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RADIO CONTROL HANDBOOK—4th Edition

nderstanding, designing, building, and using all kinds of RC systems!

BY HOWARD G. McENTEE
REVISED BY EDWARD L. SAFFORD JR.

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—4th Edition

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Preface

As I begin this fourth revision of the *Radio Control Handbook*, originally written and then revised three times by my good friend and colleague Howard G. McEntee, my mind goes back to the time when he was Editor of *Model Airplane News* and I was writing my first radio-control book. Howard assisted me with information, encouraged me, and supplied me with all that was needed to ensure that I got off to a good start in the writing field. Doing this revision, then, is, in a small way, a repayment for that debt owed by me to him. At the same time it provides a wonderful review of a most memorable period in the development and advancement of this marvelous hobby of radio control of various models. It also gives an opportunity to write about the current state of the art. It rekindles the memories of a firm friendship which lasted over many, many years.

Because Howard was an individualist and a staunch advocate of proportional radio control, he spent much time in the development and testing of equipment to further this control method. Although many devices originated years ago, they still have a useful place in model construction and control. Nowadays we have, of course, much simultaneous- and proportional-control equipment manufacturered commercially. We have a whole new chapter on these. But they may be somewhat expensive for the "tinkerer," as Howard used to call himself. So it was with this in mind that we had to carefully consider what to retain and what to eliminate as obsolete in revising this work. We had to remember that many of you, like ourselves, may enjoy building working systems "from scratch" to control model airplanes, boats, or cars. Much satisfaction results from mechanical and electrical fabrication that all work as it should in the model.

So we evaluated closely and with due respect for the careful explanatory writing of our good friend. We chose to retain as much as practical of his third revision work in this fourth revision, assuring that if you read carefully and build as shown you can expect some good results. They may not be quite as fancy nor as complex as you might obtain with the more modern systems, but they will perform. I must admit that some of the greatest pleasure I have ever had flying my RC airplanes has been when they were escapement powered and used a sponge inserted by an escapement arm or small electric motor into the engine venturi for speed control! And one beauty of all this was that it was so simple. Anyone can do it. The control is adequate and certain, and the pleasure is fantastic. To some of you it may seem like driving a vintage automobile, but think of the pleasure one gets from doing just that! We'll venture to say that if you take a model airplane with an escapement control system to the flying field you'll be the center of attention in no time at all. So we retain this vintage information in this revision.

Many changes abound and much new information appears to keep you updated and to expand your library. But we have made an effort to be selective about this. New transistors appear in proven circuits. And some explanations of the newer types of control systems available in kit form or ready to use fill out this handbook to make it current and appropriate to the current state of the art.

Some additional bits of information must be passed on to you at this time. There are many, many parts listed throughout this work. Some may require careful search and inquiry from supply houses such as Radio Shack and others. Relays, for example, are rapidly being replaced by transistor output circuits, but relays are easy to use and adjust, and can easily be made into an escapement, as you will see. Relays in small sizes and various current ratings and coil resistances can be found at Radio Shack. Escapements are not found on the market nowadays, but are especially suitable for the *very* small, economical, and lightweight aircraft. You try building one.

Now the transistor picture is also one which needs to be explained. There are many catalogs and substitution manuals on the market to give you information on alternate transistors. It is to these we will refer you rather than attempting to list various transistors for use in the circuits. Again, visit your nearest radio parts house and ask about the transistor substitution manuals.

Tuned-reed devices are no longer available on the market, but you can fabricate them if a need arises. Tone circuits to drive these reeds can be adapted to many other applications. So we have retained some reed circuits for this possibility.

Servo and actuator motors may be found at radio parts stores and hobby houses. One useful type, a small 3 volt PM motor, is available from Dumas Boat Company through your toy or hobby dealer. You'll have fun trying the servo arrangements shown and modifying the circuits to make them exactly fit your own need.

Using integrated circuits (IC) can save construction time and effort and produce smaller, lighter equipment. So as you study the circuts contained herein, remember that with a good up-to-date IC manual you can choose those fitting into the circuits we show to give good operation. That's a fun project sure to give you experience with ICs.

