Dec. 18, 1962 R. L. JAESCHKE 3,069,576

LIQUID COOLED DYNAMO-ELECTRIC MACHINE

Filed April 14, 1958 3 Sheets-Sheet 1

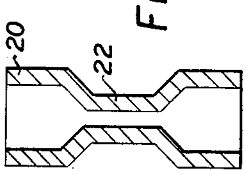


Fig. 6

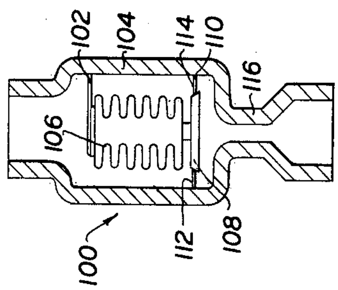


Fig. 7

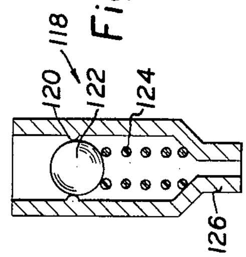


Fig. 8

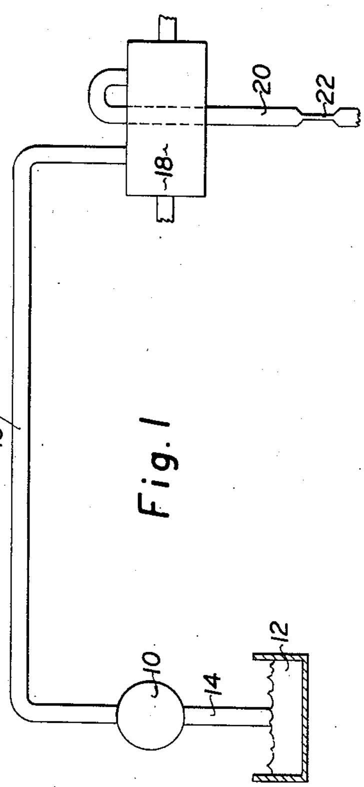


Fig. 1

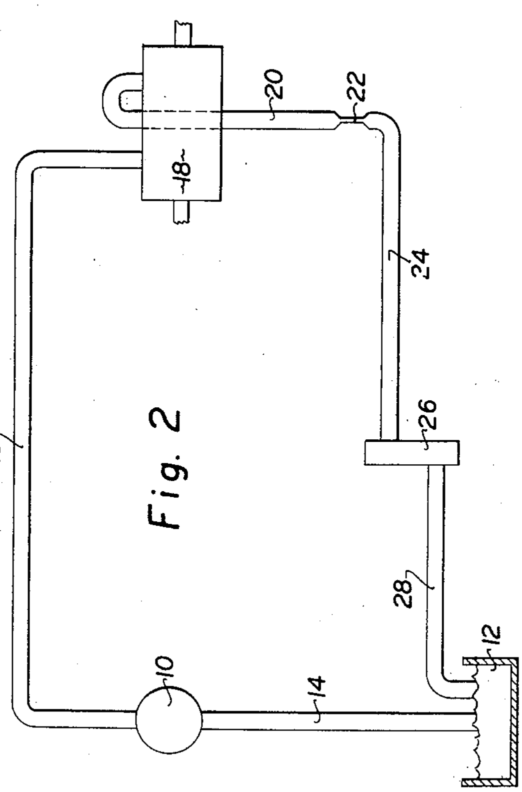


Fig. 2

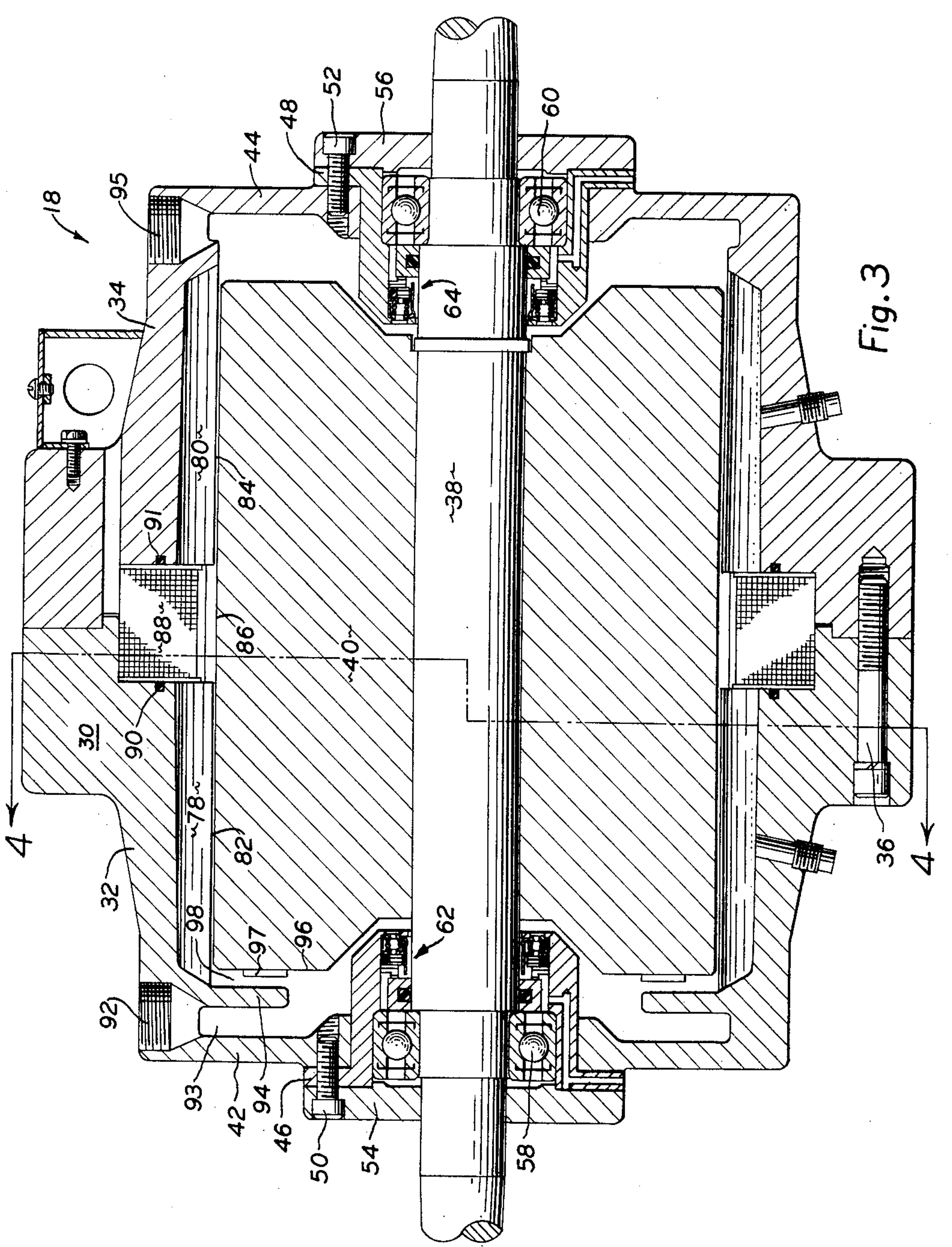
INVENTOR.
RALPH L. JAESCHKE.
BY Teagno & Stover

