LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-740344

Development of Rotational Accelerometers Final Report CRADA No. TSB-2008-99

S. Hunter, R. Crosson

October 20, 2017

Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Development of Rotational Accelerometers

Project Accomplishments Summary
CRADA No. TSB-2008-99
Date Technical Work Ended: March 31, 2002

Date: October 30, 2002 Revision: 1

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and The Fredericks Company.

The Regents of The University of California
Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550
Steve Hunter, L-208
Technical Contact
Telephone: (925) 423-2219
Fax: (925) 422-3925

The Fredericks Company
2400 Philmont Avenue
HuntingdonValley, PA 19006
Ray Crosson
Technical Contact
Telephone: (215) 938-4454
Fax: (215) 947-7464

B. Project Scope

One of the difficulties in fabricating an inexpensive angular rate or rotation sensor is producing a device that is insensitive to acceleration, including the constant acceleration of gravity. The majority of rate sensors are either tuning fork type devices sensing a relatively weak force (i.e., Coriolis effect) and thus not very sensitive, or gyroscopes (either rotating or fiber optic based) that are large, consume lots of power and are expensive.

This project was a collaborative effort between LLNL and The Fredericks Company to develop a rotational sensor as a standardized, commercial product. The Fredericks Company possessed expertise and capabilities in the technical aspects of manufacturing this type of sensor, and they were interested in collaborating with LLNL to manufacture the rotational rate sensors as a commercial product.

The Fredericks Company already manufactured tilt sensors, so they would be able to quickly develop rotational sensors based on similar principles. Potential commercial applications for the rotational rate sensor include robotics, control systems feedback, oil well tools, automotive for steering wheel motion, and video game input.

C. Technical Accomplishments

Our goal was to successfully transfer technology developed at LLNL to The Fredericks Company so the company could develop a rotational sensor as a standardized, commercial product.

There were seven tasks in this project:

1. Fluid dynamics analysis: Month 1 (LLNL)
2. Preliminary technical discussions with LLNL/The Fredericks Company: Month 1
3. Electric field analysis: Months 2-5 (LLNL)
4. Ionic Flow analysis: Months 2-5 (LLNL)
5. Integration and technology transfer to Partner: Months 1-3 (LLNL/The Fredericks Company)
6. Initial prototype/testing: Month 6 (The Fredericks Company)
7. Drafting Final Report: Month 6 (LLNL/The Fredericks Company)

This project was completed, with only some success as noted above. While the prototype sensor was sensitive to rotation, it was even more sensitive to temperature changes. Uneven heating of the sensor caused convection currents in the sensor fluid that greatly exceeded the rotation signal. The heat of a person's hand approaching the sensor would cause a large change in the circuit's output.

Several different electronic circuit techniques were used to try to improve the sensitivity of the sensor and reduce the temperature effect. These techniques included RMS averaging, synchronous demodulation, and lock-in amplifiers.

While a redesign of the sensor might reduce some of the temperature sensitivity, it was felt that it would not be possible to achieve the original goals of a highly sensitive and inexpensive sensor.

D. Expected Economic Impact

An inexpensive rotation sensor would be an enabling technology for both governmental and consumer applications.

E. Benefits to DOE

LLNL was investigating reentry vehicle flight dynamics and developing sensor systems to measure performance of our warheads in the stockpile. High performance, small, lightweight 3-axis rate of rotation sensors are needed for instrumented flight-tests for weapons certification (DOE DP10) and on-going stockpile surveillance (DOE DP20).

F. Industry Area

Potential commercial applications for the rotational rate sensor include robotics, control systems feedback, oil well tools, automotive for steering wheel motion, and video game input.

G. Project Status

This project was completed on March 31, 2002, with only some success as noted above.

H. LLNL Point of Contact for Project Information

The Regents of The University of California
Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550
Steve Hunter, L-530
Technical Contact
Telephone: (925) 423-2219
Fax: (925) 422-3925

I. Company Size and Point(s) of Contact

The Fredericks Company is a small business. Annual sales are less than $15 million, and the company employs less than 150 people.

The Fredericks Company
2400 Philmont Avenue
Huntingdon Valley, PA 19006
Francis Kull, Technical Contact
Telephone: (215) 938-4432
Fax: (215) 947-7464

J. Project Examples

A prototype sensor was manufactured by the CRADA partner and tested by LLNL.

K. Subject Inventions

This small value contractual mechanism did not anticipate any generation of Intellectual Property (IP) including subject inventions. The LLNL contributors and the company participants both indicate that no new intellectual property was generated.

Documents/Reference List

No documents were generated.

Reports

No documents were generated.

Patent/Copyright Activity

Prior to the start of the CRADA, a patent was applied for by LLNL in order to secure its intellectual property rights. Patent number 6,382,025 was granted May 7, 2002. There was no intellectual property generated by the CRADA.

Generated Information

There was no disclosure of the information.

Background Intellectual Property

U.S. Patent No. 6,382,025 (LLNL Docket IL-10534) - *Rotational Rate Sensor*, issued 5/7/2002; Inventors: Steven L. Hunter

There will be no licensing of intellectual property since the project was not successful.

L. Release of Information

I certify that all information contained in this report is accurate and releasable to the best of my knowledge.

3/24/03

Karena McKinley, Director
Industrial Partnerships and Commercialization

Date

3/5/03

Steven Hunter, Engineer
Electrical Engineering Department
LLNL Principal Investigator

Date

Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.

2/25/2003

Francis Kull
The Fredericks Company

Date