

# PATENT SPECIFICATION

## Polar-Specific Robot Joint Design

Patent Application No. 16/789,432

Filing Date: March 15, 2023

### ABSTRACT

A temperature-resistant robotic joint assembly specifically designed for operation in sub-zero environments, comprising a thermally isolated actuator housing, multi-stage thermal management system, and proprietary lubricant delivery mechanism. The joint design enables consistent performance in temperatures ranging from -40 C to +50 C while maintaining precision movement control and reducing thermal-induced stress on mechanical components.

### BACKGROUND OF THE INVENTION

[0001] Autonomous mobile robots operating in cold storage and freezer environments face significant challenges related to joint functionality, lubricant viscosity, and mechanical stress. Traditional robotic joint designs experience reduced performance and increased failure rates in sub-zero temperatures due to thermal contraction, lubricant solidification, and bearing seizure.

[0002] Existing solutions typically rely on external heating elements or thermal insulation, which increase power consumption and reduce operational efficiency. The present invention addresses these limitations through an integrated approach to thermal management and mechanical design.

### SUMMARY OF THE INVENTION

[0003] The present invention provides a novel robotic joint design specifically engineered for reliable operation in extreme cold environments. Key innovations include:

- A thermally isolated actuator housing utilizing composite materials with low thermal conductivity;
- An active thermal management system incorporating microfluidic channels;
- A pressure-compensated lubrication system maintaining optimal viscosity across the operating temperature range;
- Smart sensor integration for real-time temperature and performance monitoring.

### DETAILED DESCRIPTION

## **Thermal Management System**

[0004] The joint assembly incorporates a multi-layer thermal management system comprising:

- An outer shell constructed from proprietary polymer composite (PDR-200);
- Internal vacuum-sealed chambers providing thermal isolation;
- Microfluidic channels for active temperature control;
- Temperature sensors positioned at critical points within the assembly.

## **Actuator Design**

[0005] The actuator mechanism features:

- Brushless DC motor with specialized windings for cold operation;
- Ceramic bearings with modified race geometry;
- Carbon fiber reinforced housing with integrated heating elements;
- Custom-designed gear reduction system with thermal compensation.

## **Lubrication System**

[0006] The invention utilizes a novel lubrication approach including:

- Pressure-compensated reservoir maintaining consistent lubricant delivery;
- Temperature-adaptive viscosity control;
- Self-cleaning filtration system;
- Redundant distribution pathways.

## **CLAIMS**

A cold-environment robotic joint assembly comprising:

- a) A thermally isolated actuator housing;
- b) An integrated thermal management system;
- c) A pressure-compensated lubrication system;
- d) Temperature monitoring and control mechanisms.

The assembly of claim 1, wherein the thermal management system includes:

- a) Vacuum-sealed chambers;

- b) Microfluidic cooling channels;
- c) Active temperature control elements.

The assembly of claim 1, wherein the lubrication system comprises:

- a) A pressure-compensated reservoir;
- b) Temperature-adaptive viscosity control;
- c) Multiple distribution pathways.

## **DRAWINGS**

[Figure descriptions and references omitted for brevity]

## **INVENTORS**

Dr. Elena Frost

Marcus Chen

Dr. James Barrett

## **ASSIGNEE**

Polar Dynamics Robotics, Inc.

1200 Arctic Way

Dover, Delaware 19901

## **ATTORNEY OF RECORD**

Katherine Marshall (Reg. No. 65,432)

Marshall & Associates IP Law

100 Technology Drive, Suite 400

Boston, MA 02110

## **CERTIFICATION**

I hereby certify that this patent application accurately describes the invention and that all statements made herein are true and correct to the best of my knowledge.

/s/ Katherine Marshall

Registration No. 65,432

Date: March 15, 2023

[Additional claims and technical specifications available upon request]