

PATENT SPECIFICATION

United States Patent Application No. 16/789,432

Title: THERMAL ENERGY RECOVERY SYSTEM FOR POLAR ROBOTS

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ABSTRACT

A thermal energy recovery system for autonomous mobile robots operating in cold environments, comprising a network of thermally conductive pathways integrated within the robot's chassis, coupled with phase-change material (PCM) reservoirs and intelligent thermal management controllers. The system captures and redistributes waste heat from actuators and electronic components to maintain optimal operating temperatures in sub-zero environments while reducing overall energy consumption.

BACKGROUND

[0001] Autonomous mobile robots operating in cold storage environments face significant challenges related to battery performance, mechanical efficiency, and system reliability. Traditional thermal management systems fail to adequately address the unique requirements of robots operating in sustained sub-zero temperatures.

[0002] Existing solutions typically rely on resistive heating elements, which consume substantial power and reduce operational runtime. The present invention provides an innovative approach to thermal energy recovery and redistribution, enabling extended operation in extreme cold environments.

SUMMARY OF THE INVENTION

[0003] The present invention relates to a thermal energy recovery system comprising:

- A network of thermally conductive channels integrated within the robot's structural members
- Phase-change material reservoirs strategically positioned near critical components
- Microprocessor-controlled thermal distribution valves
- Temperature sensors and predictive thermal management algorithms
- Vacuum-insulated thermal storage chambers

[0004] The system captures waste heat generated by motors, actuators, and electronic components during normal operation. This thermal energy is stored in PCM reservoirs and redistributed as needed to maintain optimal operating temperatures for sensitive components.

DETAILED DESCRIPTION

[0005] Thermal Collection Network

The thermal collection network comprises a series of copper-alloy channels (composition: Cu 99.9%, Ag 0.1%) embedded within the robot's aluminum chassis. Channel diameter ranges from 2mm to 8mm, optimized for thermal conductivity and structural integrity.

[0006] Phase-Change Material System

The PCM system utilizes a proprietary salt hydrate compound (Patent No. 15/432,876) with the following characteristics:

- Melting point: $-15^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$
- Latent heat of fusion: 280 kJ/kg
- Thermal conductivity: 0.7 W/m K
- Volume change during phase transition: <5%

[0007] Control System

The thermal management controller employs machine learning algorithms to:

- Predict thermal loads based on mission parameters
- Optimize heat distribution patterns
- Manage PCM charging/discharging cycles
- Monitor component temperatures in real-time

CLAIMS

A thermal energy recovery system for autonomous mobile robots, comprising:

- a) A network of thermally conductive channels integrated within the robot's chassis;
- b) Multiple phase-change material reservoirs;
- c) Electronically controlled thermal distribution valves;
- d) A microprocessor-based thermal management controller.

The system of claim 1, wherein the phase-change material comprises a salt hydrate compound with a melting point between -20 C and -10 C.

The system of claim 1, further comprising machine learning algorithms for predictive thermal load management.

DRAWINGS

[0008] FIG. 1 illustrates the thermal channel network layout.

[0009] FIG. 2 shows the PCM reservoir configuration.

[0010] FIG. 3 depicts the control system architecture.

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Signed this 15th day of March, 2023

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POWER OF ATTORNEY

The undersigned hereby appoints Wilson & Roberts LLP, Registration No. 58,432, as attorney of record with full power of substitution and revocation to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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Date: March 15, 2023