Dec. 18, 1962 R. L. JAESCHKE 3,069,576

LIQUID COOLED DYNAMO-ELECTRIC MACHINE

Filed April 14, 1958

3 Sheets-Sheet 2



INVENTOR.
RALPH L. JAESCHKE
BY Teagno & Stover

ATTORNEY

Dec. 18, 1962 R. L. JAESCHKE 3,069,576

LIQUID COOLED DYNAMO-ELECTRIC MACHINE

Filed April 14, 1958 3 Sheets-Sheet 3

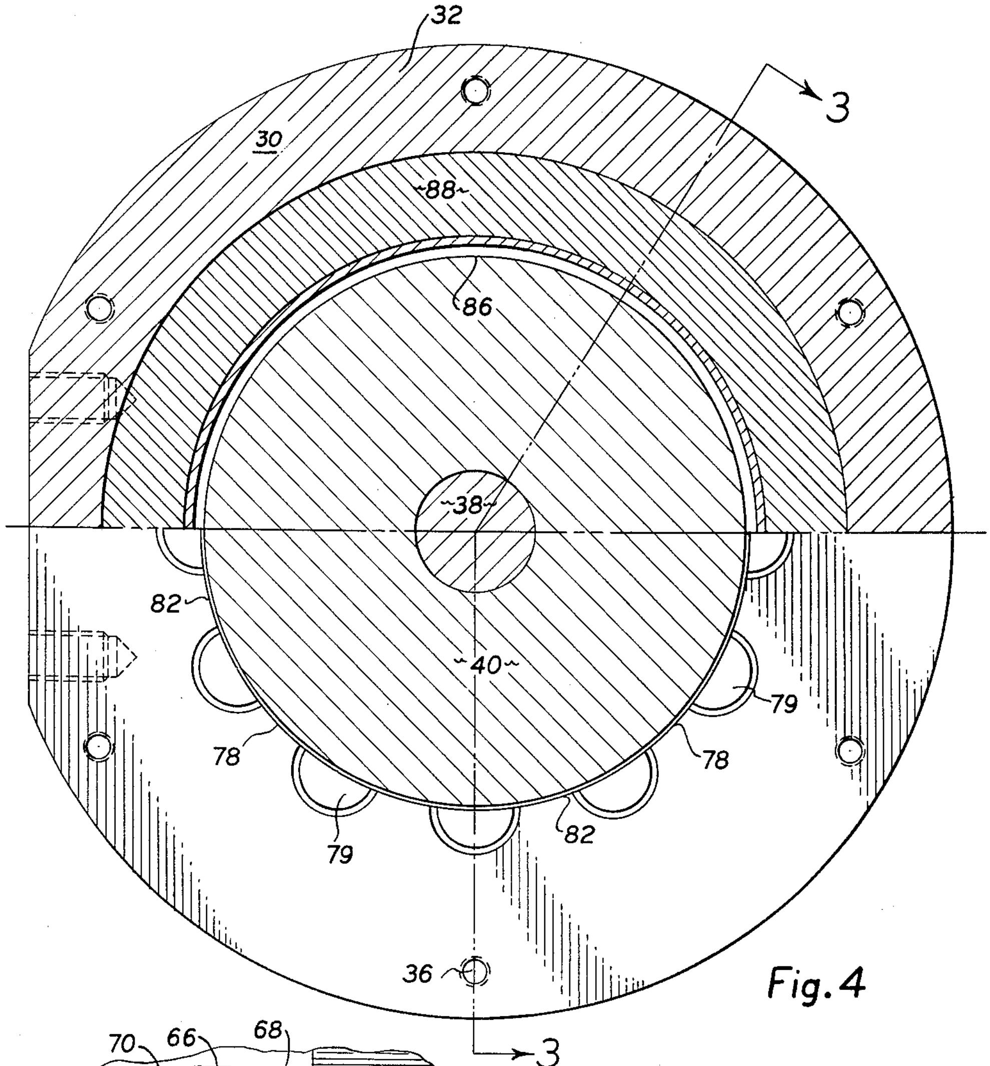


Fig. 4

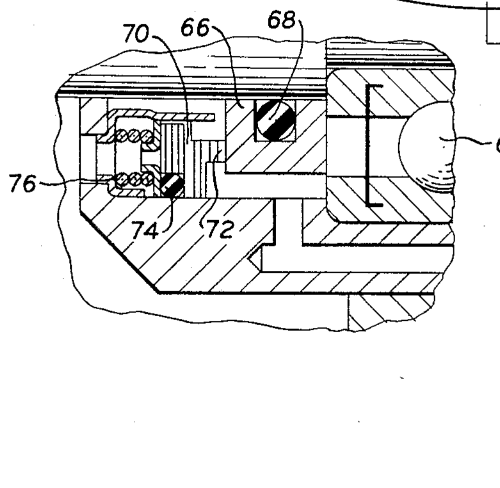


Fig. 5

INVENTOR.
RALPH L. JAESCHKE
BY Teagno & Stover
ATTORNEY

United States Patent Office

3,069,576

Patented Dec. 18, 1962

1

3,069,576
LIQUID COOLED DYNAMO-ELECTRIC MACHINE

Ralph L. Jaeschke, Kenosha, Wis., assignor to Eaton Manufacturing Company, Cleveland, Ohio, a corporation of Ohio

Filed Apr. 14, 1958, Ser. No. 728,441
3 Claims. (Cl. 310—54)

The use of a dynamo-electric machine as a dynamometer or as a retarder has been heretofore known and also the liquid cooling of such machine has been utilized. The devices heretofore known have operated satisfactorily in their function as a dynamometer or as a retarder, but under conditions of sustained operation, the problem of heat dissipation has been burdensome and many attempts have been made to solve the difficulty.

Heretofore, liquid cooled eddy current machines have been cooled by passing cooling water through a jacket, chamber, or through passages surrounding the machine. This type cooling can be generally classified as indirect cooling. Such a method has not been satisfactory due to the lack of rapid heat transfer from the heated surface to the coolant which is circulated in the jacket or passages.

A second method of cooling has been that of spraying or otherwise injecting water or any other suitable liquid directly onto the relatively rotating elements of the machine. Generally, the cooling liquid is passed through the housing at atmospheric pressure and the rapid delivery and discharge of liquid is utilized to carry away the heat energy. Such a method can be classified as a direct method of cooling. This type of cooling also has serious limitations because at normal rotor operating speeds it is very difficult to maintain intimate contact between the cooling liquid and the heated rotor member of the dynamo-electric machine. When the cooling liquid is deposited on the rotor, centrifugal force throws the liquid away from the rotating member back onto the housing and then due to the gravity, the liquid