We suggest that this book is one which you might want to spend quite a bit of time with, reading and studying carefully, before plunging into any construction project. The background acquired will make your choice of a project more valid and satisfying. It will give you some knowledge which is something that becomes yours personally and is something that you'll be proud to have all your life, just as the learning of any subject gives you wisdom and authority and capability.

As always, we want to express our sincere appreciation to you kind readers and friends who have accepted our other books, and also to those of you who for the first time we meet in these pages. We hope that you will find some stimulating new ideas along with some nostalgic older ones.

Our *Flying Model Airplanes and Helicopters by Radio Control* (TAB No. 825) is suggested as a book which could be very helpful to you as a companion book to this one.

E. L. Safford, Jr.

Contents

Chapter 1
Oldies But Goodies

All methods of radio control depend upon sending a signal, either carrier or tone, which is broken in some manner (code) to cause something in the model to produce a physical response. This physical movement can then be coupled to appropriate elements such as rudders, wheels, and carburetors to cause movement in a desired manner, making the model react as desired.

Various codes are appropriate for control purposes, and the first and most basic one is the so-called sequence code. That simply means that one pulse (burst of tone or carrier) causes one thing to happen, two pulses (like "dits" of Morse code) cause something else to happen, and three pulses cause another happening, and so on.

In order to interpret this code a decoding method is necessary. This may be a separate electronic circuit in the receiver, or it may be the mechanical assembly itself, which is connected to the output of the receiver. One such basic unit with very positive control may be easily constructed from a relay of almost any size or type, the small 6- or 12-volts relays being appropriate with modern transistorized receivers. This unit is the two-arm escapement. It is powered by a twisted rubber band. It can actually move the control or steering surfaces or a car, boat, or plane. Or it can be modified so that it becomes a rotary switch, which, in turn, causes electric motors to operate. It is an important, although basic, element in radio control of models. Its use may never be fully exploited.

For a beginner in RC who is also a "tinkerer," a transmitter, receiver, and escapement provide all that is necessary to steer a model plane, boat, or car. Let's examine escapements in more detail, then.

ESCAPEMENTS AND HOW THEY OPERATE

Escapements are built to control a surface such as the rudder in step with the electrical pulses from the radio receiver in a model, but the power to *move* the rudder comes from twisted rubber bands. In order to have available sufficient twists to allow many rudder movements, the rubber band is long; it usually runs all the way from the escapement (normally placed under the wing at the rear of the equipment compartment) to the tail of the fuselage. An escapement that moves the engine throttle is operated only a few times per flight, so here a much shorter rubber band is ample.

As the heading implies, escapements operate on a fixed sequence. For each control signal, they move the rudder one step. Neutral rudder is generally attained with power off, so the first control pulse will move the rudder to either right or left. With some systems, knowing which direction comes next is a matter of remembering which direction you moved the rudder on the last control signal. More advanced types always give right rudder or left, depending upon the number of times you punch the transmitter button.

The simplest escapement is known as the two-arm, or self-neutralizing type, and its sequence is shown in Fig. 1-1. The rotor, or catch bar, is simply a pivoted steel strip that revolves on a center shaft, driven clockwise in Fig. 1-1 by the twisted rubber band (latter not seen; it extends rearward from the hook at the end of the shaft). At neutral the rotor is vertical, as in Fig. 1-1A; the pin on the rotor holds the rudder centered via the linkage. When you push and hold the transmitter button, the magnet pulls down the armature, the rotor turns 90 degrees and is held on the second armature stop (Fig. 1-1B); we show this as right turn. Notice that there are no in-between positions—an escapement gives you all or nothing!

