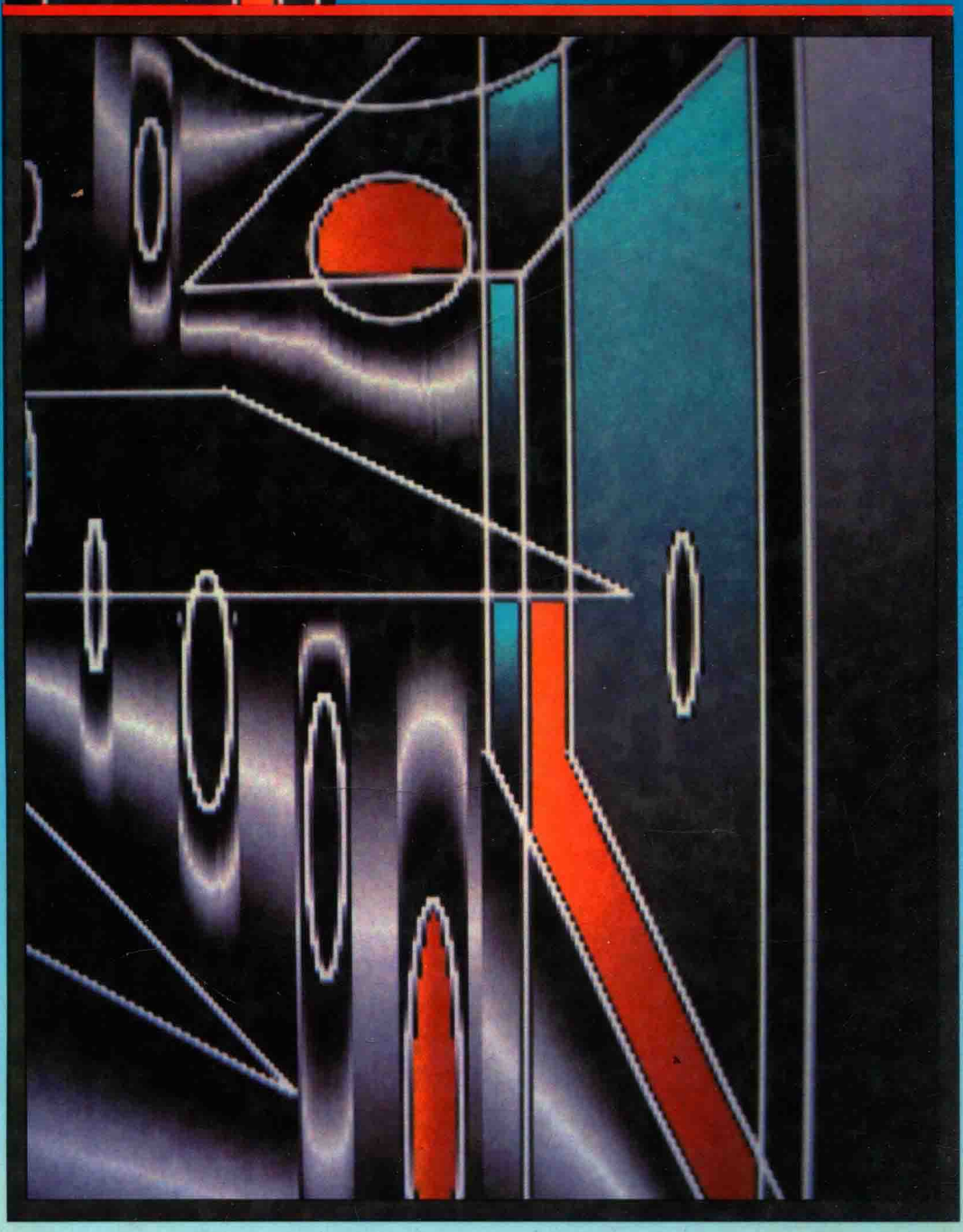
PROCESS CONTROL INSTRUMENTATION TECHNOLOGY

