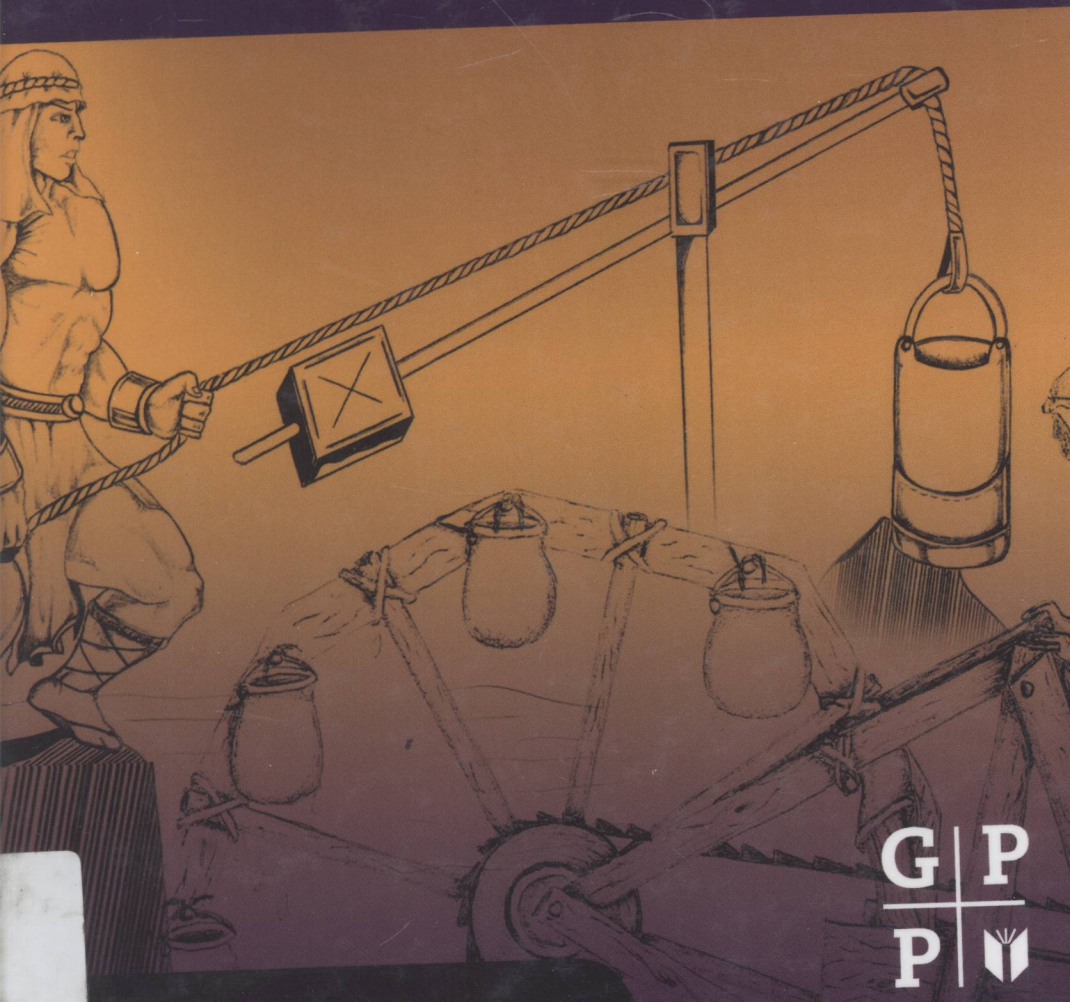
High-Pressure Pumps



High-Pressure Pumps

First Edition

Includes experience and research to help engineers, scientists and end users understand the technical side of pumps and systems for high-pressure applications.