To hold the right turn, you must hold the button depressed, which keeps the magnet energized. Let the button up and the escapement again neutralizes, but with the rotor pin downward, at Fig. 1-1C. Now the next button push will establish the position shown in Fig. 1-1D and a left turn. If you wanted another right, you would give a quick button punch and release to step the escapement so rapidly through the unwanted left turn that the plane could hardly respond, bringing the rotor back to the position in Fig. 1-1A, then another punch and hold for the desired right turn. The escapement *always* must go through the neutral-right-neutral-left-neutral sequence; you can obtain repeated turns in the same direction only by "jumping" quickly through the unwanted turns. Escapements are normally linked to rudders to produce rather sharp turns. For wide, gentle turns you give repeated short signals and release for a turn in the desired direction.

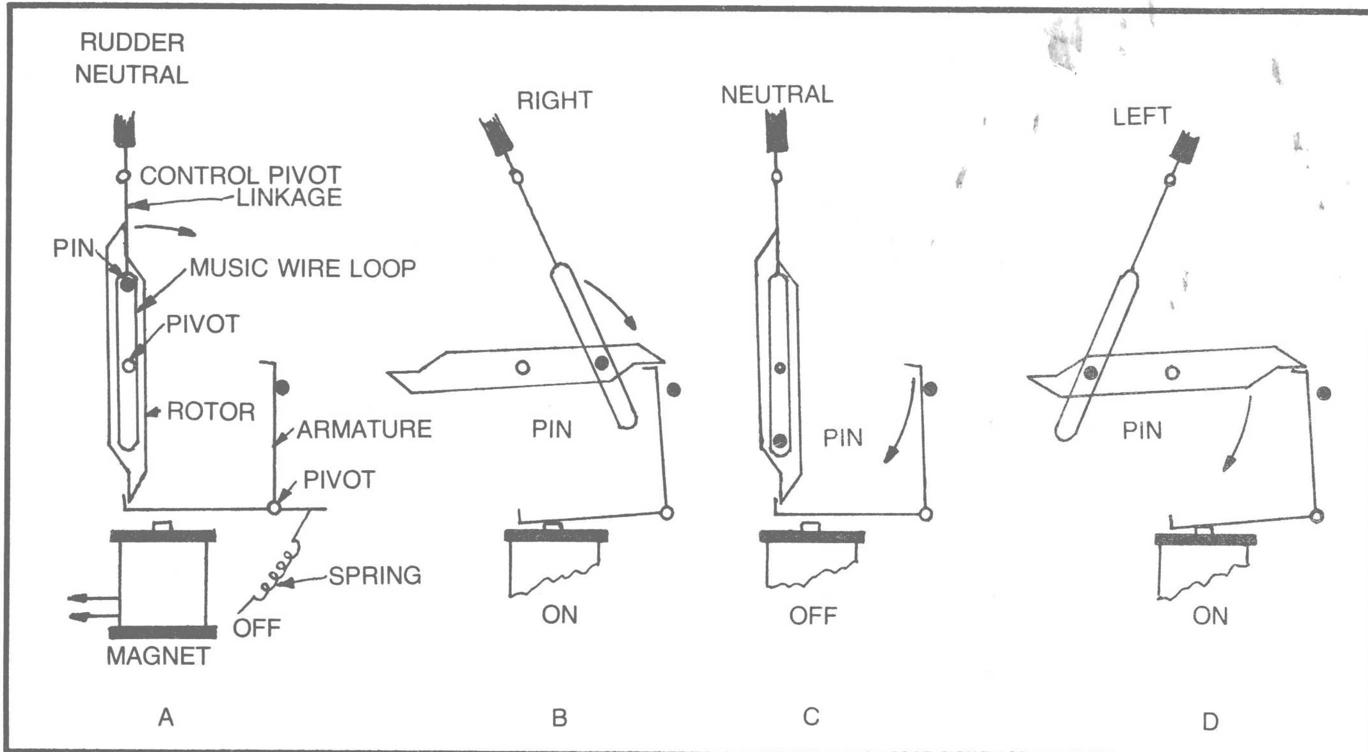

Fig. 1-1. A two-arm, or self-neutralizing, escapement.

