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HEAT TRANSFER SYSTEM FOR AIRCRAFT DE-ICING
AND ROTATING ELECTRICAL EQUIPMENT COOLING

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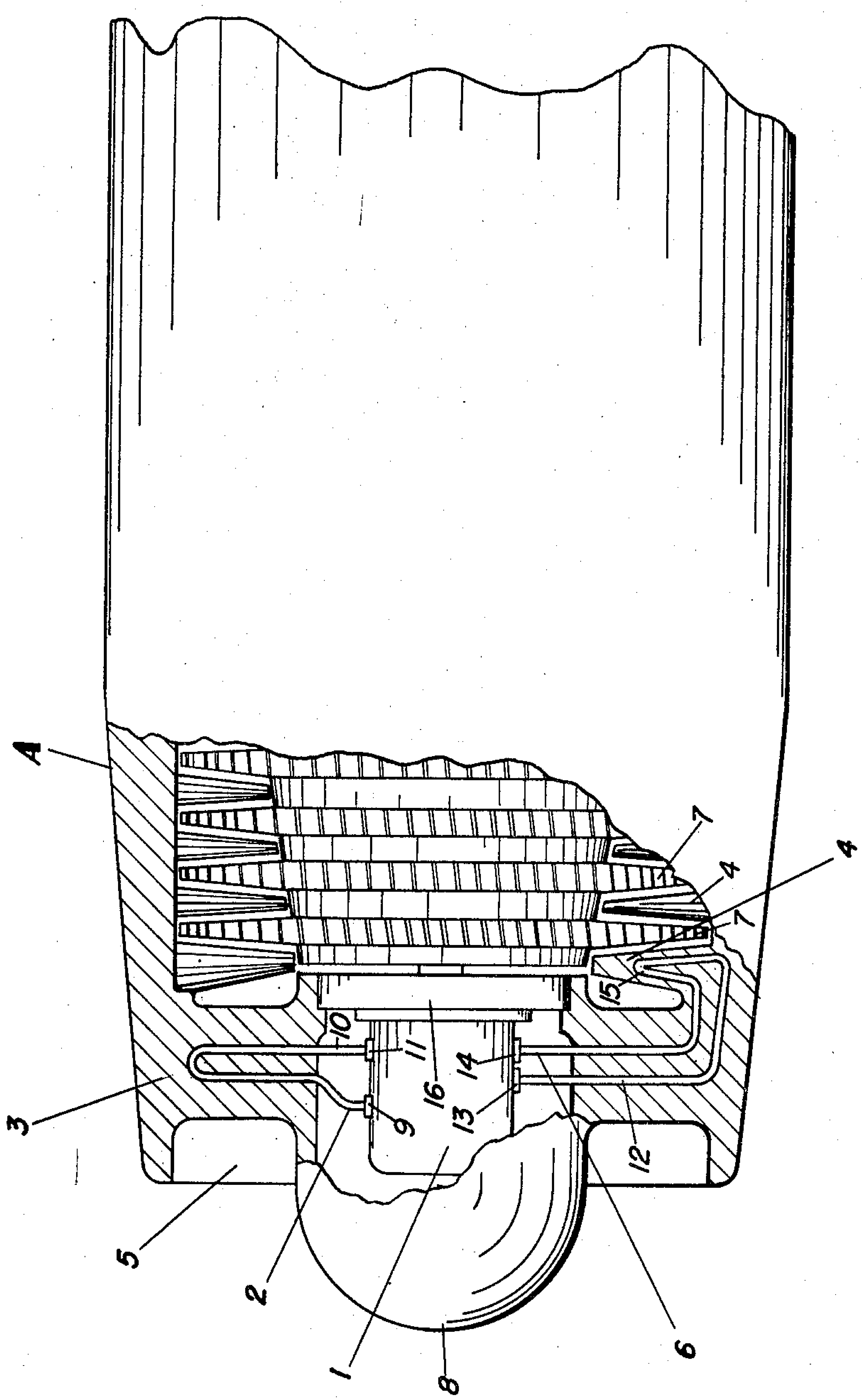

INVENTOR.
CECIL G. MARTIN

BY

Frank H. Harmon
ATTORNEY

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HEAT TRANSFER SYSTEM FOR AIRCRAFT DE-ICING AND ROTATING ELECTRICAL EQUIPMENT COOLING

Cecil G. Martin, Bedford, Ohio, assignor to Jack & Heintz, Inc., Cleveland, Ohio, a corporation of Delaware

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This invention relates in general to heat transfer systems and more particularly to improvements in systems and equipment for cooling aircraft rotating electrical equipment, such as generators, or the like, and also for providing de-icing protection for jet engine inlet guide vanes and the initial compressor stages of the jet engine.

