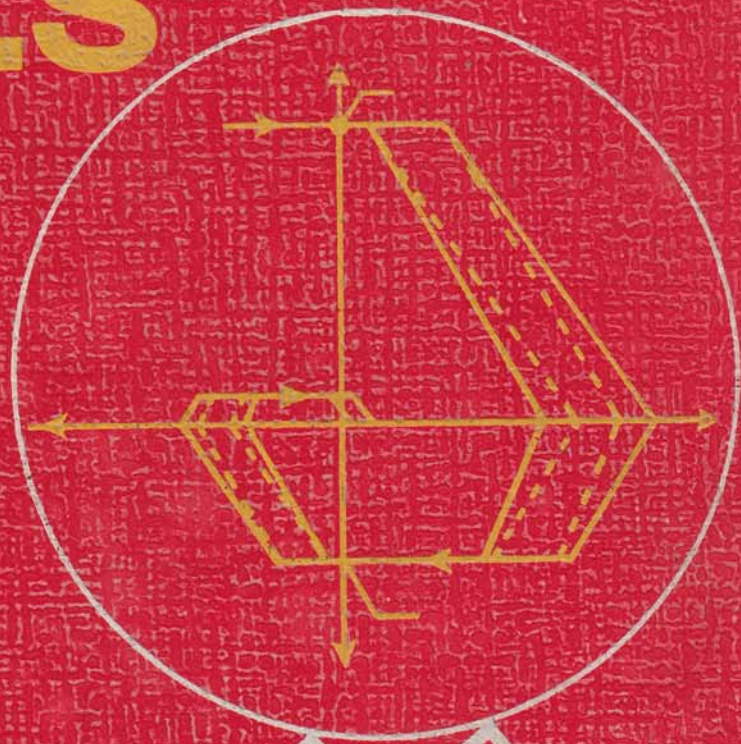


NUMERICAL CONTROL OF MACHINE TOOLS



YORAM KOREN
JOSEPH BEN-URI

KHANNA PUBLISHERS DELHI-6

**NUMERICAL CONTROL
OF
MACHINE TOOLS**

YORAM KOREN

Senior Lecturer,
Faculty of Mechanical Engineering
Technion—Israel Institute of
Technology

AND

JOSEPH BEN-URI

Professor,
Faculty of Electrical Engineering
Technion—Israel Institute of
Technology

1978

KHANNA PUBLISHERS

2-B, Nath Market, Nai Sarak,
DELHI - 110006

CONTENTS

CHAPTER	PAGES
1. Introduction	... 1—24
1·1. Definitions and Basic Information.	
1·2. Need and Advantages of N/C.	
1·3. Classification of N/C Systems.	
1·3·1. Point-to-Point and contouring.	
1·3·2. Analogue and digital control.	
1·3·3. Incremental and absolute systems.	
1·3·4. Open-loop and closed-loop systems.	
1·4. Data Feeding Methods	
1·4·1. Punched tape.	
1·4·2. Magnetic tape.	
1·4·3. Plug-board control.	
2. Machine Tool and Case Studies	... 25--46
2·1. General Construction Requirements.	
2·1·1. Productivity and N/C.	
2·1·2. Quality of machine tools and the accuracy of the workpiece.	
2·1·3. Thermal deformation.	
2·1·4. Static and dynamic forces.	
2·1·5. Special tool holders.	
2·1·6. Economy of N/C.	
2·2. Metal Removing Machine Tools.	
2·2·1. Sequence control.	
2·2·2. Drilling.	
2·2·3. Boring.	
2·2·4. Punching.	
2·2·5. Turning.	
2·3. Miscellaneous Applications.	
3. Storage and Contouring Devices	... 47—62
3·1. Logic Levels.	
3·2. Time Delay and Shaping.	
3·3. Binary Storage.	
3·4. Registers.	
3·5. Counters and Decoders.	
4. Devices of NC Systems	... 63—97
4·1. Driving Devices.	
4·1·1. Hydraulic systems.	
4·1·2. DC motors.	
4·1·3. Stepping motor.	
4·2. Feedback Devices.	
4·2·1. Encoders.	
4·2·2. Motor fringes digitizer.	
4·2·3. Resolver.	
4·2·4. Inductosyn.	
4·2·5. Tachometer.	
4·3. Digital-	

to-Analogue Converters. 4·3·1. Resistor ladder network. 4·3·2. Weighed resistor network. 4·3·3. D/A driving an operational amplifier. 4·4. DDA Integrator. 4·4·1. Principle of integration. 4·4·2. Generation of basic function.

