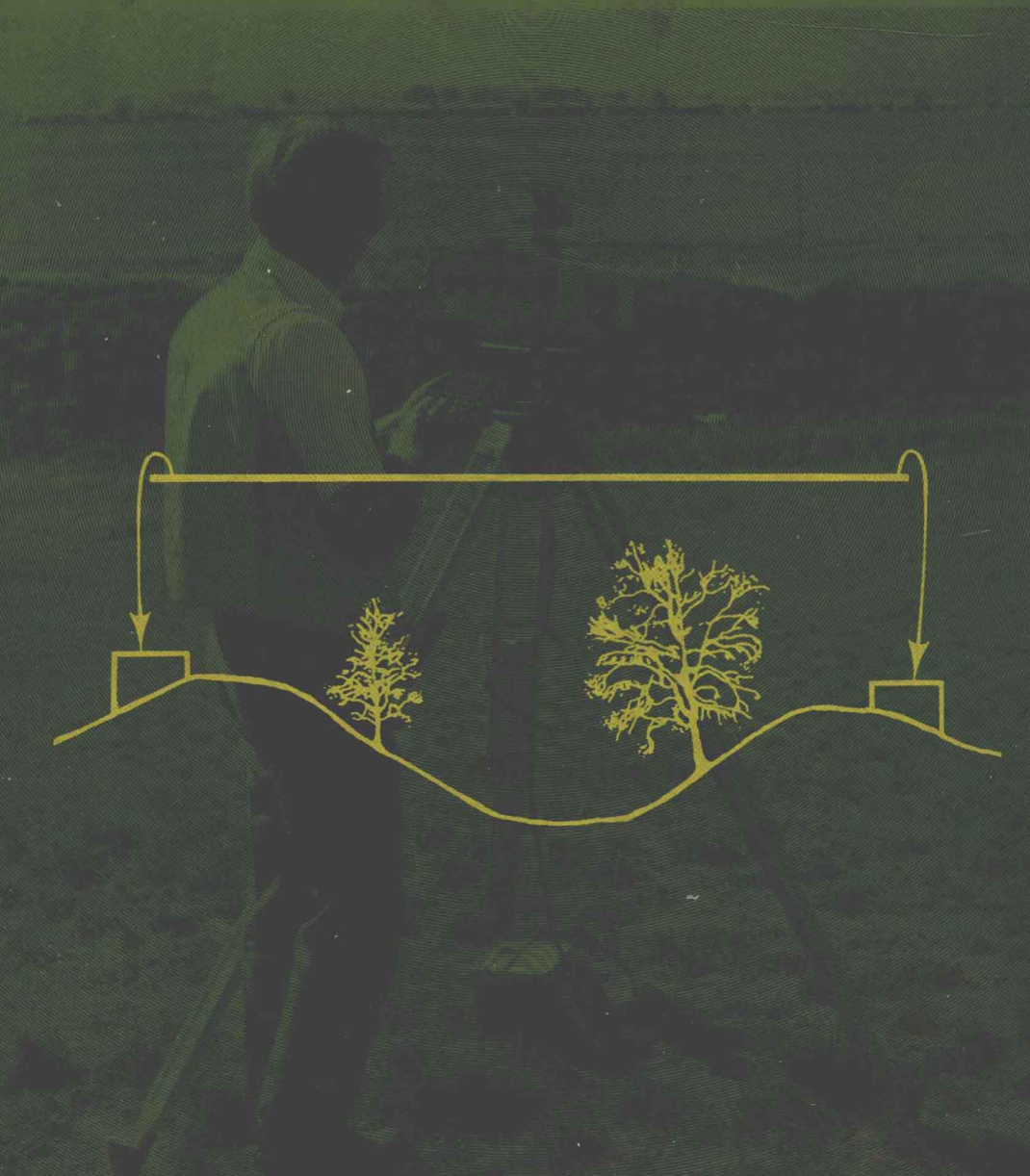
SURVEYING

Jack C. McCormac



SURVEYING

JACK C. McCORMAC

Department of Civil Engineering
Clemson University, South Carolina

PRENTICE-HALL, INC. Englewood Cliffs, New Jersey

Library of Congress Cataloging in Publication Data

McCORMAC, JACK C
Surveying.

Includes bibliographical references.
1. Surveying. I. Title.
TA545.M17 526.9 75-6711
ISBN 0-13-879064-7

10 9 8 7 6 5

Printed in the United States of America

PRENTICE-HALL INTERNATIONAL, INC., *London*
PRENTICE-HALL OF AUSTRALIA, PTY. LTD., *Sydney*
PRENTICE-HALL OF CANADA, LTD., *Toronto*
PRENTICE-HALL OF INDIA PRIVATE LIMITED, *New Delhi*
PRENTICE-HALL OF JAPAN, INC., *Tokyo*
PRENTICE-HALL OF SOUTHEAST ASIA (PTE.) LTD., *Singapore*

SURVEYING

Distance meter shown in operation on construction site.
(Courtesy Hewlett-Packard)

PREFACE

The purpose of this book is to serve as an introduction to surveying and to present the elementary principles in such a manner as to interest the student in the subject.

In Chapters 1-12, the measurements of distances, elevations, and directions are discussed; while Chapters 13-19 are devoted to the application of these measurements to the determination of land area, the preparation of topographic maps, construction surveys, horizontal and vertical curves, the practice of land surveying, computers and programmed desk calculators, electronic distance measurement, and professional ethics.