is again deposited on the rotor and thrown away from such member by centrifugal force. This intermittent flow of liquid results in erratic and unsatisfactory cooling. Also, when the machine is used as a dynamometer, cavitation, slugging, and surging of the cooling liquid results in erratic dynamometer readings. To obviate this difficulty, it is necessary to control and direct the flow of coolant so as to obtain constant and stable performance and to devise an arrangement to prevent centrifugal force from propelling the fluid away from the rotor.

This invention is directed to a means for adequately cooling the components of an eddy current machine by subjecting relatively rotatable elements of the machine directly to cooling liquid under pressure so that intimate and continuous contact will be maintained between the cooling liquid and the relatively rotating members of the machine. This is accomplished by passing cooling liquid under pressure through the machine and through a suitable restriction in the cooling liquid discharge line or at the discharge side of the machine, to effect a back pressure of the cooling liquid in the dynamo-electric machine so that the machine housing is completely filled at all times with cooling liquid under suitable pressure. In devices heretofore known of the direct cooling type, intermittent water flow through the machine results in velocity changes of the liquid as it passes from the upper to the lower part of the machine and thus causes a varying hydraulic torque reaction. Pressurizing of the liquid coolant results in laminar distribution of the liquid and therefore, maintains the hydraulic torque reaction at a constant lower level than is attainable with devices heretofore known. Also, by using cooling liquid which is under a pressure head at all times, the boiling point of the liquid is raised an amount which is dependent upon the pressure

2

of the liquid, resulting in increased cooling capacity for a given volume of liquid. For example, using water as a coolant, the maximum allowable temperature of the water is about 160° F. at atmospheric pressure. At 60 p.s.i., the boiling point of water is approximately 300° F. and it is therefore possible to increase the water temperature above that normally used to around 260° F. so that the coolant has over twice the heat absorption capacity as at atmospheric pressure.