Michael T. Gracey, P.E.
Weatherford International
Houston, TX

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Gulf Professional Publishing is an imprint of Elsevier

Gulf Professional Publishing is an imprint of Elsevier
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
Linacre House, Jordan Hill, Oxford OX2 8DP, UK

Library of Congress Cataloging-in-Publication Data
Application Submitted

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

ISBN 13: 978-0-7506-7900-8
ISBN 10: 0-7506-7900-X

For information on all Gulf Professional Publishing publications visit our Web site at www.books.elsevier.com

06 07 08 09 10 11 10 9 8 7 6 5 4 3 2 1

Printed in the United States of America

Preface

This book is to document the development of high-pressure pumps and systems technology that is being used in almost every industrial endeavor. High-pressure pumps and ultra-high pressure equipment is being used for hydrostatic testing, erosion testing, surface preparations, cutting material, machining metals and cleaning surfaces. The new technology is used in the aerospace industry, petrochemical-related fields, steel mills, automotive plants and food processing. It has been found effective to reduce the cost and improve results over other methods of accomplishing a given task. The experiences and research discussed herein will help engineers, scientists, and end users to understand the technical side of pumps, nozzles, accessories and power pump systems that have been developed for special applications. With this background, more uses can be found for the technology so that the pump industry can continue to grow in the future.

Michael T. Gracey

Acknowledgments

The high-pressure pump industry as a whole and each of us individually would not be where we are today if not for the ones who came before us. My very job depends on a man named C.J "Cobe" Coberly, who started working with pumps over 90 years ago. Men like R.G. LeTourneau, who said, "I'm just a mechanic that God used," inspired me to enter engineering by his example of what can be achieved by one individual. Original ideas are rare—we learn from those around us and teach what we have learned to others. Chapter 1 is the acknowledgment of people who helped make the high-pressure pump industry what it is today. They left a legacy of innovative design, good engineering practices, and integrity to inspire us. Further acknowledgment is given to those people who have contributed to the subject at the end of each chapter. Thanks to Oscar Hernandez and especially to Emil Levek for many of the CAD drawings used in the book.

Michael T. Gracey

For by Him were all things created, that are in heaven, and that are in earth, visible and invisible, whether they be thrones, or dominions, or principalities, or powers: all things were created by Him, and for Him. Colossians 1:16

About the Author

Mike Gracey was born in Port Arthur, TX, in 1942, and grew up around the oil refineries & chemical plants in that area. His early fascination with mechanisms like engines and transmissions led him to pursue an engineering education in order to understand "how things work." After studying at LeTourneau College in Longview, TX, he attended night school at Lamar University in Beaumont, TX, while working as an apprentice pipefitter in a shipyard, where he eventually moved into the engineering department. After returning to full-time studies, he worked as a licensed tankerman in the Port Arthur and Beaumont areas until graduating in 1971. By 1973, he was working at the National Maritime Research Center (NMRC) in Galveston, TX, and became involved in testing specialized equipment and methods for water-blast cleaning, surface preparation, and coatings. This led him to the more specialized area of high-pressure pumps used for water jetting. Starting in 1976, he designed and built systems for high-pressure pump manufacturers and packagers in Texas, Maryland, and Michigan. Currently, he works for Weatherford International, Inc., using Kobe's line of industrial pumps to handle chemicals, water, oil products, hot fluids, and cryogenics. He has published over 40 articles and technical papers.

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Chapter 1

History of High-Pressure Pumps

1.0 Introduction to High-Pressure Pumps

A reciprocating pump can be defined as a mechanical device that consists of one or more single- or double-acting positive-displacement elements (pistons or plungers) that imparts a pulsating dynamic flow to a liquid. This definition also explains that the pistons or plungers are driven in a more or less harmonic motion by a rotating crank with a connecting rod arrangement. This motion generates flow by pulling the fluid through inlet check valves and pushes the fluid through outlet check valves that are located near the inlet and outlet of the pump.

An alternative definition describes pumps as devices for exerting pressure on fluids for transportation or {through them to transmit pressure to a more or less remote point where it is transformed into work.} For positive-displacement, high-pressure, and piston or plunger pumps, it could be said that they create flow (not pressure) until the flow is restricted, which, in turn, causes the pressure to increase in the fluid.

