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LIQUID COOLED ROTOR AND STATOR

Filed April 4, 1958

FIG. 2.

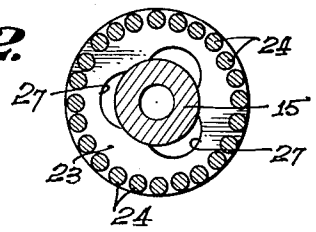


FIG. 1.

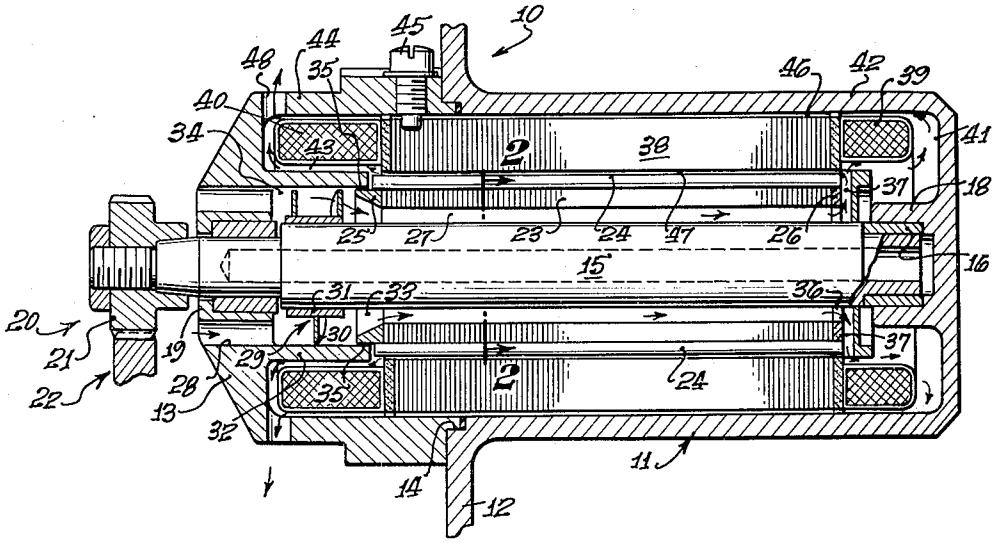
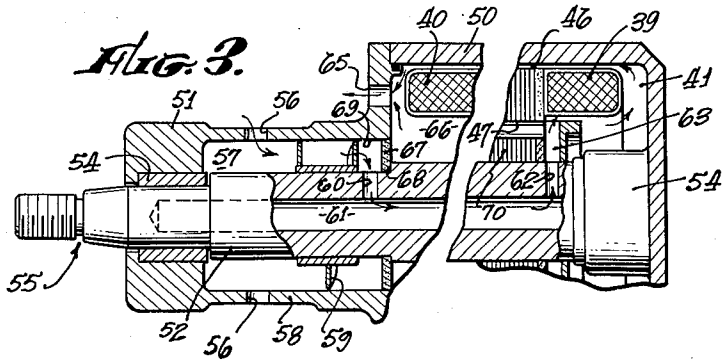


FIG. 3.



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LIQUID COOLED ROTOR AND STATOR

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This invention relates generally to liquid cooled electrical machinery, and more particularly has to do with liquid cooling of electrical motors, particularly induction motors at least partially surrounded by liquid coolant and driving mechanism operable to froth the coolant prior to circulation thereof through the motor.

Motors designed to drive mechanism bathed in a lubricant that is also taken into the motor for cooling purposes are subject to overheating due to improper cooling when the coolant does not flow through the motor in a continuous stream. One not uncommonly encountered circumstance causing discontinuous flowage of the coolant through a motor is the presence of extensive froth or bubbles dispersed in the circulating coolant. Formation of such froth may often be traced to the churning action of gear mechanism driven by the motor shaft while submerged in the coolant-lubricant outside the motor housing.

The present invention has for its major objects the provision of an improved liquid cooled electrical motor and also the correction of this problem source of overheating of electrical motors, and is predicated on the concept of physically collapsing the coolant froth before it is circulated through rotor and stator passages in the motor assembly. Accordingly, there is incorporated in the motor assembly an axial flow type rotary impeller positioned in the path of coolant circulation prior to entrance thereof into the rotor and stator passages, so that coolant froth upon passage through the impeller is collapsed and a steady pressurized stream of coolant-lubricant is delivered to the cooling passages in the motor assembly. The invention particularly contemplates the provision of a spiral vane type impeller delivering coolant to rotor passages, the froth eliminating impeller operating in conjunction with a centrifugal impeller located downstream from the rotor passages for throwing the de-frothed coolant radially outwardly toward stator passages, from which the coolant exits from the motor to the exterior bath.

Additional objects include particularly advantageous structural incorporation of the impellers in the motor assembly to achieve the results desired.

These and other features and objects of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following detailed description of the drawings, in which:

FIG. 1 is an elevation taken in section through the electrical motor and the impellers incorporated therein;

FIG. 2 is a section taken on line 2—2 of FIG. 1; and

FIG. 3 is a view similar to FIG. 1 showing a modified motor and impeller assembly.

