

TAB BOOKS/No. 1174

\$6.95

MODEL RADIO CONTROL

3rd Edition



A complete,
updated guide
to the
fascinating
world of
model radio
control!



by Edward L. Safford Jr.



***MODEL RADIO
CONTROL-3rd Edition***
by Edward L. Safford Jr.

TAB BOOKS

BLUE RIDGE SUMMIT, PA. 17214

FIRST EDITION

FIRST PRINTING—NOVEMBER 1979

Copyright © by TAB BOOKS

Printed in the United States of America

Reproduction or publication of the content in any manner, without express permission of the publisher, is prohibited. No liability is assumed with respect to the use of the information herein.

Library of Congress Cataloging in Publication Data

Safford, Edward L.
Model radio control.

Includes index.

1. Models and modelmaking—Radio control systems.

I. Title.

TT154.S3 1979 629.04'022'8 79-17079

ISBN 0-8306-9762-4

ISBN 0-8306-1174-6 pbk.

Contents

| | |
|--|------------|
| Preface | 7 |
| 1 Fundamental Concepts, Devices and Operations..... | 11 |
| The Necessary Motions—The Actuator—Simplest Electric Motor Control—The “Glo-Plug” Engine—Electric Motor Direction of Rotation—A Radio-Controlled Model Car—The Superregenerative Receiver—The Superheterodyne Receiver—Channels, Coding and Decoding—Two-Channel Toy Car—A Simple Steering Arrangement—The Steering Code—The Airplane Self-Neutralizing Motor | |
| 2 Coding and Coders | 45 |
| Analysis of the Simple Command Code—Automatic Transmission of Codes—Off-On Carrier or Tone Code—Harmonic Considerations—Pulse Codes—A Model Racing Car—How Many Channels? | |
| 3 Examining Transmission Systems | 59 |
| Radio Transmission—Sound-Wave Transmission—Light-Beam Transmission—Infrared Wave Transmission—Wired Transmission—Magnetic Transmission—Radio Transmission—Methods of Modulation—A More Complex Transmitter—Testing Transmitters and Receivers—Finding Solutions to Equipment “Dogs”—Transmitting Antennas—Some Specific Antenna Systems—Field-Strength Indicators—Radiation Patterns | |
| 4 More About Receivers..... | 80 |
| Superregenerative Receivers—The Output Stage—Relay Adjustment—Superheterodyne Receivers—Interference Monitoring—Model Receiver Mounting | |
| 5 Decoders..... | 88 |
| Mechanical Decoders—Electromechanical Decoders—Electronic Decoders | |
| 6 Power Control Circuits..... | 121 |
| Latching Relays—Reversing Relays—One Operational Circuit Using Relays—An Integrated Circuit Power Control—An Electromechanical Switching Device—Babcock Speed Control and Reversing Relay—Power Control Circuits for AC Motors—Power Control with Digital Servos | |

| | | |
|-----------|--|------------|
| 7 | Servo Motors | 132 |
| | Limit Switches—Self-Neutralizing Switches—Commercial Servos—A Cam-Controlled Steering Arrangement—Modifying a Commercial Servo—A Self-Neutralizing Servo Using Transistors—A Very Simple Robot Control System | |
| 8 | Integrated Circuits and Transistors | 145 |
| | Definitions—Integrated Circuit Packages—Transistors—Some Soldering Techniques—Solder Removal Techniques—Heat Sinks for Operational Units—Some Circuits for Experimenters | |
| 9 | Evaluating and Selecting Radio Control Systems | 167 |
| | Linear Versus Nonlinear Servos—How Many Channels?—What Equipment to Buy?—Determining Your Requirements—Selective and Proportional Control—Discrete and Simultaneous Control—The Cost Factor—Compatibility of Systems—The More Economical Systems—Modern Digital Equipment Limitations—Summary | |
| 10 | Radio-Controlled Model Cars | 179 |
| | Equipment and Mounting Arrangement—A Home-Built Concept—Size, Gearing, Motors and Other Details—Interference—Test Equipment and Tools—Partial Parts Costs—A Visit to a Model Race Car Event—The Future in Model Cars—Model Race Car Nationals | |
| 11 | Radio-Controlled Model Airplanes | 196 |
| | Scale and Nonscale Models—Construction and Radio Installation—Commonly Used Airplane Sizes—A Beginner's Airplane Construction Details—Another Radio Control Installation—Some Other Installations—The Aileron Connection—A Completed Model—To the Flying Field—The Support Equipment—The Pylon Races | |
| 12 | Radio-Controlled Model Boats | 222 |
| | Types of Boats—Some Sailboat Definitions—Airboats—Model Yacht Construction and R/C Installation | |
| 13 | Single-Channel and Three-Channel Systems | 235 |
| | Pulse-Width Space-Rate Decoder—Second Function Control—Decoder for Fixed Pulse Width—Resonant-Reed Decoder—Numerical-Sequence Coder and Decoder | |
| | Index | 253 |