A further advantage of the instant structure is not only that a lesser amount of cooling liquid is required for adequate cooling, but since the coolant is maintained in intimate contact with the surfaces of the relatively rotatable elements, the heat rejection ability for a given size machine is greatly increased.

Of course, a lubricating fluid can be used as the liquid coolant which eliminates the need for a separate lubricating system for the machine. In such an application, the cooling liquid performs the dual function of carrying away heat energy and also lubricating the machine.

It is an object of this invention to provide liquid cooling means for a dynamo-electric machine under sufficient fluid pressure to prevent centrifugal force caused by rotation of a smooth rotor of the machine from propelling the liquid away from the rotor.

A further object is to provide cooling means for a dynamo-electric machine which prevents surging, slugging, and intermittent cooling of the components of the machine.

A still further object is to provide a cooling system for a dynamo-electric machine which enables the use of a housing of reduced size to accomplish the same amount of cooling that is derived conventionally.

These and other objects and advantages will become more apparent from the following detailed description of the device and from the accompanying drawings wherein:

FIGURE 1 is a schematic drawing of the invention disclosed herein.

FIGURE 2 is a modification of the structure shown in FIGURE 1.

FIGURE 3 is a view taken on 3—3 of FIGURE 4.

FIGURE 4 is a view taken on 4—4 of FIGURE 3.

FIGURE 5 is an enlarged view of a portion of the structure of FIGURE 3.

FIGURE 6 is a modification of the structure shown in FIGURE 1.

FIGURE 7 is a further modification of the structure shown in FIGURE 1.

FIGURE 8 is a further modification of the structure shown in FIGURE 1.

Briefly, this invention is comprised of a dynamo-electric machine which consists of a housing for the machine, a source of liquid coolant under pressure which is communicable with an inlet passage and a cooling outlet passage in the housing to receive the discharge of cooling liquid from the housing. The machine disclosed in the drawing is of the eddy current type and is comprised of a smooth surfaced armature member and a plurality of armature encompassing pole members which are comprised of permanent magnets or of magnetic material adapted to be energized by energizable electro-magnetic coil means.

In some structural applications, it is necessary to provide fluid pumping means rotatable with the armature member in order to build up a higher back pressure and aid in pumping the cooling liquid through the system. The housing is pressure sealed so that the liquid coolant can escape from the housing only through the discharge outlet. A suitable restricting means such as an orifice or a pressure or temperature responsive valve means is arranged in the outlet line or in the discharge portion of the dynamo-electric machine so that the cooling liquid in the machine is at all times under pressure even though the temperature or pressure responsive valve means is in a wide open position.

Referring to the drawing for a more detailed description of the device, FIGURE 1 illustrates a schematic showing of the cooling system for a dynamo-electric machine comprising a pump **10** supplied with reservoir fluid from a suitable source **12** by conduit means **14** and an output conduit **16** connected from the output side of the pump to an inlet conduit of a dynamo-electric machine **18**. A conduit **20** is connected to the liquid outlet of the eddy current machine and a suitable back pressuring means **22** is series related to the discharge line **20**.

In this adptation, the cooling liquid which has passed through the machine is discharged to waste or can be used for any other suitable industrial purpose.

FIGURE 2 illustrates a modification of the system shown in FIGURE 1 with the cooling liquid being conducted from the backpressureing means **22** by conduit **24** to a cooling radiator **26**. After passing through the cooling radiator, a conduit **28** conducts the liquid back to reservoir **12**.