1.1 Early History of Pumps

Since the beginning of civilization, there has been a need to move water from one place to another. Cupped hands have given way to clay vessels, wooden buckets, and aqueducts to provide water to remote locations.

The earliest mechanical device of authentic record for lifting water was called the *shadoff*. The Egyptians used this device as early as 1500 BC for watering their herds and irrigating farmland, which is depicted in Fig. 1.1.

The shadoff consists of a counterweighted, pivoted pole with a rope and bucket that the operator uses to his advantage to draw water from a water source, such as the Nile River. This type of device was used on *The Amazing Race* (CBS, August 14, 2004), when the contestants had to draw water from the Nile and fill a one liter jar, then ride a donkey across the fields to a village where they filled a two liter clay pot. It took the contestants at least two trips to accomplish the task. The Chinese may have made the next improvement to this system by attaching buckets at intervals to a loop of rope over a windlass that could be turned by hand or treadmill. This device, the *Chinese continuous bucket rope*, is depicted in Fig. 1.2 and enabled the villagers to move water from a river into the rice fields for irrigation.

Around the beginning of the Christian Era, the Romans extended the rotary principle by creating the *Roman bucket wheel.* Buckets were attached to a large wheel that would spin and dip each bucket into the water. The wheel then lifted the buckets and dumped the water into aqueducts, as illustrated in Fig. 1.3.

1.2 The Force Pump

A Greek engineer named Ctesibius is believed to be the inventor of the *force pump*. This pump had two vertical cylinders mounted side by side with single-acting pistons. A walking beam actuated these pistons so the pumps provided a practically continuous stream. Today, Weatherford International manufactures the Ram Pump to handle multiphase oil products, and it is powered by hydraulic cylinders, as shown in Fig. 1.4.

