full depth of said radial portion of the duct. 80
4. A core element for a dynamo-electric machine, comprising a group of assembled laminæ lying in radial planes and provided with a through ventilating duct including a passage extending in a radial direction from the periphery of said core to an interior portion thereof and having an offset portion, said duct being formed through the assemblage of said laminæ with perforated portions thereof in alinement, and the perforations through said laminæ being of a radial depth substantially less than the full radial depth of said passage. 85
5. A core element for a dynamo-electric machine, comprising a group of assembled laminæ provided with a ventilating duct therethrough, said duct having communicating axially and radially extending portions and being formed through the assemblage of laminæ with perforations through adjacent laminæ in communication with each other, the radial portion of said duct being provided with an offset, and the radial depth of the perforations through said laminæ forming said radially extending portions of said duct being less than the full radial depth of said radially extending portion of the duct. 90
6. A core for a dynamo-electric machine, comprising laminæ assembled between rigid end heads and having a plurality of series of ventilating ducts each of which includes axially and radially extending communicating portions, the several series of ducts opening through opposite ends of the core, and the radial portions of said ducts being formed by laminæ assembled with perforations therethrough in alinement and of a depth substantially less than the full radial depth of said radial portion of the duct. 95
7. A core element for a dynamo-electric machine, comprising a group of assembled laminæ provided with two annularly arranged series of ventilating ducts formed by alined perforations in said laminæ, the ducts of the two series each having an axial portion opening to the space axially outside of said core, and the two series extending from opposite axial sides of said core and arranged symmetrically about the center line of said core, each of said ducts having a radial portion adjacent the center line of the core and provided with an offset, and the radial depth of the perforations in said laminæ forming said radial portion of the duct being less than the full radial depth of said radial portion of the duct. 100
8. A core element for a dynamo-electric machine, comprising a group of assembled laminæ provided with two annularly arranged series of ventilating ducts formed by alined perforations in said laminæ, each of said ducts having an axial portion opening to the space axially outside of said core and opening into a radial portion adjacent the center line of the core, the ducts of the two series opening from opposite axial sides of said core, and the radial portion being provided with an offset, with the radial depth of the perforations in said laminæ forming said radial portion of the duct less than the full radial depth of said duct. 105
9. In a dynamo-electric machine, a rotor core having longitudinal slots therethrough, tubular conductors extending through said slots and projecting beyond the ends of said core, an annular casing disposed along each side of said core, each of said casings communicating with the interior of alternate ones of said tubular conductors, fan means having portions disposed within said casing for forcing cooling air through said casing and the tubular conductors opening thereinto. 110
10. In a dynamo-electric machine, a rotor core having longitudinal slots therethrough, tubular conductors extending through said 120 125 130

slots and projecting beyond the ends thereof, end rings for interconnecting corresponding ends of said conductors, said conductors opening into said end rings, an annular shroud associated with each end ring and cooperating therewith to form a casing with which a separate group of said tubular conductors communicates.

11. In a dynamo-electric machine, a rotor core having longitudinal slots there-
through, tubular conductors extending
through said slots and projecting beyond
the ends of said core, end rings for inter-
connecting corresponding ends of said con-
ductors, said conductors opening into said
end rings, an annular shroud associated with
each end ring and cooperating therewith to
form a casing with which one group of said
tubular conductors communicates, conduc-
tors of another group having their discharge
ends outside of said chamber, and fan means
disposed at the inner side of said shroud
and serving to circulate air through those
tubular conductors opening into the casing
formed by said shroud and associated end
ring.

12. In a dynamo-electric machine, a rotor
core having longitudinal slots adjacent its
periphery, tubular conductors extending
through said slots and projecting beyond the
ends thereof, end rings for interconnecting
corresponding ends of said conductors, said
conductors extending into said end rings, an
annular shroud axially outside of each end
ring and cooperating with the latter to form
a casing with which one group of said tubular
conductors communicates, conductors of
another group passing through said cham-
ber without communicating therewith and
discharging to the outer side thereof, and
fan means adapted during operation of said
rotor to circulate cooling air through said
conductors.

13. In a dynamo-electric machine, a rotor
core having longitudinal slots therethrough,
tubular conductors extending through said
slots and projecting beyond the ends of said
core, end rings for interconnecting corre-
sponding ends of said conductors, said con-
ductors extending into said end rings, an
annular shroud axially outside of each end
ring and cooperating with the latter to form
a casing with which one group of alternate
tubular conductors communicate, conductors
of the other group passing through said
chamber without communicating therewith
and discharging to the outer side thereof,
deflecting means associated with the dis-
charge end of said conductors, and fan
means adapted during the operation of said
machine to circulate air through said tubular
conductors.

14. In a dynamo-electric machine, a core
having longitudinal slots adjacent its pe-
riphery, tubular conductors extending

through said slots and projecting beyond
the ends of said core, end rings for intercon-
necting corresponding ends of said conduc-
tors and into which said conductors extend,
an annular casing at each end of said core
and communicating with the interior of an
end portion of each of a group of said tubular
conductors, means for forcing cooling
air through said casing and the tubular con-
ductors communicating therewith, and means
associated with one of said casings for caus-
ing the air discharged from the tubular
conductors communicating with the other
casing to assume a direction having a sub-
stantial radially outward component.

15. In a dynamo-electric machine, a core
having longitudinal slots therethrough, tu-
bular conductors extending through said
slots and projecting beyond the ends of said
core, means for causing a circulation of cool-
ing air through said conductors from end
to end thereof with the direction of circula-
tion through the conductors of one group
opposite to the direction of circulation
through the conductors of another group.

16. In a dynamo-electric machine, a
slotted rotor core, tubular conductors ex-
tending through the slots in said core and
projecting beyond the ends thereof, an an-
nular casing disposed along each side of
said core, each of said casings communicat-
ing with the interior of certain ones of said
tubular conductors, fan means associated
with each of said casings for forcing cool-
ing air therethrough and those tubular con-
ductors opening therein too, and means as-
sociated with said casings for deflecting air
discharged from the others of said conduc-
tors to cause said air to assume a radially
outward direction.

17. In a dynamo-electric machine, the
combination of a stator having a core
formed of laminæ assembled between rigid
end heads, end bells secured in position out-
side of said end heads, the spaces within
said end bells opening to the space radially
outside of said stator core, a slotted rotor
core having tubular conductors extending
therethrough and projecting beyond the
ends thereof, means associated with said
rotor and effective to circulate air through
the tubular conductors, and means for de-
flecting air discharged from said conductors
radially outward to the space within one
of said end bells.

18. In a dynamo-electric machine, the
combination of a stator having a core
formed of laminæ assembled between rigid
end heads, end bells secured in position out-
side of said end heads, said stator providing
communication between the spaces within
said end bells and the space radially out-
side of said stator core to permit the dis-
charge of ventilating air to the latter space,
a slotted rotor core having tubular conduc-

tors extending therethrough and projecting beyond the ends thereof, means associated with said rotor and effective to circulate air through said tubular conductors, the directions of passage of air therethrough being opposite in different groups of conductors, and means for deflecting air discharged from said conductors radially outward to the spaces within the adjacent end bells whence it is conducted to the space radially outside of said stator core.

In testimony whereof, the signature of the inventor is affixed hereto.

GEORGE L. RINGLAND.