Non-driven Micromechanical Gyroscopes and Their Applications

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国防工業出版社
National Defense Industry Press

Springer

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ISBN 978-3-662-54043-5 ISBN 978-3-662-54045-9 (eBook)
https://doi.org/10.1007/978-3-662-54045-9

Jointly published with National Defense Industry Press

The print edition is not for sale in China Mainland. Customers from China Mainland please order the print book from: National Defense Industry Press.

Library of Congress Control Number: 2017955248

Printed on acid-free paper

This Springer imprint is published by the registered company Springer-Verlag GmbH, DE part of Springer Nature
The registered company address is: Heidelberger Platz 3, 14197 Berlin, Germany

Preface

According to their working principle, gyroscopes can be divided into either electromechanical gyroscopes or optical gyroscopes. Electromechanical gyroscopes include the ball bearing gyroscope, the liquid floated gyroscope, the flexible gyroscope, the electrostatic gyroscope, the piezoelectric gyroscope, the airstream gyroscope and the micromechanical gyroscope, while optical gyroscopes include the laser gyroscope and the optical fiber gyroscope. At present the laser gyroscope and the optical fiber gyroscope have seen the fastest development.

Electromechanical gyroscopes can be also be divided into two type according to their structure, namely driven gyroscopes and non-driven gyroscopes. The former have been successively developed and put into use in developed countries such as the United States, Japan and in China, while the latter has fewer patent and reports at home and abroad. Non-driven micromechanical gyroscope appears such that the gyroscope is expanded from a kind of driven structure to two kinds of the driven structure and the non-driven structure.

A non-driven micromechanical gyroscope has a simple structure, low cost and high reliability. Its biggest advantage is that it can perceive the transverse angular velocity and the rolling angular velocity of the rotating flight carrier simultaneously, that is, it has the function of two driven micromechanical gyroscopes, which greatly reduces cost. Over the last ten years, the non-driven micromechanical gyroscope has been successfully developed and used for rotating carriers in China. A total of 29 invention patents has been licensed relating to the non-driven micromechanical gyroscope in China, Britain, France, Germany and America. It has won one first prizes and five second prizes on the Provincial Technological Invention Awards, 149 papers have been published in domestic and foreign academic journals and at academic conferences. This book describes this gyroscope and its application in detail.

During the writing of this book, Wang Jiaguang of China Aerospace Science and Technology Corporation carefully reviewed the revised book and Prof. Li Yaozong provided the translation of the foreign sources in Part 1. My doctoral candidates, namely Yan Qingwen, Wang Hongwei, Mao Xu, Wu Lifeng, Liu Yu, Zhao Hui, Zhang Zengping and Wang Ling, and my postgraduates, namely Zhang Nan, Xu

Xiaosong, Sun Chengxiang, Xu Hongzhuo, Liu Hailin, Wen Jiangchuan, Ye Qing, Yue Guannan, bright, Jiang Shiyu, Wang Ling, Zhao Qifeng, Lin Xia, Qin Shengjie and Yu Xiaolong talk, Dan Yanfeng, Guo Heng, Wan Pinjun, Meng Dong, happy, Ma section, Gao Yinjuan, Zhang Ning, Liu, Yuan Min, Xu Hongwei, Qiao Li and Zhao Haixiao, have participated in the development of non-driven micromechanical gyroscopes and their applications or the proofreading of the manuscript and the fruits of their labor are included in this book. I would like to express my deep gratitude to them.

Many technical problems relating to non-driven micromechanical gyroscopes and their applications still need to be addressed and solved. If there are some defective descriptions, I hope the readers of this book do not hesitate to offer their valuable advice.

Beijing, China
October 2013

Fuxue Zhang
Wei Zhang

About the Book

This book comprehensively and systematically introduces the theories, structures, performances and applications of non-driven mechanical gyroscopes and non-driven micromechanical gyroscopes.

This book comprises three parts. The first part includes four chapters and mainly discusses mathematic models, precision, performance and the operating error of non-driven mechanical gyroscopes. The second part includes five chapters covering operating theory, error, phase shift and performance tests of non-driven micromechanical gyroscopes in rotating flight carriers. The third part includes two sections and mainly focuses on the applications of non-driven micromechanical gyroscopes in the control system of a rotating flight carrier.

This book can be used by the scientific and technological personnel in development department working on the use of inertial devices and automatic control systems of rotating flight carriers, and can also be used as a teaching reference book for bachelors, graduate students and teachers of related majors in colleges and universities.

Contents

Author's Introduction

Zhang Fuxue, born in 1939, Xuanwei City of Yunnan province. A piezoelectric and sensing technology expert, Professor, Ph.D. supervisor, Beijing Information Science and Technology University.

In 1960s, he invented the piezoelectric ceramic with the high mechanical quality factors and high mechanical and electrical coupling coefficients before the inventions of the United States and Japan. In 1970s, by using the aforementioned ceramic piezoelectric gyroscope, in China he firstly achieved the assumption of solidified inertial device through the new theory and the new technology proposed by Tsien Hsueshen. In 1980s, he found the "gas pendulum" phenomenon, proposed the new concept of "gas pendulum", and established the gas pendulum theory, which formed a new subject branch of the inertial technology—the gas pendulum inertia technology. Based on this theory, he invented 1-D, 2-D and omnibearing level posture sensor than those of the United States similar as early as three years. In 1990s, because there is no constant temperature environment in the use of the weapon's accelerometer and level posture sensor, the standard period is twelve years, and the error of the standard scale factor is less than 1/1000, he invented the piezoelectric accelerometer and the level posture sensor. In the early twenty-first Century, he found the gyroscope effect of silicon pendulum, invented the carrier-driven gyroscope, and pioneered a new field of the carrier-driven gyroscope.

He won the second prize of state technological invention twice, the third prize of state technological invention twice, the second prize of national scientific and technological progress once, and the first prize and the second prize of the province and the minister 25 times; He won 50 invention patents (including 18 patents of the United States, Britain, France and Germany). His inventions were widely used in missiles, ships and robots, and his research results and academic thoughts have important guiding significance for the development of the technology of the piezoelectric and inertial technology in China. He published 25 books, where "the piezoelectricity", "the robot technology and its applications", and "the modern piezoelectric" were awarded the second prize of national outstanding science and technology books in 1988, the second prize of Chinese Book Award in 2002 and the second prize of the electronic information science and technology in 2008. He was awarded the "National advanced science and technology worker" and "the national labor model".