In FIG. 1 the motor housing generally indicated at **10** includes a receptacle **11** having a flange **12** extending about the receptacle, and a cap **13** closing the open end of the receptacle, the cap and receptacle having aligning engagement at **14**. Extending axially within the motor housing **10** is a rotor shaft **15** journaled in bearings **16** and **17** respectively carried by a receptacle boss **18** and

by the cap portion **19**, the shaft projecting through the cap to the exterior. The rotor drives gear mechanism **20** including a spur gear **21** mounted on the threaded end of the motor shaft and other gearing generally indicated at **22**. It will be understood that the gear mechanism and that portion of the motor housing leftward of the flange **12** are bathed in a lubricant-coolant, such as a light oil lubricating the gearing and being taken into the motor housing for cooling purposes.

Carried by the rotor shaft **15** intermediate the bearings **16** and **17** is a laminated iron core **23**, the laminations of which extend in planes perpendicular to the shaft axis. A series of circularly spaced, axially directed parallel conductor bars **24** are received or sunk in the core, forming the common squirrel cage associated with induction motors. These bars are shorted at their opposite ends by conductor rings **25** and **26** typically made of copper, as are the bars. The iron core laminations **23** form three axially extending passages **27** spaced about the rotor shaft for conducting coolant axially through the rotor assembly.

The coolant is received from the exterior of the housing through a series of circularly spaced inlets **28** in the cap for delivery to the passages **27** by an axial flow type impeller **29**. The latter includes a spiral vane **30** carried by a sleeve **31** on the rotor shaft, with a ring shaped partition **32** integral with the cap closely surrounding the periphery of the spiral vane so as to form in effect a pump casing. From the impeller the coolant enters passages **27** through a reduced opening **33** formed by the conductor ring **25**, the latter together with the partition **32** effectively sealing off the impeller chamber **34** and the entrance ends of passages **27** from the stator passages to be described, the annular seal being effected at **35**.

After passing axially through passages **27**, the coolant enters the eye **36** of a centrifugal impeller, the eye being formed by conductor ring **26**. The centrifugal impeller is also mounted on the rotor shaft so as to operate in conjunction with the defrothing impeller **29** upstream of the entrance ends of passages **27**. Coolant passing through the centrifugal impeller is thrown radially outwardly toward the stator passages to be described. The stator includes an elongated laminar core **38** containing openings, not shown, through which the stator windings extend in an axial direction, the windings at opposite ends of the core, as shown by winding rings **39** and **40**, being cooled by the flow of coolant as indicated by the arrows. Ring **39** extends generally in the annular space **41** formed at the closed end of the motor between boss **18** and the receptacle outer wall **42**, the winding ring being displaced radially outwardly from the impeller **37**. Winding ring **40**, on the other hand, extends in the annular space **43** formed between the partition **32** and the outer wall **44** of the cap.

The stator is held in position in the housing by a set screw **45** threaded into the cap wall and received in the stator core. Endwise extending annular passages are formed between the housing wall and the stator core **38** as designated at **46**, and also between the stator core and the rotor conductor bars **24**, as designated by the gap **47** therebetween. The coolant delivered by the centrifugal impeller is free to flow axially through passages **46** and **47** from space **41** to space **43**, in cooling relation with the stator, the coolant exiting from the motor via outlet **48** in the cap. As described previously, the seal at **35**

prevents short-circuiting of coolant from the impeller chamber **34** directly into the space **43**.

In operation, the spiral vane **30** rotated by shaft **15** collapses the froth and bubbles formed in the coolant by the gearing **30**, so that a steady defrothed stream of coolant is delivered through the rotor passages **27** to the centrifugal impeller **37**. The latter operates to deliver the steady stream of coolant under pressure to the endwise extending stator passages **46** and **47**. Coolant in spaces **34** and **41** is, of course, free to lubricate the bearings **16** and **17** exposed to those spaces.

Referring now to FIG. 3 a somewhat modified form of the invention is illustrated. A motor housing receptacle **50** and end cap **51** receive the rotor shaft **52** journaled in bearings **53** and **54**, similar to those previously described, the shaft projecting through the cap at **55**. The latter takes coolant in through side inlets **56** to an annular chamber **57** formed between the shaft and wall **58** of the cap. The spiral vane impeller **50** in the space **57** defroths the coolant and delivers same through radial openings **60** in the rotor shaft to an axially extending passage **61** in the shaft. In this embodiment, the coolant flows axially through the passage **61** toward bearing **54** in cooling relation with the rotor shaft, and exits through a number of radial openings **62** in the shaft into the centrifugal impeller **63** mounted on the shaft. From there, the coolant flows as previously described through the stator passages **46** and **47**, and finally exits through outlets **65** in the cap, after flowing in space **66**. An annular seal ring **67** mounted against shoulder **68** on the rotor shaft extends to the inner wall **69** of the cap and seals off between space **57** and **66**, to prevent short-circuiting of the coolant around the rotor and stator passages.

In flowing through the shaft passage **61**, the coolant absorbs heat generated in the annular rotor core laminations **70** and transferred to the rotor shaft by conduction, the laminations being mounted directly on the shaft and containing no passages as were indicated at **27** in FIG. 2.