The conventional practice in this art has been to cool such electrical equipment by ducting blast air through the generator, or the like, and then exhausting the heated air emerging from the other end of the generator either overboard or into the engine air intake. Where electrical anti-icing means are utilized, the conventional practice is to send the generator output current through resistance wire heaters into the jet engine inlet guide vanes or initial compressor stator stages, or both. Such a practice has been found to be inefficient, as a de-icing system. The use of liquid as a cooling medium makes for much higher heat transfer coefficients, as compared to air, so as to permit much higher coolant operating temperatures. Moreover, the conventional air blast machine cooling systems impose large drag forces on the aircraft, by reason of the loss of momentum of the cooling air as it is impeded during its circulation through the rotating electrical machine. This often leads to a loss in aircraft carrying capacity far in excess of the weight of the machine being cooled.

One of the primary objects of my invention is to provide a heat transfer system, involving the use of a liquid coolant for a jet engine aircraft rotating electrical accessory machine, with recirculating means located external of the machine for the liquid coolant and in intimate heat exchange contact with the jet engine inlet guide vanes, or the engine initial compressor stages, or both, so as to be cooled thereby in the presence of cooling air flow inlet vane and initial compressor stages of the engine, without this air flow being impeded sufficiently to induce undesired added aircraft drag.

Another object is to so design and construct such liquid coolant recirculating and cooling equipment, with respect to the jet engine inlet guide vane and initial compressor stages, that the heat generated by the losses of the electrical machine, rather than using the electrical output of the machine, is used to provide means for de-icing of the jet engine and its inlet guide vane and initial compressor stages.

With the foregoing and other objects in view, the invention resides in the combination of parts and in the details of construction hereinafter set forth, in the following specification and appended claims, certain embodiments thereof being illustrated in the accompanying drawing, which is a fragmentary view in side elevation of a jet engine, partly broken away to show a rotating electrical machine and external coolant circulating tubing in side elevation and, in section, the inlet air guide vanes and rotors and stators of the initial compressor stages.

Referring more particularly to the drawing, the jet engine, as well as the rotating electrical machine, or the like, which for illustrative purposes, I will refer to as a

generator, and also the combination generator cooling system and jet engine de-icing unit, are generally enclosed in a housing A.

The generator 1 may be suitably supported by a stationary housing member 16 and behind the diffuser dome 8. The jet engine inlet end 5 includes a blast air inlet guide vane 3 surrounding the diffuser dome 8. Behind the blast air inlet guide vane 3 are alternately arranged circumferentially hollow radially inwardly extending stationary vanes 4 and rotary vanes 7 that rotate in unison between the hollow stationary vanes 4 as part of the compressor.

The generator employs a circulating liquid as a coolant. For purposees of cooling and circulating the coolant liquid, I employ external tubing between the generally forward and rear ends of the generator. Instead of ducting the blast air through the generator, I have shown one continuous piece of tubing having an inlet leg 2 secured at 9 to the generator near its front end and an outlet leg 10 secured to the generator at 11 near its outlet end and the major portion of the tubing extending into substantailly the annular depth of the blast air inlet guide vane 3 in the jet engine intake end. The tubing is in intimate heat transfer contact with the blast air inlet guide vane.

Moreover, by way of example, I have also shown another piece of continuous tubing having its inlet leg 12 connected at 13 to the generator, its outlet leg 6 connected at 14 to the generator and its intermediate loop portion extending through the blast air inlet guide vane and into a forward hollow stationary vane of the initial compressor stage, the apex of the loop of the tubing being shown at 15.