Preface

This book is a second revision of the book first published in 1951. The first revision was published in 1959, and we thank you for your acceptance of those two works. We hope and trust that you will find this work just as valuable. It is practically a *new* book on radio control.

There is much new material in this edition. It still retains all of the valuable and still useable ideas and information of the two previous works. They are updated and now considered in light of the current state of the art of radio control. We hope and trust that all of you whom we have met through the pages of the previous works, or our other books, and those of you whom we meet for the first time in these pages, will find this new edition as worthy as you have reported the original and first revision to have been. As in the previous editions, we start at the beginning and will advance the ideas fully and carefully so that if you are not familiar with radio control, you can learn what it is all about and how it works. If you are familiar with the hobby, you can still find valuable ideas and concepts within these pages.

Radio control enthusiasm has not diminished during the years since its inception. If anything, its popularity has increased. We are constantly amazed at how many new applications modern technology is able to develop. In some cases the gains are not just in a hobby sense. For example, there are now on the market, some remote (triggered by radio control) alarm systems to warn neighbors if an intruder is present. The alarm will report if an intruder is present or

if there is a fire burning out of control. It might even be able to tell someone if you are hurt or seriously ill. In a way this is remote monitoring of your welfare and as such can be extremely valuable.

The fact is that radio control of models—and other things—is an accepted hobby and business throughout the world. Radio control simply means that someone or something (a computer) somewhere is going to cause certain events, operations, or conditions to occur at some other place. This happens only when certain commands are sent by radio, sound, light, heat, or other method suitable for the conveyance of commands.

Citizens band radio came, was accepted, and is here. We think nothing of being able to communicate with that car at our “front door” or “back door”. In fact, we get upset if we cannot communicate with everyone we want to. We use radio transmission to convey ideas in this case, and not necessarily commands to do things. So there is really nothing unusual, except for the change in equipment. All we need do is convert a *talking* system into a *commanding* system, which is necessary for radio control.

Everyone would like to be a pilot—well, almost everyone. Some can't for various reasons. But almost everyone can become a *model pilot*, flying a true airplane from the safety and security of a ground position. A dream is thus realized, and believe me, the feeling is almost the same as flying the big machine. So this is one reason for radio control of a model airplane. Then there is that great desire to build something, to fabricate and construct, to design and assemble, to plan and activate. Some can build skyscrapers and bridges and whatnot. Some cannot. But again they can realize the essential elements and satisfaction of this desire in the building of models. And since radio-controlled models must, in reality, function and operate just as their larger counterparts do, they must be made properly. Therefore, a second dream is thus realized.

Escape from boredom is another reason why models are built and sailed or raced or flown, or operated. For the most part, people like to have “brain challenges.” The building of the models, the installation and operation and test adjustment of the radio control equipment will provide a challenge that is rewarding and satisfying. And everyone can do it. There is no restriction as to sex, age (except young), color, race or creed. And costs can be selected to be within the means of just about everyone. When hobbyists get together with their models, there is no boredom, and the results of these gatherings, or even the isolated building and operation of models, will give that fertile brain new concepts and directions and challenges, so believe me, the boredom can be gone forever.

Radar control is being tested in automobiles as an automatic safety system to prevent a car from getting too close to the car ahead. Also, automatic information transmission and activation of various auto control devices can take place without appreciably slowing down the car or causing the driver or occupants any discomfort.

Radio control will be used more and more in conjunction with home computers as it becomes necessary to gather physical sensor data and activate various electrical-mechanical devices through this increasingly popular instrument. Wireless as well as wired remote control systems—wherein the signal is transmitted over the air or on wires already carrying electrical currents in your home—will be used extensively in the future.