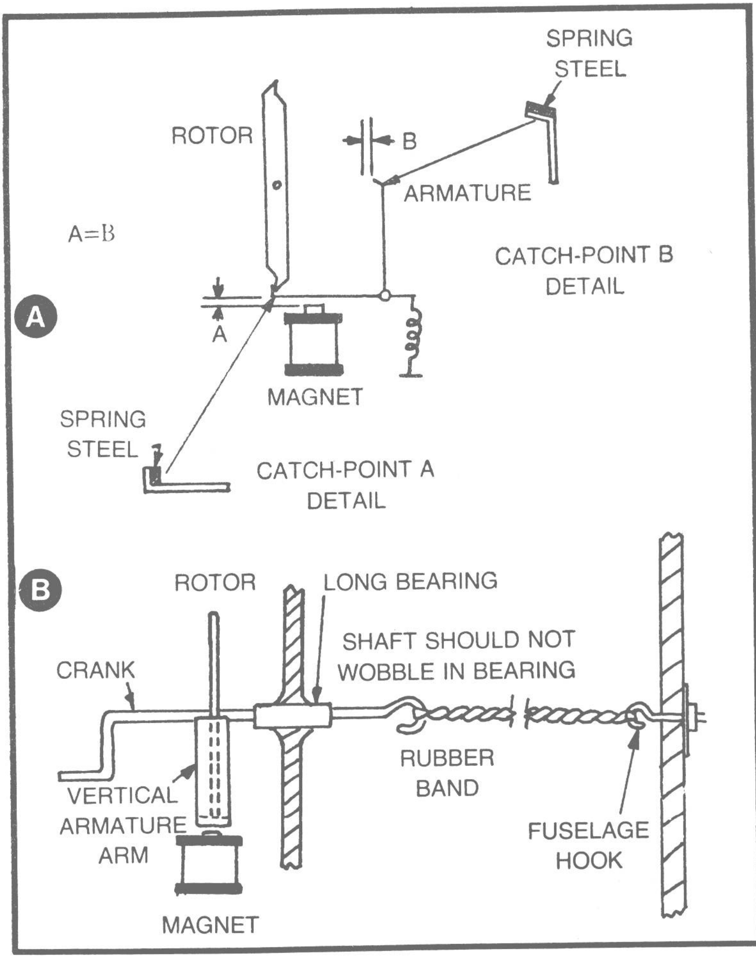

Fig. 1-2. Escapement details.

This sounds like a crude way to control a model, and it really is, but experts can demonstrate amazing maneuvers with escapements.

MAKING AN ESCAPEMENT

In Fig. 1-1 you saw that the basic elements are a magnet and an armature pivoted to move when the magnet is energized. Experience has taught that the iron of the relay armature is generally too soft to withstand the sudden impact of the rotor, so we need to reinforce the tips of the armature with small, thin strips of spring steel such as you can get from an old clock. This is shown in the two detail drawings of Fig. 1-2.

When activated by the magnet, the armature catch point tips must travel an equal distance. This is shown as dimensions A and B in the figure.

Notice that the rotor pivot (its shaft), the two catch points, and the armature pivot point form the four corners of an almost perfect square. In operation, the rotor is held as shown. When the relay armature pulls down because of a signal, the catch point at A pulls down, releasing the rotor so it rotates clockwise 90° to be caught at B, which had just moved to the left. It will hold there as long as a signal is present.

A spring on all relay armatures is adjusted in tension so that when the signal is off, the armature will pull catch point B away from the rotating bar. The bar then can rotate to be caught at A again. Thus, a signal followed by no signal rotates the bar 180 degrees. All you have to do, then, is to make sure that the bar catches and

