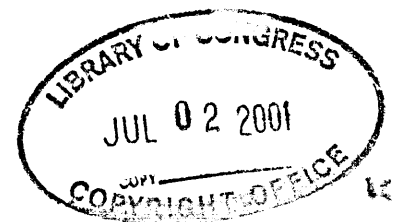

MECHANISMS & MECHANICAL DEVICES SOURCEBOOK

Third Edition

NEIL SCLATER
NICHOLAS P. CHIRONIS



McGraw-Hill
New York • Chicago • San Francisco • Lisbon • London • Madrid
Mexico City • Milan • New Delhi • San Juan • Seoul

Sclater, Neil.

Mechanisms and mechanical devices sourcebook / Neil Sclater, Nicholas P. Chironis.—
3rd ed.

p. cm.

Rev. ed of: Mechanisms & mechanical devices sourcebook / [edited by] Nicholas P.
Chironis, Neil Sclater. 2nd ed. 1996.

ISBN 0-07-136169-3

1. Mechanical movements. I. Chironis, Nicholas P. II. Mechanisms & mechanical
devices sourcebook. III. Title.

TJ181.S28 2001
621.8—dc21

2001030297

McGraw-Hill



A Division of The McGraw-Hill Companies

Copyright © 2001, 1996, 1991 by The McGraw-Hill Companies, Inc. All rights reserved, Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a data base or retrieval system, without the prior written permission of the publisher.

1 2 3 4 5 6 7 8 9 0 KGP/KGP 0 7 6 5 4 3 2 1

ISBN 0-07-136169-3

The sponsoring editor for this book was *Larry S. Hager* and the production supervisor was *Pamela A. Pelton*. It was set in Times Roman by *TopDesk Publishers' Group*.

Printed and bound by Quebecor/Kingsport.

McGraw-Hill books are available at special quantity discounts to use as premiums and sales promotions, or for use in corporate training programs. For more information, please write to the Director of Special Sales, Professional Publishing, McGraw-Hill, Two Penn Plaza, New York, NY 10121-2298. Or contact your local bookstore.

This book is printed on acid-free paper.

Information contained in this work has been obtained by The McGraw-Hill Companies, Inc. ("McGraw-Hill") from sources believed to be reliable. However, neither McGraw-Hill nor its authors guarantee the accuracy or completeness of any information published herein and neither McGraw-Hill nor its authors shall be responsible for any errors, omissions, or damages arising out of use of this information. This work is published with the understanding that McGraw-Hill and its authors are supplying information but are not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought.

PREFACE	xiii
ACKNOWLEDGMENTS	xv
CHAPTER 1 MOTION CONTROL SYSTEMS	1
Motion Control Systems Overview	2
Glossary of Motion Control Terms	9
High-Speed Gearheads Improve Small Servo Performance	10
Modular Single-Axis Motion Systems	12
Mechanical Components Form Specialized Motion-Control Systems	13
Servomotors, Stepper Motors, and Actuators for Motion Control	14
Servosystem Feedback Sensors	22
Solenoids and Their Applications	29
CHAPTER 2 ROBOT MECHANISMS	33
Industrial Robots	34
FANUC Robot Specifications	38
Mechanism for Planar Manipulation With Simplified Kinematics	43
Tool-Changing Mechanism for Robot	44
Piezoelectric Motor in Robot Finger Joint	45
Six-Degree-of-Freedom Parallel Minimanipulator	46
Self-Reconfigurable, Two-Arm Manipulator With Bracing	47
Improved Roller and Gear Drives for Robots and Vehicles	48
All-Terrain Vehicle With Self-Righting and Pose Control	49
CHAPTER 3 PARTS-HANDLING MECHANISMS	51
Mechanisms That Sort, Feed, or Weigh	52
Cutting Mechanisms	56
Flipping Mechanisms	58
Vibrating Mechanism	58
Seven Basic Parts Selectors	59
Eleven Parts-Handling Mechanisms	60
Seven Automatic-Feed Mechanisms	62
Seven Linkages for Transport Mechanisms	65
Conveyor Systems for Production Machines	68
Traversing Mechanisms for Winding Machines	73
Vacuum Pickup Positions Pills	75
Machine Applies Labels from Stacks or Rollers	75
High-Speed Machines for Adhesive Applications	76
Automatic Stopping Mechanisms for Faulty Machine Operation	82
Electrical Automatic Stopping Mechanisms	88
Automatic Safety Mechanisms for Operating Machines	90
CHAPTER 4 RECIPROCATING AND GENERAL-PURPOSE MECHANISM	93
Gears and Eccentric Disk Combine in Quick Indexing	94
Timing Belts, Four-Bar Linkage Team Up for Smooth Indexing	95
Modified Ratchet Drive	96
Odd Shapes in Planetary Give Smooth Stop and Go	97
Cycloid Gear Mechanism Controls Stroke of Pump	99
Converting Rotary-to-Linear Motion	100
New Star Wheels Challenge Geneva Drives for Indexing	100