I claim:

1. A liquid cooled electrical machine, comprising means including a housing and rotor and stator assemblies within the housing, said means containing an inlet and an outlet and passages for circulating a coolant received through said inlet along said rotor and stator assemblies to discharge from said outlet, said coolant circulation passages including gaps between the rotor and stator and between the stator and housing, said rotor assembly including a shaft projecting outside the housing for driving mechanism operable to froth the coolant prior to circulation thereof through said inlet, and a rotary impeller in the path of said circulation for delivering received coolant to said passages in response to rotor assembly rotation, whereby coolant froth received through said inlet is collapsed by said impeller prior to coolant circulation through said passages.

2. A liquid cooled electrical motor, comprising means including a housing and coaxial rotor and stator assemblies within the housing, said means containing an inlet and an outlet respectively communicating with the rotor and stator assemblies and axially directed rotor and stator passages in series communication for circulating a coolant received through said inlet successively along said rotor and stator assemblies to discharge from said outlet, said rotor assembly including a shaft projecting outside the housing for driving mechanism operable to froth the coolant prior to circulation thereof through said inlet, an axial flow type rotary impeller in the path of said circulation for delivering received coolant to said passages in response to rotor assembly rotation whereby coolant froth received through said inlet is collapsed by said impeller prior to coolant circulation through said passages, and a second impeller downstream from said axial flow type impeller for delivering coolant received from said rotor passage to said stator passage.

3. The invention as defined in claim 2 wherein said impellers are axially spaced and rotatable by said rotor, said second impeller being of centrifugal type.

4. A liquid cooled electrical motor, comprising means including a housing and coaxial rotor and stator assemblies within the housing, said means containing an inlet and an outlet respectively communicating with the rotor and stator assemblies and axially directed rotor and stator passages in series communication for circulating a coolant received through said inlet successively along said rotor and stator assemblies to discharge from said outlet, said rotor assembly including a shaft projecting outside the housing for driving mechanism operable to froth the coolant prior to circulation thereof through said inlet, an axial flow type rotary impeller in the path of said circulation for delivering received coolant to said passages in response to rotor assembly rotation whereby coolant froth received through said inlet is collapsed by said impeller prior to coolant circulation, through said passages, and a second impeller downstream from said axial flow type impeller for delivering coolant received from said rotor passage to said stator passage, said impellers being axially spaced and rotatable by said rotor, said second impeller being of centrifugal type, said axial flow type impeller having a spiral vane facing the entrance to said rotor passage, and said stator passage extending along the outside of said stator assembly.

5. The invention as defined in claim 4 in which said rotor passage extends alongside the rotor shaft.

6. The invention as defined in claim 4 in which said rotor shaft contains said rotor passage.

7. The invention as defined in claim 5 comprising an induction motor in which said rotor assembly includes a plurality of circularly spaced and axially directed conductor bars and a conductor annulus connected with end portions of said bars, said annulus forming said entrance to said rotor passage.

8. The invention as defined in claim 7 in which said housing includes an annular partition cooperating with said conductor annulus to seal off between said rotor and stator passages.

9. A liquid cooled electrical motor, comprising means including a housing and coaxial rotor and stator assemblies extending lengthwise within the housing, said means containing an inlet and an outlet respectively communicating with the rotor and stator assemblies and axially directed passages extending lengthwise along said assemblies and in series communication for circulating a liquid coolant received through said inlet successively lengthwise along said rotor assembly and then lengthwise along said stator assembly, said coolant circulation passages including gaps between the rotor and stator and between the stator and housing, said rotor assembly including a shaft projecting outside the housing for driving mechanism operable to froth the coolant prior to circulation thereof through said inlet, and a centrifugal impeller within the housing and rotatable by said rotor assembly in the path of coolant circulation for drawing said coolant through said rotor passage and for impelling said coolant outwardly toward said stator passage, and an axial flow type rotary impeller within the housing and rotatable by said rotor assembly in the path of coolant circulation upstream of said centrifugal impeller for collapsing coolant froth prior to coolant circulation through the major extent of said passages.

10. A liquid cooled electrical machine, comprising means including a housing and rotor and stator assemblies within the housing, said means containing an inlet and an outlet and passages for circulating a coolant received through said inlet along said rotor and stator as-

semblies to discharge from said outlet, said coolant circulation passages including gaps between the rotor and stator and between the stator and housing, other means outside said passages for driving structure operable to froth the coolant prior to circulation thereof through said inlet, and a rotary impeller in the path of said circulation for delivering received coolant to said passages in response to rotor assembly rotation, whereby coolant froth received through said inlet is collapsed by said impeller prior to coolant circulation through said passages.

References Cited in the file of this patent

UNITED STATES PATENTS

1,531,724	Arutunoff	Mar. 31, 1925
2,706,260	Heintz	Apr. 12, 1955
2,735,026	Moerk	Feb. 14, 1956
2,854,594	Philippovic	Sept. 30, 1958

FOREIGN PATENTS

704,030	Germany	Mar. 21, 1941