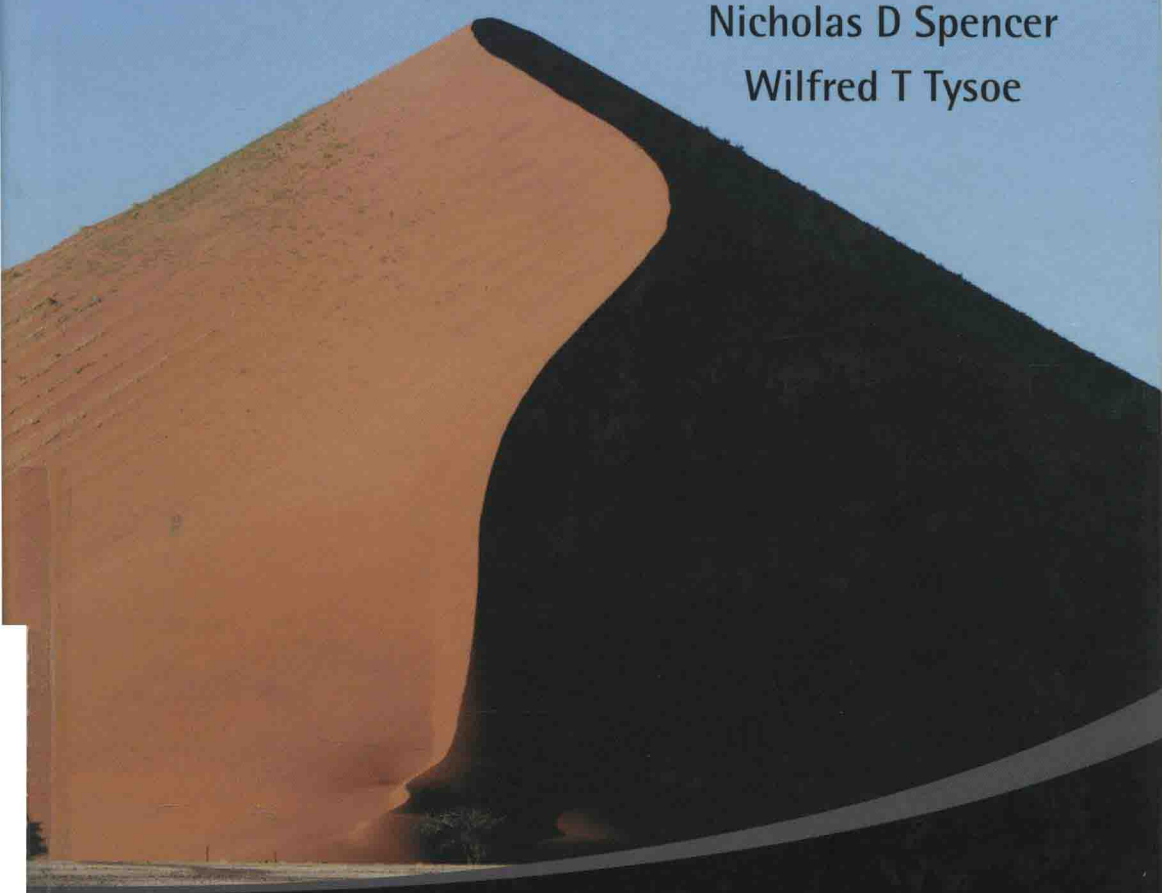
THE CUTTING EDGE OF TRIBOLOGY

A Decade of Progress in Friction, Lubrication, and Wear

Nicholas D Spencer
Wilfred T Tysoe



World Scientific

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NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.
5 Toh Tuck Link, Singapore 596224
USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601
UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

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ISBN 978-981-4656-55-9
ISBN 978-981-4663-23-6 (pbk)

In-house Editor: Rhaimie Wahap

Typeset by Stallion Press
Email: enquiries@stallionpress.com

Printed in Singapore

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Dedication

We dedicate this book to practicing tribologists worldwide.

Preface

In 2003, the Society of Tribologists and Lubrication Engineers was planning to update their image by changing the format and title of their society magazine, then called Lubrication Engineering. The aim was to capture the breadth of the society and the new magazine, launched in late 2003, was entitled Tribology and Lubrication Technology (TLT). A decade earlier, we had taken the step, at the behest of Gabor Somorjai, to launch a new journal in the area of tribology, named Tribology Letters, based on the successful format of Catalysis Letters, launched some years earlier by Somorjai and John Thomas. The aim of Tribology Letters was to be a leader in the area of tribological science, rather than having the engineering emphasis that characterized most tribology journals at that time. After a brief visit to Berkeley to visit Gabor Somorjai, to pick up hints on how to launch a journal, we officially launched Tribology Letters in mid-1995. We realized that it would be helpful to counterbalance our emphasis on tribological science by having a sister journal that emphasized the more engineering aspects of tribology, such as Tribology Transactions. We therefore entered into successful negotiations with STLE for Tribology Letters to become part of their official journal family. Consequently, it was rather natural that STLE contacted us when they were thinking about creating a new column in TLT that would keep their readers abreast of new developments in tribology. We agreed that we would jointly write a bimonthly column. While we have tried to include articles on the most exciting aspects of tribology that came to our attention, there has been an inevitable bias towards articles that have appeared in Tribology Letters.