5. Data Processing Unit ... 98—126

5·1. Data Reading. 5·1·1. Tape reader. 5·1·2. Reading circuits. 5·2. Distributors. 5·2·1. Tape formats. 5·2·2. Digital circuits. 5·3. Data Conversion. 5·3·1. BCD-to-binary conversion. 5·3·2. Binary-to-BCD conversion. 5·4. Interpolator. 5·4·1. Linear interpolator. 5·4·2. Circular interpolator. 5·4·3. Complete interpolator. 5·4·4. Parabolic interpolator.

6. Control Loops ... 127—168

6·1. Introduction. 6·1·1. Basic structure of control loop. 6·1·2. System resolution. 6·1·3. Increment versus absolute systems. 6·2. Positioning Control loops. 6·2·1. Incremental open-loop circuit. 6·2·2. Incremental closed-loop circuit. 6·2·3. Direction sensing circuit. 6·2·4. Absolute closed-loop circuit. 6·2·5. Resolver as a feedback device. 6·3. Contouring control loops. 6·3·1. Basic concepts. 6·3·2. Principle of operation. 6·3·3. Mathematical analysis. 6·3·4. Control loop based on phase-comparison.

7. Numerical Control Loops ... 169—232

7·1. General Introduction. 7·2. Magnetic N/C systems. 7·3. The General Electrical System. 7·4. Photo-Electric Microscope Adjustment. 7·5. Philips (Holland) Equipment. 7·6. Dyna-Path Equipment of Bendix. 7·7. The Dialin N/C System of Herbert. 7·8 The Plessy Continuous Path N/C for Lathes. 7·9. Thread Cutting. 7·10. The ASEA system. 7·11. Special Features of Cincinnati Acromatic System. 7·12.

N/C for Printed Circuits Drilling by Guttinger. 7·13. Computer Numerical Control (CNC). 7·14. Geometrical Data Processing. 7·15. Interferometric Readout with Lasers.

- 8. Programming** ... 233—287
- 8·1. Introduction. 8·2. Manual Programming. 8·2·1. Basic concepts. 8·2·2. Tape Format. 8·2·3. Contour Programming-Example. 8·3. Computer programs. 8·3·1. General Information. 8·3·2. Post-processors. 8·3·3. APT language. 8·3·4. Other programming systems. 8·4. Quality Classification. 8·4·1. Characteristics of N/C systems. 8·4·2. Format Classification.
- 9. Computer Control and AC Systems** ... 288—310
- 9·1. Computer Control Concepts. 9·2. DNC Systems. 9·3. CNC Systems. 9·4. Adaptive Control System. 9·4·1. ACC Systems. 9·4·2. ACC Systems. 9·5. The role of the Microprocessor in N/C. 9·5·1. The Microprocessor. 9·5·2. Microprocessor in N/C Equipment.

Numerical Control of Machine Tools

By Y. Koren and J. Ben-Uri (Delhi, India: Khanna, 1978, 310 pp.).

Reviewed by Thomas J. Higgins, Department of Electrical and Computer Engineering,
University of Wisconsin, Madison, WI 53706.

This review appeared in

IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS,
VOL. SMC-10, NO. 3, MARCH 1980.

Numerical control (NC) as applied to machine tools covers three different fields: machine tool operation, design of control loops, and programming of the part being produced. The present book is unique insofar as it covers all three aspects of the subject within a single volume.

The book is divided into nine chapters covering the entire NC field, starting with conventional automatic machines and NC systems and progressing to more recent developments-DNC, CNC, and adaptive control. A comprehensive overview of the subject is provided, together with the necessary technical fundamentals for the design of NC systems.

This book can be used as a textbook for a one-semester advanced undergraduate course in a mechanical, electrical, or manufacturing engineering curriculum; or it can be used as a sourcebook for the practicing engineer.