All this is in addition to the ever popular hobby aspect of radio control. How much fun it is to guide your beautiful—and some not so beautiful—airplanes and sail planes through the sky or drive your model car or sail your model boat! What a feeling of freedom and power as you make the model do whatever your mind can conceive in the way of airplane aerobatics, or picture taking, monitoring, or whatever! And how graceful the modern model ship, sailboat, or racing boat is as it cuts through the waters responding to your slightest whim. One just can't find an end to the R/C things which can be incorporated into a model boat. Just think of launching a small plane from a ship deck, and controlling this at the same time that you are controlling the speed direction, whistles and the lowering of lifeboats of the mother ship. Imagine trimming the sails—just so—to gain the greatest speed and the thrill of winning a sailboat race.

Model car racing with either fuel-powered or electric-powered motors is fast becoming a great area of hobby fun and a test of your coordination and skill. Races are being held all over the globe. This gives the electro-mechanically inclined hobbyist a chance to really get involved as well as to give a good show. Of course, he can have fun trying to negotiate the various turns and straight-ways of model car racing roadways.

All this means that radio control systems have come into their own. They have progressed from the single-channel escapement-operated systems into multichannel, proportional systems. The latter are extremely reliable, easy to apply, install and use. A far cry, indeed, from “those days when....” Those of you “old timers” will gain a bit of nostalgia from our mentioning some of the older systems. And, of course, they still work. They can still be used even though they are limited in what they can do. You might want to develop and modify them “just for the fun of it.”

The sages tell us that the days of computers and robots are in the offing. Of course, radio control will have its place in this scheme of things. Remote control of scientific robots is best illustrated by the Mars, Saturn and Venus ventures of NASA, and the techniques they use are but extensions of those used in R/V.

We have written and have required many books on radio control. In each we have given the reader something a little different, and perhaps a little more advanced, depending on which book you choose as your next bookshelf addition. This book is the fundamental one that gives basic information on the mechanics of the systems involved. We hope this will be the one to give you a foundation of knowledge for our more advanced and specific books on R/C.

So let us get at it. Grant us permission to keep intact those concepts and systems which are fundamental for those who aren't familiar with Radio Control. We hope the new material here meets with your approval. Thank you again, as always, for your acceptance of our works. We hope that your own imagination and creativity will be sparked by what you read herein.

As always, we have met many wonderful people over the years at so many flying fields, R/C club meetings, hobby shops, and homes who have added to our basic supply of knowledge that we just cannot list them individually here. We do, however, extend our gratitude to each and every one of you in a most personal way.

So be it! Let us begin.

Edward L. Safford, Jr.

Index

| | | | |
|---------------------------------|-----|----------------------------------|--------|
| A | | | |
| Actuator | 12 | motor-driven | 102 |
| Aileron connection | 213 | Compatibility of systems | 174 |
| Airboats | 226 | Computer code | 54 |
| Airplane | | Concept, home-built | 184 |
| construction details, | | Construction | 207 |
| beginner's | 204 | body | 207 |
| engines | 205 | wing | 207 |
| sizes, commonly used | 204 | Control | 170 |
| Amateur band, 53-MHz | 62 | discrete | 170 |
| Antenna | | proportional | 170 |
| systems, specific | 74 | second-function | 238 |
| transmitting | 73 | selective | 170 |
| Astable multivibrator | 114 | simultaneous | 170 |
| Automatic transmission of codes | 46 | Control code | 41 |
| | | left | 41 |
| | | neutral | 41 |
| | | right | 41 |
| | | Cost factor | 172 |
| | | Counterpoise effect | 74 |
| | | Covering, ready | 210 |
| | | D | |
| | | Decoders | 37, 88 |
| | | electromechanical | 89 |
| | | electronic | 104 |
| | | for fixed pulse width | 240 |
| | | integrated circuit | 104 |
| | | mechanical | 88 |
| | | numerical-sequence | 243 |
| | | resonant-reed | 242 |
| | | tone | 113 |
| | | Decoding | 36 |
| | | Definitions | 145 |
| | | Delay lines | 114 |
| | | Digital | |
| | | equipment limitations, | |
| | | modern | 175 |
| | | systems | 53 |
| | | Diminishing returns | 175 |
| | | Director | 76 |
| | | Discrete control | 170 |
| | | Dog | 72 |
| | | finding solutions | 72 |
| | | Drive motor | 142 |
| | | E | |
| | | Electric motor, | |
| | | control | 12 |
| | | direction | 15 |
| | | rotation | 15 |
| | | Electromechanical decoders | 89 |
| | | Electronic decoders | 104 |
| | | Engine | |
| | | glo-plug | 14 |
| | | mounting | 210 |
| | | Equipment | |
| | | arrangement | 180 |
| | | what to buy | 168 |
| | | F | |
| | | Feedback | 146 |
| | | potentiometer | 137 |
| | | Filters | 108 |
| | | bandpass | 108 |
| | | band-rejection | 111 |
| | | null-bridge type | 111 |
| | | Fixed impedance load | 74 |
| | | Flying field, to the | 214 |
| | | Frame | 105 |
| | | Front wheel mounting | 210 |
| | | Function control | 39 |
| | | G | |
| | | Gearing | 184 |
| | | Glo-plug engine | 14 |
| | | Grommet mounting | 87 |
| | | H | |
| | | Harmonic considerations | 49 |
| | | Heat sinking | 157 |
| | | conduction | 157 |
| | | convection | 157 |
| | | Heat sinks for operational units | 157 |
| | | I | |
| | | Indicators | |
| | | field-strength | 77 |
| | | performance | 63 |
| | | Infrared wave transmission | 60 |
| | | Installations, others | 212 |
| | | Integrated circuit | |
| | | decoders | 104 |
| | | packages | 146 |
| | | power control | 125 |
| | | Interference | 185 |
| | | monitoring | 86 |
| | | Inverter | 146 |