FIGURES 3 and 4 illustrate the details of the dynamo-electric machine **18** illustrated in FIGURES 1 and 2. The machine illustrated is of the eddy current type and is composed of a housing **30** having two semi-annular portions **32** and **34** which are connected together by bolts or other suitable connecting means **36**. A shaft **38** is rotatably disposed within housing **30** and is connected for rotation with a rotor or an armature member **40** which is also disposed within housing **30**. End wall portions **42** and **44** of housing **30** are provided with central annular openings having bearing support hubs **46** and **48** fixed therein by bolt means **50** and **52**, respectively. Bearing positioning plates **54** and **56** are also connected to the housing end walls by bolts **50** and **52** and are positioned in axially abutting relationship with bearing support hubs **46** and **48**, respectively. A pair of axially spaced ball bearings **58** and **60** are supported by bearing support hubs **46** and **48**, respectively, and are disposed to rotatably support armature shaft **38**.

High pressure seals **62** and **64** are positioned axially inward of bearings **58** and **60** and function to prevent loss of fluid which is used to cool the machine.

Referring to FIGURE 5, seals **62** and **64** are each comprised of a seal ring **66** have a static O-ring seal **68** disposed therein. A follower **70** is provided with a seal lip **72** which serves as a running seal between follower **70** and seal ring **66**. A static O-ring seal **74** is interposed between follower **70** and the bearing support hub and a plurality of annularly disposed coil springs **76** are provided to maintain contact between the follower **70** and seal ring **66**. This seal structure prevents leakage of fluid around shaft **38** and out of housing **30**.

Disposed within housing **30** are a plurality of annularly disposed, axially spaced magnetic pole teeth **78** and **80** having voids **79** therebetween and are formed integral with or suitably connected to housing portions **32** and **34** in a circumferentially spaced pattern. The arcuate end faces **82** and **84** of pole teeth **78** and **80**, respectively, are radially spaced from lateral surface portion **86** of armature **40** and thereby forming an annular air gap between armature **40** and pole teeth **78** and **80**. An energizable electromagnetic coil **88** is disposed axially between pole teeth **78** and **80** and is radially spaced with respect to lateral surface portion **86** of armature **40**. A suitable resin coating is provided to seal and separate the coil from the cooling system and a pair of static O-ring seals **90** and **91** are provided to prevent leakage of cooling fluid around coil **88** and out of the casing through the abutting surface of housing portions **32** and **34**.

A cooling liquid inlet **92** is provided in housing portion **32** and is in communication with an annular passage **93** defined by housing end wall **42** and an inner flange portion **94**. A cooling liquid outlet **95** is disposed in housing portion **34** adjacent end wall portion **44** and is adapted to transmit cooling liquid from the interior of casing **18** to conduit means **20**, as illustrated in FIGURE 2.

When the novel eddy-current machine disclosed herein is utilized as a retarder to decelerate a moving mass such as a vehicle, a pumping means is provided to additionally increase the pressure of the cooling fluid and increase the rate of flow thus insuring sustained contact between the cooling liquid and the surfaces to be cooled and also to raise the thermal capacity of the liquid. An end surface **96** of rotor **40** has provided thereon a plurality of circumferentially spaced, radially directed pumping elements **97** projecting into an annular passage **98** defined by end surface **96** of rotor **40** and inner flange portion **94** which is disposed radially adjacent to and axially spaced from pumping elements **97**. This additional pressure raising means is provided to avoid cavitation by insuring that the pressure of the cooling liquid will exceed the centrifugal force caused by armature rotation and tending to throw the fluid outwardly.

When the eddy current device is in operation, cooling liquid is introduced through inlet **92** and passes inwardly through annular passage **93** and is pumped through pumping elements **97** into passage **98** and then passes longitudinally through the air gap formed between lateral surface **86** of rotor **40** and arcuate end faces **82** and **84** of pole teeth **78** and **80**, respectively, and voids **79** formed between the pole teeth.