	Geneva Mechanisms	103
	Modified Geneva Drives	106
	Indexing and Intermittent Mechanisms	108
	Rotary-to-Reciprocating Motion and Dwell Mechanisms	116
	Friction Devices for Intermittent Rotary Motion	122
	No Teeth on These Ratchets	124
	Cam-Controlled Planetary Gear System	125
CHAPTER 5	SPECIAL-PURPOSE MECHANISMS	127
	Nine Different Ball Slides for Linear Motion	128
	Ball-Bearing Screws Convert Rotary to Linear Motion	130
	Three-Point Gear/Leadscrew Positioning	131
	Unique Linkage Produces Precise Straight-Line Motion	132
	Twelve Expanding and Contracting Devices	134
	Five Linkages for Straight-Line Motion	136
	Linkage Ratios for Straight-Line Mechanisms	138
	Linkages for Other Motions	139
	Five Cardan-Gear Mechanisms	140
	Ten Ways to Change Straight-Line Direction	142
	Nine More Ways to Change Straight-Line Direction	144
	Linkages for Accelerating and Decelerating Linear Strokes	146
	Linkages for Multiplying Short Motions	148
	Parallel-Link Mechanisms	150
	Stroke Multiplier	150
	Force and Stroke Multipliers	152
	Stroke-Amplifying Mechanisms	154
	Adjustable-Stroke Mechanisms	155
	Adjustable-Output Mechanisms	156
	Reversing Mechanisms	158
	Computing Mechanisms	159
	Eighteen Variations of Differential Linkage	163
	Space Mechanisms	165
	Seven Popular Types of Three-Dimensional Drives	167
	Inchworm Actuator	172
CHAPTER 6	SPRING, BELLOW, FLEXURE, SCREW, AND BALL DEVICES	173
	Flat Springs in Mechanisms	174
	Pop-Up Springs Get New Backbone	176
	Twelve Ways to Put Springs to Work	177
	Overriding Spring Mechanisms for Low-Torque Drives	179
	Spring Motors and Typical Associated Mechanisms	181
	Flexures Accurately Support Pivoting Mechanisms and Instruments	183
	Taut Bands and Leadscrew Provide Accurate Rotary Motion	185
	Air Spring Mechanisms	186
	Obtaining Variable Rates from Springs	188
	Belleville Springs	189
	Spring-Type Linkage for Vibration Control	190
	Twenty Screw Devices	191
	Ten Ways to Employ Screw Mechanisms	194
	Seven Special Screw Arrangements	195
	Fourteen Adjusting Devices	196
	Linear Roller Bearings Are Suited for High-Load, Heavy-Duty Tasks	197
CHAPTER 7	CAM, TOGGLE, CHAIN, AND BELT MECHANISMS	199
	Cam Basics	200
	Cam-Curve Generating Mechanisms	201

	Fifteen Ideas for Cam Mechanisms	207
	Special-Function Cams	209
	Cam Drives for Machine Tools	210
	Toggle Linkage Applications in Different Mechanisms	211
	Sixteen Latch, Toggle, and Trigger Devices	213
	Six Snap-Action Mechanisms	215
	Eight Snap-Action Devices	217
	Applications of the Differential Winch to Control Systems	219
	Six Applications for mechanical Power Amplifiers	221
	Variable-Speed Belt and Chain Drives	224
	Getting in Step With Hybrid Belts	227
	Change Center Distance Without Affecting Speed Ratio	231
	Motor Mount Pivots for Controlled Tension	231
	Bushed Roller Chains and Their Adaptations	232
	Six Ingenious Jobs for Roller Chain	234
	Six More Jobs for Roller Chain	236
	Mechanisms for Reducing Pulsations in Chain Drives	238
	Smoother Drive Without Gears	240
CHAPTER 8	GEARED SYSTEMS AND VARIABLE-SPEED MECHANISMS	241
	Gears and Gearing	242
	Nutating-Plate Drive	243
	Cone Drive Needs No Gears or Pulleys	244
	Variable-Speed Mechanical Drives	245
	Unidirectional Drive	253
	More Variable-Speed Drives	254
	Variable-Speed Friction Drives	256
	Variable-Speed Drives and Transmissions	258
	Precision Ball Bearings Replace Gears in Tiny Speed Reducers	260
	Multifunction Flywheel Smooths Friction in Tape Cassette Drive	261
	Controlled Differential Drives	262
	Twin-Motor Planetary Gears Provide Safety Plus Dual-Speed	263
	Harmonic-Drive Speed Reducers	263
	Flexible Face-Gears Make Efficient High-Reduction Drives	266
	Compact Rotary Sequencer	267
	Planetary Gear Systems	268
	Noncircular Gears	275
	Sheet-Metal Gears, Sprockets, Worms, and Ratchets	279
	How to Prevent Reverse Rotation	281
	Gear-Shift Arrangements	282
	Shifting Mechanisms for Gears and Clutches	284
	Fine-Focus Adjustments	286
	Ratchet-Tooth Speed-Change Drive	287
	Twinworm Gear Drive	287
	Compliant Gearing for Redundant Torque Drive	289
	Lighter, More-Efficient Helicopter Transmissions	290
	Worm Gear With Hydrostatic Engagement	290
	Straddle Design of Spiral Bevel and Hypoid Gears	292
CHAPTER 9	COUPLING, CLUTCHING, AND BRAKING DEVICES	293
	Coupling of Parallel Shafts	294
	Novel Linkage Couples Offset Shafts	295
	Disk-and-Link Coupling Simplifies Transmissions	296
	Interlocking Space-Frames Flex as They Transmit Shaft Torque	297
	Off-Center Pins Cancel Misalignment of Shafts	299
	Hinged Links and Torsion Bushings Give Drives a Soft Start	300

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.