It is to be understood that the liquid coolant heated by the generator losses flows out the outlet legs 10 and 6 and back into the generator cooling system through inlet legs 2 and 12. The blast air induced into and through the inlet guide vane and flowing through the initial compressor stages has a marked cooling effect thereon. Inasmuch as the liquid coolant recirculating tubing is in intimate contact therewith, a highly efficient heat transfer system is provided. First, the recirculating liquid coolant is efficiently cooled before reentering the generator through the tubing inlet legs 2 and 12. This is accomplished without the impedance of air flow, and resulting aircraft drag that attends the direction of blast air flow through the generator, itself, for cooling purposes. The circulation of the liquid coolant within the generator may take the form disclosed in the United States Letters Patent to Frank G. Baum, 1,691,696 for Dynamo Cooling System, November 13, 1928.

Secondly, this heat transfer system provides for an efficient means for de-icing the jet engine and its inlet blast air guide vane and initial compressor stages. This effectively supplants the conventional practice of draining the electrical output of the electrical machine to provide heat in these areas through electrical resistance wires for such de-icing purposes and its attending disadvantages.

Thus, it will be seen that I have provided a simple and effective unitary heat transfer system for rotating electric machine cooling and jet engine de-icing. By using a liquid coolant, my system provides a liquid coolant that recirculates through the electrical machine to pick up heat generated by the machine losses. I then send the liquid coolant at high temperatures through the tubing to the inlet guide vane and the stator vanes of the initial compressor stages where the heat is transferred from the coolant to the engine inlet guide vane and initial compressor stages which are cooled by the air when the jet engine is in operation. I obtain higher heat transfer coefficients and much higher coolant operating temperatures, up to 200 degrees Fahrenheit higher, as compared to cooling systems employing air alone. The large heat transfer areas available in the inlet guide vanes and initial compressor stator blades, with which the liquid coolant recirculating tubing is in intimate contact, tend to reduce the effect of high temperature and high altitude on allowable rating of the rotating electrical machine. This makes the generator more environment free than the conventional air cooled type installation.

It is to be understood that any number of pieces of such continuous liquid coolant recirculating tubing for the liquid coolant may be used in the blast air inlet guide vane and also in one or more stator vanes of the compressor stages of the jet engine.

I claim:

1. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane to convey thereto the heat resulting from losses of said machine in operation.

2. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with at least one of said compressor stator vanes to convey thereto the heat losses resulting from losses of said machine in operation.

3. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane and at least one of said compressor stator vanes to convey thereto the heat losses resulting from losses of said machine in operation.

4. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane to convey thereto the heat resulting from losses of said machine in operation for cooling said electrical machine.

5. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane to convey thereto the heat resulting from losses of said machine in operation for providing a deicing effect on said jet engine.

6. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane to convey thereto the heat resulting from losses of said machine in operation for providing a deicing effect on the air inlet guide vane of said jet engine.

7. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with at least one of said compressor stator vanes to convey thereto the heat losses resulting from losses of said machine in operation for cooling said electrical machine.

8. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with at least one of said compressor stator vanes to convey thereto the heat losses resulting from losses of said machine in operation for providing a deicing effect on a compressor stage of said jet engine.

9. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid cooling circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane and at least one of said compressor stator vanes to convey thereto the heat losses resulting from losses of said machine in operation for cooling said electrical machine.

10. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane and at least one of said compressor stator vanes to convey thereto the heat losses resulting from losses of said machine in operation for providing a deicing effect on said jet ingine.

11. In combination with an aircraft jet engine having a housing, a blast air inlet and an air inlet guide vane, a compressor including alternately arranged rotor vanes

and stator vanes, a rotating electrical machine carried by said housing, a liquid coolant circulating system for said machine, a heat transfer system including a conduit in communication with said liquid coolant circulating system for recirculating said liquid coolant from and back into said liquid coolant circulating system in said machine, said conduit being disposed in intimate heat exchange surface contact with said air inlet guide vane and at least one of said compressor stator vanes to convey thereto

the heat losses resulting from losses of said machine in operation for providing a deicing effect on the air inlet guide vane and at least one compressor stage of said jet engine.

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