It is to be understood that pumping elements **97** are provided generally only in applications where centrifugal force would be great enough to throw the cooling liquid away from the armature if separate pumping means was not provided. This type of pump must be carefully distinguished from a pumping means which is formed by surface interruptions in the annular lateral surface of the rotating member, such as pole teeth formations, etc., because in such objectionable arrangements, the pumping effected by the lateral surface interruptions on the rotor actually causes the fluid to be thrown outwardly due to centrifugal force and it is not practical, and sometimes impossible, to raise the pressure sufficiently by a downstream restriction or other suitable means, to prevent cavitation caused by the resulting outward movement of the fluid. In the instant arrangement, the lateral, annular surface **86** of armature **40** is smooth and without surface interruptions thus contributing an absolute minimum to any tendency of outward movement of the fluid and therefore, prevents cavitation.

In addition, by having pumping means **97** disposed upstream with respect to armature surface **86**, the pump functions most efficiently in causing intimate contact between the cooling liquid and surface **86** as well as the configurated pole tooth surfaces **79, 82** and **79, 84**, and induces an axial flow of cooling liquid through the air gap and voids **79** instead of an objectionable radial movement of liquid. Also, by providing a smooth surfaced rotor, turbulence and surging is minimized because there are no interrupted surfaces on the rotor member having different characteristics of energy absorption which might tend to cause this undesirable flow condition. It is believed that it is novel to provide a smooth surfaced rotor member which is energized by toothed poles to minimize turbulence, surging, and cavitation. With this arrangement, the dynamo-electric machine is always filled with cooling liquid under pressure and since the rotating member is designed to offer a minimum amount of resistance, that is, a smooth annular surface, the machine is capable of more constant and stable performance. The disposition of pump **97** is also believed to be novel in that the provision of the blades on the lateral end surface of the rotor takes advantage of the radial flow of the fluid caused by centrifugal force as well as other aspects which were heretofore discussed.

FIGURE 6 is an enlarged showing of the discharge restricting means **22** shown in FIGURES 1 and 2. This embodiment provides a simple restriction in the line to insure a back-pressuring of the cooling liquid in the housing of the eddy current machine.

FIGURE 7 illustrates a modification wherein the back-pressure assembly means is utilized in conjunction with a temperature responsive valve means **100** which is adapted to open when the temperature of the cooling liquid in the housing of the eddy current machine is raised above a predetermined value. This structure is comprised of a mounting flange member **102** attached to a wall portion **104** and a sealed temperature responsive bellows **106** fixed thereto. A movable valve member **108** is attached to the end of the bellows remote from the mounting flange member **102** and is adapted to be moved downwardly, as viewed in FIGURE 7. An annular valve seat **110** is also connected to the wall portion **104** and is provided with an annular sealing surface **112** which is adjacent to annular surface **114** of valve member **108**. A line restriction **116** provides for adequate back-pressuring of the cooling liquid in the dynamo-electric machine whenever the valve member **108** is in a partially or fully opened position.

A further modification of this structure is illustrated in FIGURE 8 wherein the back-pressure assembly is utilized in conjunction with a pressure relief means which is adapted to open when the cooling liquid pressure in the dynamo-electric machine becomes excessive. This structure is comprised of a pressure responsive valve **118** having a valve seat **120** and a ball valve member **122** which is resiliently biased against valve seat **120** by a coil spring **124**. When the fluid pressure in the exhaust conduit on the upstream side of ball **122** becomes excessive, ball member **122** is moved away from the seat **102** and relieves the pressure in the conduit. A line restriction **126** provides for adequate back-pressuring of the cooling liquid in the machine whenever valve **118** is fully open.

It is to be understood that the concept involved herein is not based upon any specific back-pressuring means, but is comprised basicaly of a dynamo-electric machine having an armature with a smooth annular surface, pole teeth mounted in a liquid sealed housing and encompassing the armature, cooling liquid communicable with the housing and back-pressuring means to maintain the liquid in the housing under pressure sufficiently high to prevent centrifugal force from throwing the cooling liquid away from the rotor of the machine. It is also to be understood that if the cooling liquid which is utilized is also a satisfactory lubricating means, it might be advisable to provide a basic leak flow through the bearings for lubrication, but the leakage would not be sufficient to prevent adequate back-presuring of the cooling liquid in the housing to perform the cooling function as disclosed herein.