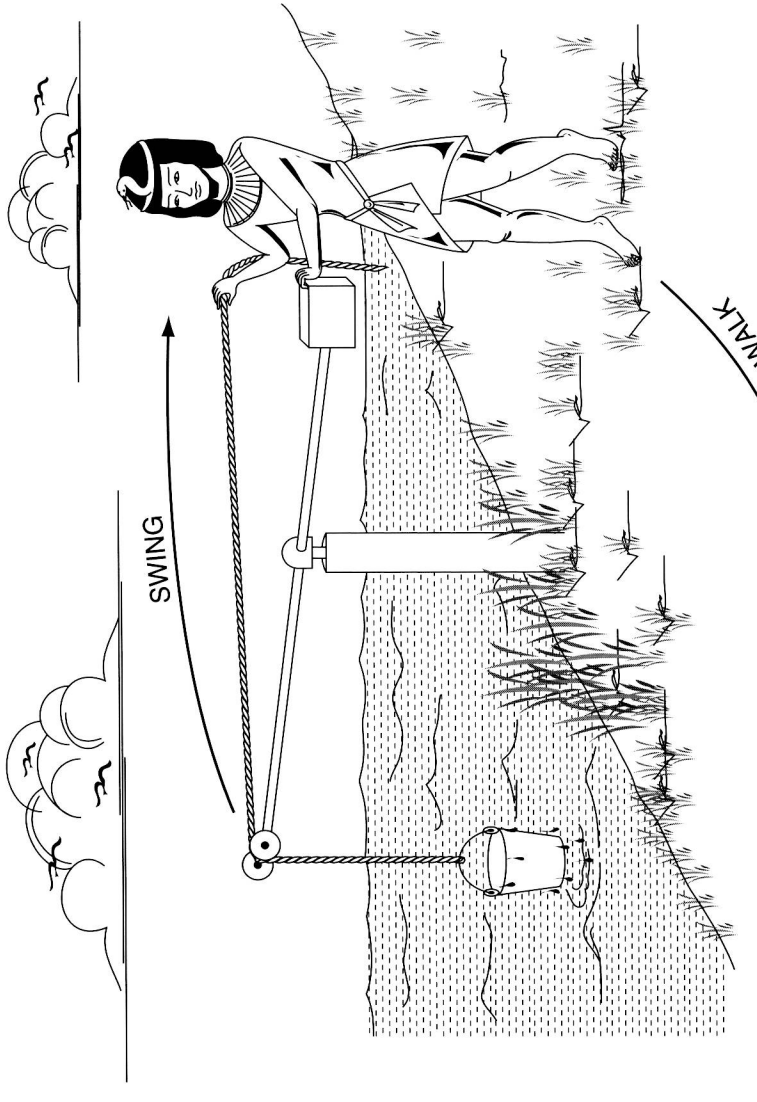

Figure 1.1. Shadoff used to lift water by Egyptians circa 1500 BC

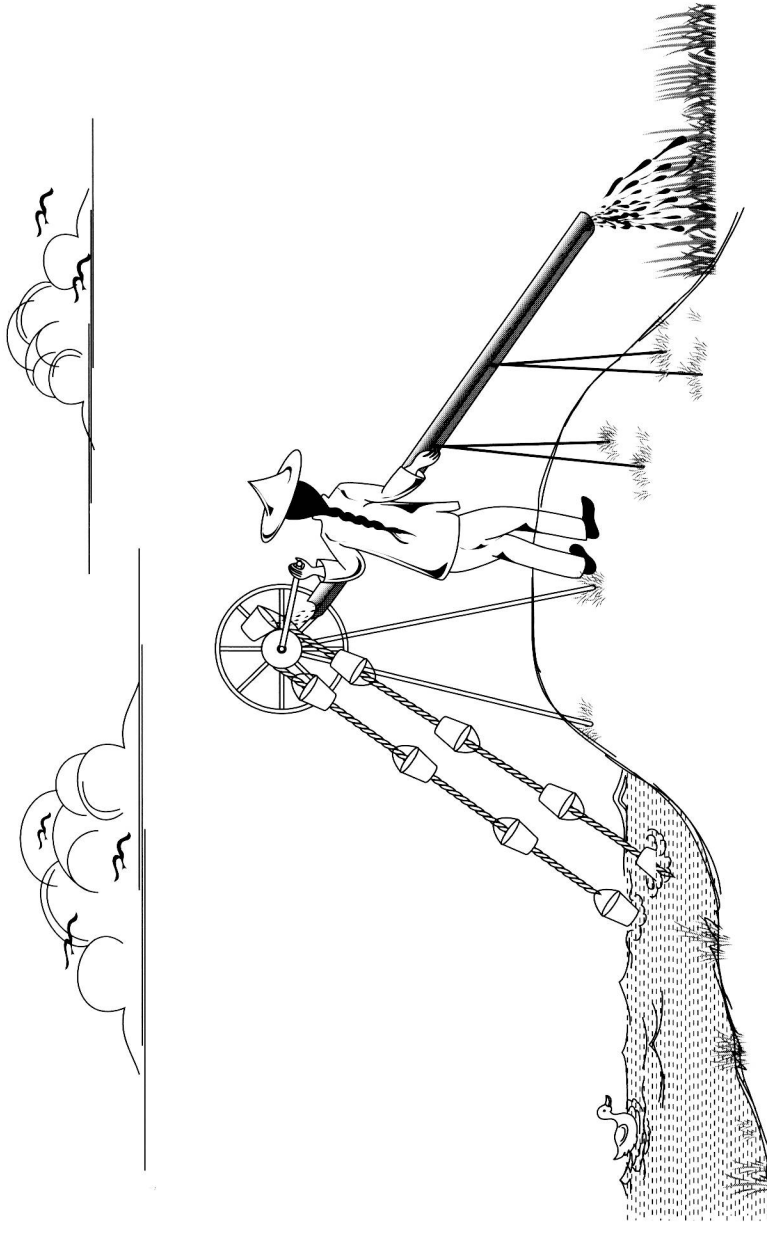