| | | | | | | | | | |
|----------------------------------|----------|--------------------------------|----------|----------------------------|----------|--|--|--|--|
| | L | | | | | | | | |
| Light-beam transmission | 60 | constant | 52 | linear versus nonlinear | 167 | | | | |
| Limit switches | 132 | train | 105 | Short-range radio system | 17 | | | | |
| | | width | 51 | Signal, modulated | 34 | | | | |
| | | width-spacing variation- | | Simultaneous control | 170 | | | | |
| | | individual pulses | 53 | Size | 184 | | | | |
| Magnetic transmission | 61 | width variation-spacing | | Soldering techniques | 151 | | | | |
| Mechanical | | constant | 51 | Solder removal techniques | 155 | | | | |
| decoders | 88 | Pylon racers | 217 | Sound signal | 30 | | | | |
| motions, necessary | 11 | | | Sound-wave transmission | 59 | | | | |
| Microsecond pulses, generation | 119 | | | Steering arrangement | | | | | |
| Mirror image antenna | 74 | R | 190 | cam-controlled | 138 | | | | |
| Model | | Races | 57 | simple | 40 | | | | |
| completed | 213 | Racing car, model | 211 | Steering code | 41 | | | | |
| construction | 201 | Radio | 17 | Steppers | 100 | | | | |
| nonscale | 200 | control installation, another | 201 | Superheterodyne receiver | 34, 84 | | | | |
| scale | 200 | -controlled model car | 18 | advantages | 35 | | | | |
| yacht construction | 228 | installation | 59, 62 | Superregenerative receiver | 31, 80 | | | | |
| Model cars, future | 194 | link, elements | 79 | Support equipment | 216 | | | | |
| Model racing car | 57 | transmission | 71 | Switches | 132 | | | | |
| Model race car | | Radiation patterns | 228 | limit | 132 | | | | |
| event, a visit | 187 | Range test | 188 | self-neutralizing | 13+ | | | | |
| nationals | 195 | R/C | 26 | Switching device, | | | | | |
| Modulation, methods | 66 | installation | 142 | electromechanical | 126 | | | | |
| Motors | 184 | race cars, obtaining | 34, 84 | Sync pause | 53 | | | | |
| shaft | 246 | Receiver | 31, 80 | pulse | 107 | | | | |
| Monitoring, interference | 86 | relay | 70 | Systems, more economical | 17 | | | | |
| Mounting | 86 | superheterodyne | 89 | | | | | | |
| arrangement | 180 | superregenerative | 137 | T | | | | | |
| engine | 210 | testing | 77 | Telemetry system | 38 | | | | |
| front wheel | 210 | Reeds, resonant | 19 | Test equipment | 185 | | | | |
| grommet | 87 | Reference pulse | 83 | Tone | | | | | |
| model receiver | 86 | Reflector | 96 | code | 48 | | | | |
| Multivibrator, astable | 114 | Relay | 93 | decoder | 113 | | | | |
| | | adjustment | 104 | encoder | 113 | | | | |
| | | as amplitude detectors | 121 | section | 48 | | | | |
| | | chains | 92 | Tools | 185 | | | | |
| | | delay | 89, 95 | Toy car, two-channel | 39 | | | | |
| | | diagram | 122, 126 | Transistors | 148 | | | | |
| | | latching | 89 | RF oscillator circuits | 159 | | | | |
| | | polarized | 89 | Transmission | 59 | | | | |
| | | resonant | 89 | infrared wave | 60 | | | | |
| | | reversing | 89 | light-beam | 60 | | | | |
| | | single | 242 | magnetic | 61 | | | | |
| Operational circuit using relays | 124 | Resonant | 89, 95 | of codes, automatic | 46 | | | | |
| Output stage | 82 | reeds | 89, 95 | radio | 59, 62 | | | | |
| | | -reed decode | 169 | sound-wave | 59 | | | | |
| | | relays | 142 | wired | 60 | | | | |
| | | Requirements, determining your | 105 | Transmitter | 19 | | | | |
| Partial parts costs | 186 | Robot control system, simple | 105 | keying | 64 | | | | |
| Performance indicators | 63 | Routing | | more complex | 69 | | | | |
| Power control | | | | one type | 19 | | | | |
| circuits for AC motors | 129 | | | technical details | 27 | | | | |
| with digital servos | 129 | S | | testing | 70 | | | | |
| Proportional control | 54, 170 | Sailboat definitions | 226 | Truth table | 104, 146 | | | | |
| Pulse | 48 | Selective control | 170 | Two buttons | 39 | | | | |
| amplitudes | 56 | Self-neutralizing | 42 | | | | | | |
| codes | 50 | motor, airplane | 140 | W | | | | | |
| intelligence | 53 | servo using transistors | 40 | Wired transmission | 60 | | | | |
| -rate variation | 56 | Sequence device | | | | | | | |
| sequences | 54 | Servos | | | | | | | |
| spacing variation—width | | commercial | 136 | | | | | | |