While the present invention has been described in connection with certain specific embodiments, it is to be understood that the foregoing description is merely exemplary and that the concept of this invention is susceptible of numerous other modifications, variations, and applications which will be apparent to persons skilled in the art. The invention is to be limited, therefore, only by the broad scope of the appended claims.

I claim:

1. A dynamo-electric machine comprising an elongated stationary housing portion, end wall portions connected to said elongated portion and forming an enclosure with said elongated portion, a plurality of longitudinally directed circumferentially spaced magnetic poles disposed within and carried by said elongated housing portion, electro-magnetic, energizable coil means carried by said housing portion, a rotatable armature member disposed within said elongated housing portion and arranged to form an annular air gap between said armature member and said magnetic poles, said armature member having a smooth annular surface disposed at a uniform distance from the rotational axis of said armature member and

extending continuously throughout the length of the armature, circumferentially spaced centrifugal pumping elements mounted on an end wall section of said armature, and a flanged housing member extending radially inward between one of said end wall housing portions and said armature end wall section, a liquid coolant passage communicating with said air gap, said passage defined by said flanged member and said armature end wall section, liquid inlet means communicable with said passage and liquid outlet means communicable with said air gap, and liquid flow restricting means communicable with said liquid outlet means whereby cooling liquid within said enclosure is maintained under pressure.

2. A liquid cooled dynamo-electric machine comprising a liquid tight housing, a rotatable cylindrical armature member having a smooth peripheral surface and end wall portions disposed substantially normal to said peripheral surface, a plurality of axially extending magnetic pole elements within said housing and carried thereby, an energizing coil disposed coaxially with said plurality of pole elements, said housing having a stationary annular flanged portion therein and being axially spaced from one of said end wall portions of said armature, pumping elements on said end wall portion of said armature and disposed adjacent said flanged portion of said housing, a liquid passage defined by said flanged portion and said end wall portion, a liquid cooling inlet means communicating with said liquid passage, a liquid cooling outlet means in said housing remote from said inlet means, and flow restricting means cooperating with said outlet means whereby cooling liquid is introduced through said inlet means and sufficient fluid pressure is maintained in said housing by said pumping elements to prevent centrifugal movement of the fluid away from the armature when the armature is rotating.

3. A liquid cooling dynamo-electric machine comprising a fluid tight housing having a cylindrical shaped cavity within said housing, magnetic pole means connected to said housing and defining a peripheral portion of said cavity, a rotor means having a smooth peripheral surface thereon and being disposed in said cavity, centrifugal pumping means mounted on an end wall portion of said rotor, said housing including a stationary inner flange portion disposed axially adjacent said rotor end wall portion and defining therebetween a liquid passage to said cavity, said liquid passage having an inlet and outlet, said pumping means disposed in said liquid passage adjacent said inlet, liquid inlet and outlet means communicable with said housing, fluid flow restricting means communicable with said liquid outlet means whereby cooling liquid is admitted to said housing through said liquid inlet means and is pumped radially outward and moves longitudinally between said magnetic poles and said smooth surface of said rotor and said fluid flow restricting means maintaining said cooling liquid under a fluid pressure sufficient to prevent slugging and surging of said fluid in the housing.

References Cited in the file of this patent

UNITED STATES PATENTS

1,216,242	MacDonald	Feb. 13, 1917
1,761,783	Freiburghouse	June 3, 1930
2,188,398	Bernard	Jan. 30, 1940
2,460,750	Hertel	Feb. 1, 1949
2,462,451	Winther	Feb. 22, 1949
2,568,548	Howard	Sept. 18, 1951
2,749,049	Smith	June 5, 1956
2,814,254	Litzenberg	Nov. 26, 1957
2,864,015	King	Dec. 9, 1958

FOREIGN PATENTS

279,065	Great Britain	Mar. 1, 1928
576,689	Great Britain	Apr. 16, 1946