Figure 1.2. Continuous bucket rope used by the Chinese to irrigate rice fields

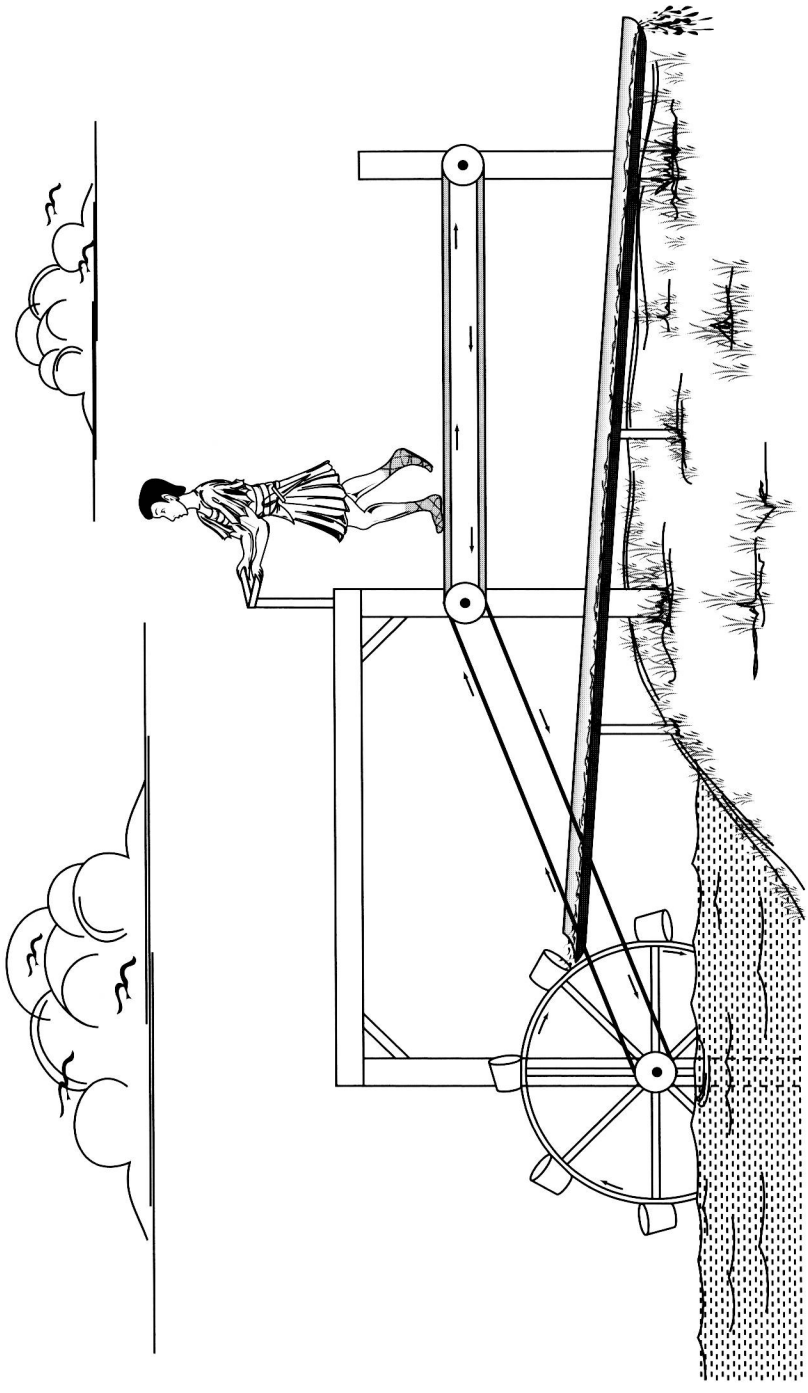

Figure 1.3. Bucket wheel used by the Romans about the start of the Christian era