MODEL RADIO CONTROL-3rd Edition *by Edward L. Safford Jr.*

This *all new* and complete revision will thoroughly acquaint you with everything you need to know about model radio control—how it works, how to design a system, how to install it, and how to operate model airplanes, cars, boats, toys or virtually anything by radio control. Starting out with fundamental RC concepts, the author takes you through all the latent and most modern equipment, including coding and coders, relays, superregenerative receivers, decoders, power control circuits, servo motors, tone-operated and proportional control systems and much more!

Here is complete description of every RC system ever devised—including the latest digital proportional control systems. *Nothing* is left out—you can choose the system you prefer and then read all about it. Even if you're a novice in the world of radio control, you can learn from this book, and be in charge of a radio control system in no time at all! If you're a veteran hobbyist, there's still plenty of *all-new* info on the most modern equipment here. This book will bring you up to date and keep abreast of the constantly changing, constantly developing RC technology. So, if you want to keep up with the changes in radio-controlled modeling, or if you want to get in on the ground floor of the hobby, this lucid guide should be part of your library.



Edward L. Safford, Jr. is a technical writer and amateur radio buff of long standing who has published over 60 articles, 20 technical books and 5 novels. He is the author of several TAB electronics books, and lives in Houston, TX.

OTHER POPULAR TAB BOOKS OF INTEREST

Radio Control Manual-Systems, Circuits, Construction-3rd Edition

(No. 1135—\$5.95 paper; \$9.95 hard)

Radio Control Handbook—4th Edition

(No. 1093—\$9.95 paper; \$14.95 hard)

The Model Car Handbook

(No. 1117—\$5.95 paper; \$9.95 hard)

Building Model Airplanes From Scratch

(No. 1027—\$5.95 paper; \$9.95 hard)

Flying Model Airplanes & Helicopters by Radio Control

(No. 825—\$5.95 paper; \$7.95 hard)

Radio Control for Models

(No. 812—\$6.95 paper; \$9.95 hard)

RC Modeler's Handbook of Gliders & Sailplanes

(No. 747—\$4.95 paper; \$7.95 hard)

Model Sail & Power Boating . . . by Remote Control

(No. 693—\$4.95 paper; \$7.95 hard)

TAB BOOKS

ALSO PUBLISHERS OF MODERN AUTOMOTIVE SERIES & MODERN AVIATION SERIES
BLUE RIDGE SUMMIT, PA. 17214

Send for FREE TAB Catalog describing over 700 current titles in print.