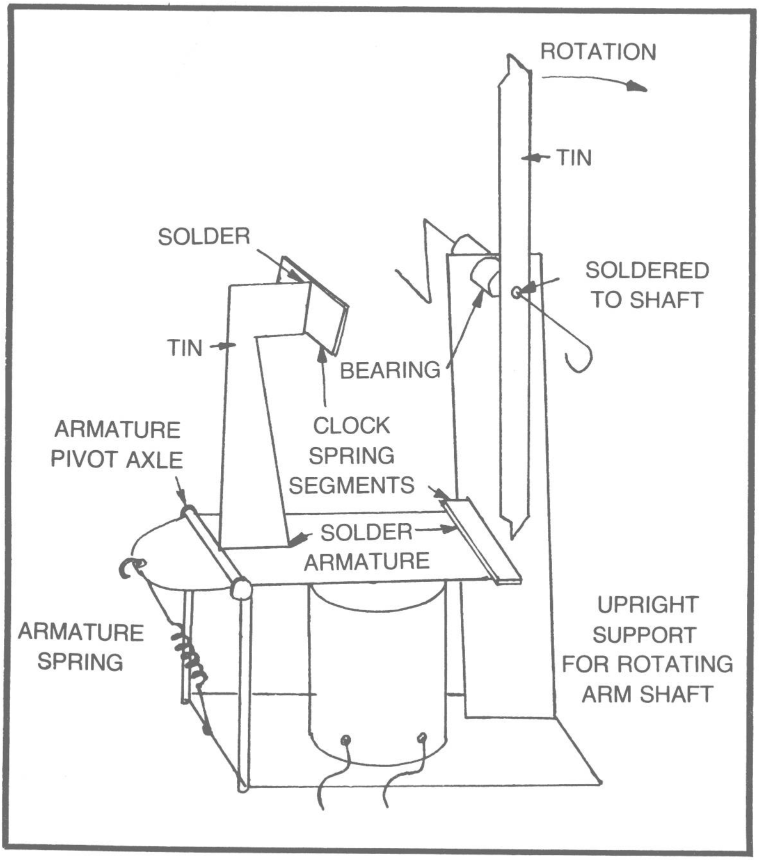

Fig. 1-3. Escapement construction.

releases at the points shown under the conditions stated. Be sure to make the physical layout a perfect square, as this minimizes the binding forces on the catch points and permits free motion of them. Be sure to make the catch points out of small strips of an old clock spring soldered to a tin upright and to the armature. The rotor should be a straight piece of tin with spring ends so it won't deform either. In Fig. 1-2B note the long shaft bearing which is necessary to prevent wobble. Figure 1-3 shows the escapement construction.

USING THE ESCAPEMENT

Escapements such as the one shown may be located at either a forward position, near the cabin of an aircraft, or back near the tail section. It is generally connected by a linkage to the rudder for steering the model aircraft because the airplane can be trimmed to climb under power, and will then glide for a long time if the motor run is relatively short. Also, if you have a large angle of rudder movement, holding the rudder in a maximum deflected position can cause the model to spiral dive to lose altitude any time it gets too high. You then just go "hands off" on the controls and the model will right itself—if it is properly trimmed. It will then begin a slow climb again. So steering is probably the most important control, and you use the rudder for that.

Whether you position the escapement forward toward the cabin or back toward the tail section will probably depend upon the balance of the aircraft. If it is tail heavy, you don't want to add more weight to the tail, so you use the forward position. If it is light in the tail, or the escapement is light enough (some commercial units have weighed less than ½ ounce), you can position it in front of the tail section with no ill effect on the plane balance. Study the balancing of an aircraft such as this in our TAB book No. 825, *Flying Model Airplanes & Helicopters by Radio Control.*

When the escapement is used in either position, it will be mounted as shown in Fig. 1-4. This shows the torque rod type of connection to the rudder.

With the escapement mounted on a bulkhead in the plane cabin area, the forward end of the torque rod has a U-loop (often called a "hairpin") that is a snug but not binding fit over the pin on the rotor. As the rotor pin revolves it forces the U-loop and the torque rod to rotate a few degrees back and forth. Another U-loop at the rear of the torque rod rocks back and forth in step and moves the pin attached to the rudder.

Torque rods can be of music wire or lengths of wood with wire fittings at both ends. They must be stiff enough to transmit the twist from the escapement without too much twist in the rod itself, which would lead to loss of rudder movement. The loss would be greatest