The author hopes the reader will enjoy surveying as much as those in the profession.

Clemson, South Carolina JACK C. McCORMAC

ACKNOWLEDGMENTS

The author gratefully acknowledges the aid he has received from several sources. He is indebted to Jerome L. Spurr, Frank J. Hatfield, Ben Benson, and Michael Orlandella, who have by their suggestions and criticisms directly contributed to the preparation of this manuscript, and to his own surveying professor, the late Colonel John Anderson, who patiently instructed him in his surveying class. He is further grateful to his associates, who have helped in his study of surveying. These include J.P. Rostron, I.A. Trively, and the late J.M. Ford, Jr. Finally, thanks are due Mrs. Janice Ruelle who helped type the manuscript.

CONTENTS

1

INTRODUCTION

1-1
FAMOUS SURVEYORS

Many famous men in our history have engaged in surveying at some period in their lives. Particularly notable among these are several presidents–Washington, Jefferson, and Lincoln. Although the practice of surveying will not provide a sure road to the White House, many members of the profession like to think that the characteristics of the surveyor (honesty, perseverance, self-reliance, and so on) contributed to the development of these great men. Surveying is an honored profession respected by all and a knowledge of its principles and ethics is useful to a person whatever his future endeavors may be.

1-2
EARLY HISTORY OF SURVEYING

It is impossible to determine when surveying was first used, but in its simplest form it is surely as old as recorded civilization. As long as there has been property ownership there have been means of measuring the property or distinguishing one person's land from another. Even in the *Old Testament* there are frequent references to property ownership, property corners, and property transfer. For instance, Proverbs 23:28: "Remove not the ancient

landmark, which thy fathers have set." The Babylonians surely practiced some type of surveying as early as 2500 BC because archaeologists have found Babylonian maps on tablets of that estimated age.

The early development of surveying cannot be separated from the development of astronomy, astrology, or mathematics because they were so interrelated. In fact, the term *geometry* is derived from Greek words meaning earth measurements. The Greek historian Herodotus ("the father of history") says that surveying was used in Egypt as early as 1400 BC when that country was divided into plots for taxation purposes. Apparently geometry or surveying was particularly necessary in the Nile valley in order to establish and control landmarks. When the yearly floods of the Nile swept away many of the landmarks, surveyors were appointed to replace them. These surveyors were called "rope-stretchers" because they used ropes (with markers on them at certain intervals) for their measurements.

During this same period surveyors were certainly needed for assistance in the design and construction of irrigation systems, huge pyramids, public buildings, and so on. For instance, the dimensions used for the Egyptian pyramids were quite good. It is thought that the rope-stretchers layed off the sides of the pyramid bases with their ropes and checked squareness by measuring diagonals. In order to obtain the almost level foundations of these great structures, the Egyptians probably either poured water into long narrow clay troughs (an excellent method) or used triangular frames with suspended plumb lines as shown in Fig. 1-1.[1]

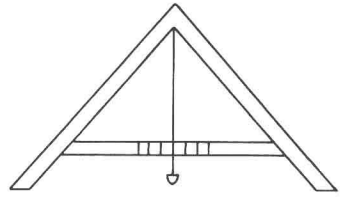


FIGURE 1-1.

The practical-minded Romans produced many advances in surveying by establishing an amazing series of engineering projects throughout their empire. They layed out projects such as cities, military camps, and roads by using a system of rectangular coordinates. They surveyed the principal routes used for military operations on the European continent, in the British Isles, in northern Africa, and even in parts of Asia.

[1] A. R. Legault, H. M. McMaster, and R. R. Marlette, *Surveying* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1956), p. 5.

Two instruments used by the Romans were the *odometer*, or measuring wheel, and the *groma*. The groma, from which Roman surveyors received their name of *gromatici*, was used for laying off right angles. It consisted of two crossarms fastened together at right angles in the shape of a horizontal cross with plumb lines hanging from each of the four ends. The groma which was pivoted eccentrically on a vertical staff could be leveled and sights taken along its crossarms.

From Roman times until the last few centuries there were few advances in the art of surveying, but these latter centuries have seen the introduction of the telescope, the vernier, the transit, and many other excellent devices. These developments will be mentioned in subsequent chapters. For a detailed historical list of instrument development, the reader is referred to "The Civil Engineer: His Origins."[2]

1-3 SURVEYING DEFINED

Surveying is the science of determining the dimensions and contour (or three-dimensional characteristics) of the earth's surface by the measurements of distances, directions, and elevations. It also includes staking out the lines and grades needed for the construction of buildings, roads, dams, etc. In addition to these field measurements, the computation of areas, volumes, and other quantities, as well as the preparation of necessary maps and diagrams, is involved. Surveying has many industrial applications, for example, setting equipment, assembling aircraft, laying out assembly lines, and so on.

1-4 PLANE SURVEYS

Plane surveys are made on such small areas that the effect of the earth's curvature may be neglected. The great majority of surveys are of this type and it can be shown that they are sufficiently accurate for all but the largest areas. Surveys for farms, subdivisions, buildings, highways, railroads, and in fact most of the works of man are plane surveys.

It can be shown that an arc along the earth's curved surface of 11.5 mi length is only approximately 0.05 ft longer than a plane or chord distance between its ends. Plane surveys, however, are not generally considered to be sufficiently accurate for establishing state and national boundaries and they are used in combination with surveys taking into account the earth's curvature in subdividing the public lands of the United States.

[2] *Transactions of the American Society of Civil Engineering*, 30 (1893), 91–106.