THIRD EDITION



CURTIS D. JOHNSON

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THIRD EDITION

Curtis D. Johnson
University of Houston

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PROCESS CONTROL INSTRUMENTATION TECHNOLOGY

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PREFACE

The advancement of both knowledge and technique has resulted in the development of specialists in process control. Today, it is possible to delineate process-control activities into three categories, each with specific requirements with regard to training. The process-control system engineer is concerned with the design of an overall process-control system that will provide the regulation specified by the manufacturing process experts. This activity requires a good theoretical understanding of stability, mode characteristics, and general process-control loop dynamic characteristics. The process-control technologist or applied engineer is responsible for the design of specific elements required to implement the overall design specified for the system. This involves a good, design-level understanding of the measurement, electronic, and pneumatic features inherent in process-control loops. The process-control technician or mechanic is responsible for the final assembly and testing of the elements of the process-control loop and the system as a whole. This requires a good working knowledge of the electronics, pneumatics, and mechanical features of process-control loop installations.

This book was developed primarily to fulfill the instructional needs of the last two categories, that is, the applied process engineer, technologist, and advanced technician. Many fine textbooks exist that cover the stability and design criteria of process-control systems, usually involving the use of Laplace transform methods. Often these books do not cover the system elements per se, such as measurement methods, signal conditioning, and final control elements. Indeed, there has been a serious lack of texts that cover process-control elements with less than the mathematical rigor of Laplace transforms and yet enough math to allow the design of loop elements to satisfy specifications. This volume has been prepared to fill this need. Its overall objective is to provide instructional material for a general understanding of process-control characteristics such as elements, modes, and stability along with detailed knowledge of measurement technique, control mode implementation, and final control element functions. In keeping with modern trends, the digital aspect of process-control technology is stressed.

The student background is assumed to consist of that acquired by an advanced sophomore in a two-year engineering/technology program or a junior in a four-year program. Consequently, a basic knowledge of physics and analog and digital electronics is assumed along with math through college algebra, although some knowledge of calculus would be beneficial.

It is quite remarkable how the technology of process control has evolved in a scant ten years since the first edition of this text. It will be of no surprise to anyone working in this field that most of the changes have to do with

computers. Consequently, most of the changes in this book have to do with computers and digital processing.

In recognition of the growing application, a new chapter on programmable controllers has been added. Actually it is a chapter on the control of discrete-state processing systems, but that is usually done by programmable controllers. Although I only touched on it in this book, the programmable controller is even taking over control of continuous processes, for example, using PID.

Chapters 3 and (now) 11 have to do with digital signal processing and computer-based control. Many changes have been made to these chapters in an attempt to make them more current with new practice.

I wish to thank the users of the book for the many excellent suggestions forwarded for consideration in this edition. I could not use them all, but I took them all into account. A special thanks to Helene J. Blake for being patient, understanding, helpful, and a great inspiration to me in all aspects of my life.

Curtis D. Johnson

CONTENTS

CHAPTER 1

INTRODUCTION TO PROCESS CONTROL

INSTRUCTIONAL OBJECTIVES

This chapter will consider the overall process-control loop, its function, and its description. After you read it, you should be able to

1. **Draw a block diagram of a process control loop with a description of each element.**
2. **List three typical dynamic variables.**
3. **Describe three criteria used to evaluate the response of a process-control loop.**
4. **Define analog signal processing.**
5. **Describe the two types of digital process control.**
6. **Define accuracy, hysteresis, and sensitivity.**
7. **List the SI units of measure for length, time, mass, and electric current.**
8. **Convert a physical quantity from SI to English units and vice versa.**
9. **Define the types of measurement time response.**

1.1 INTRODUCTION

To study the elements of process control effectively, it is necessary to have an overall understanding of process-control principles. With such an understanding, how particular elements affect the overall control problem can be fully described. This chapter provides a general introduction to process control with an emphasis on industrial applications. An equally important facet of the chapter is the definition of common terms and units of measure that are a necessary part of any study of the subject.

The elements of a complex system are much easier to understand if the operation of the whole system is considered first. Obviously, it would be quite frustrating to study all the elements of an automobile without first noting that the result would be a transportation vehicle with certain characteristics. In keeping with this idea, this chapter discusses the overall process-control loop, its function, and its description.