Neither of us thought that we would be able to keep writing articles for very long — the challenge of writing to a deadline is completely different from scientific writing, where publication is only considered when the data have been obtained, analyzed, and hopefully understood. But we were wrong, and are still cheerfully turning out columns in our second decade. Another challenge was to come up with a name and, after some discussion we settled on (perhaps the rather corny) Cutting Edge. This set the stage for our future titles, which, were often a play on old jokes (Karma Runs Over Dogma), an attempt at new ones (Alcohol Gets You no Wear) or, at the very least, alliterative (The Continuing Contact Conundrum).

When the 10th anniversary of the Cutting Edge arrived, and with the 20th anniversary of Tribology Letters on the horizon, we approached World Scientific to see if they would be interested in putting together this anthology of past articles as part of TLT's anniversary celebrations, and they kindly agreed.

In 2013 we found ourselves at a number of the same conferences, in various parts of the world. This was a good opportunity to start to assemble this collection. Discussing how to do this on a balcony in Sardinia, we found that the subjects we had chosen over the years for the various articles fell quite naturally into distinct categories, which now form the basis for each chapter. These include our musings on Biotribology, Friction Fundamentals, Hard-Drive Lubrication, New Materials and Methods, Opinions and People, The Contact Conundrum, Tribochemistry and Weird and Wonderful Effects.

We would like to thank Karl Phipps and Tom Astrene at STLE for working with us on the production of these columns and now and then tolerating our missed deadlines, and we hope that you enjoy browsing through the last decades of our thoughts on what is exciting about our field. Many of these columns were written at the weekends, and therefore we also acknowledge the patience of our wives, Cristina Tysoe and Jennifer Davidson, over the last ten years. Finally, we would like to thank Josephine Baer for her great help during the preparation of the manuscript.

Nic Spencer, Zollikon, Switzerland
Eddy Tysoe, Milwaukee, USA

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Topic 1

Opinions and People

Sometimes we have taken the opportunity to express opinions on topics we consider significant for our field. These have ranged from reports on workshops or conferences that we viewed as important, developments in tribology that could have an impact on the way people do or report research, or our current views on the state of the field.

Our "op-ed" pieces over the last decade included our initial column on the nature of tribological science (*Laws of Past Slowly Foster Today's Technology,* October, 2003), the proposed introduction of a new unit for wear, the *Bowden* (*Some Wear or no Wear*, December, 2005), the National Science Foundation's workshop on Grand Challenges in Tribology (*Frontiers of Tribological Research*, June, 2005), and reports on two important international meetings on tribology fundamentals: the Trends in Nanotribology conference in Trieste, Italy in 2010 (*The Fundamentals of Friction*, December 2010) and the first Faraday Meeting on Tribology, held in Southampton, UK, in 2012 (*Advancing our Understanding,* August 2012).

As editors-in-chief of Tribology Letters, we have also highlighted new aspects of our journal, such as the inclusion of a new type of article, aimed at establishing "best practices" in experimental tribological research (*Doing it Right*, April 2009), and our focus issue on the way in which experiment and theory can now be combined into collaborative research, to the benefit of a deeper understanding of tribological phenomena (*Experiment and Theory — Rubbing Along Together*, June 2013).

We have also felt the need to pay homage to great tribologists, upon their passing. Over the history of our column, these have included David

Tabor (*Remembering David Tabor*, August, 2006), Mike Gardos (*Tribute to the late, great Mike Gardos*, June, 2004), and our combined tribute to Sanjay Biswas and Brian Briscoe (*2013 Sees the Passing of Two Eminent Tribologists*, February, 2014). All of these influential scientists were also editorial board members of Tribology Letters.

Laws of Past Slowly Foster Today's Technology

Developments in the late 17th Century laid the basis for what we understand as tribology today

The title of this column, "Cutting Edge," was chosen with a very definite purpose. Every other month we'll bring you news about the most recent advances in tribology research and discuss how they are relevant to you. For our inaugural issue, however, we've chosen to look backward for a moment and cast the spotlight on two scientific giants. For as all scientists know, the roads we travel in the future were built, stone by stone, in the past.

The latter half of the 17th Century was a remarkable period in the development of our modern view of the scientific method. It was also the time when two momentous works dealing with the motion of bodies were published. In 1687 Isaac Newton published *Philosofiæ Naturalis Principia Mathematica* ("The Mathematical Principles of Natural Philosophy"). The treatise examined the motion of non-contacting bodies. In 1699 Guillaume Amontons, following the work of Leonardo Da Vinci, published a paper in Paris in *Memoires de l'Académie des Sciences* entitled *De la Resistance Causéedans les Machines* ("On the Resistance Caused in Machines").

That paper established Amontons' First Law, which states that frictional force is proportional to the normal force between the bodies in contact. The ratio between the two is the friction coefficient, and Amontons believed this to be a universal constant with a value of 0.3.

Although initially propounded at almost the same time, the subsequent evolution of these laws has been completely different.

Sir Isaac Newton, 1643–1727.

Under most conditions, Newton's laws have proven remarkably precise, enabling us to project objects with great accuracy, including from the earth to the moon. Einstein's modifications to Newton's classical theory at velocities approaching the speed of light resulted in the theory of relativity. Applied to microscopic particles, where the very act of measuring them has to be incorporated into the theory, the modifications resulted in the development of quantum mechanics, which provided the theoretical basis for a vast array of modern technologies.