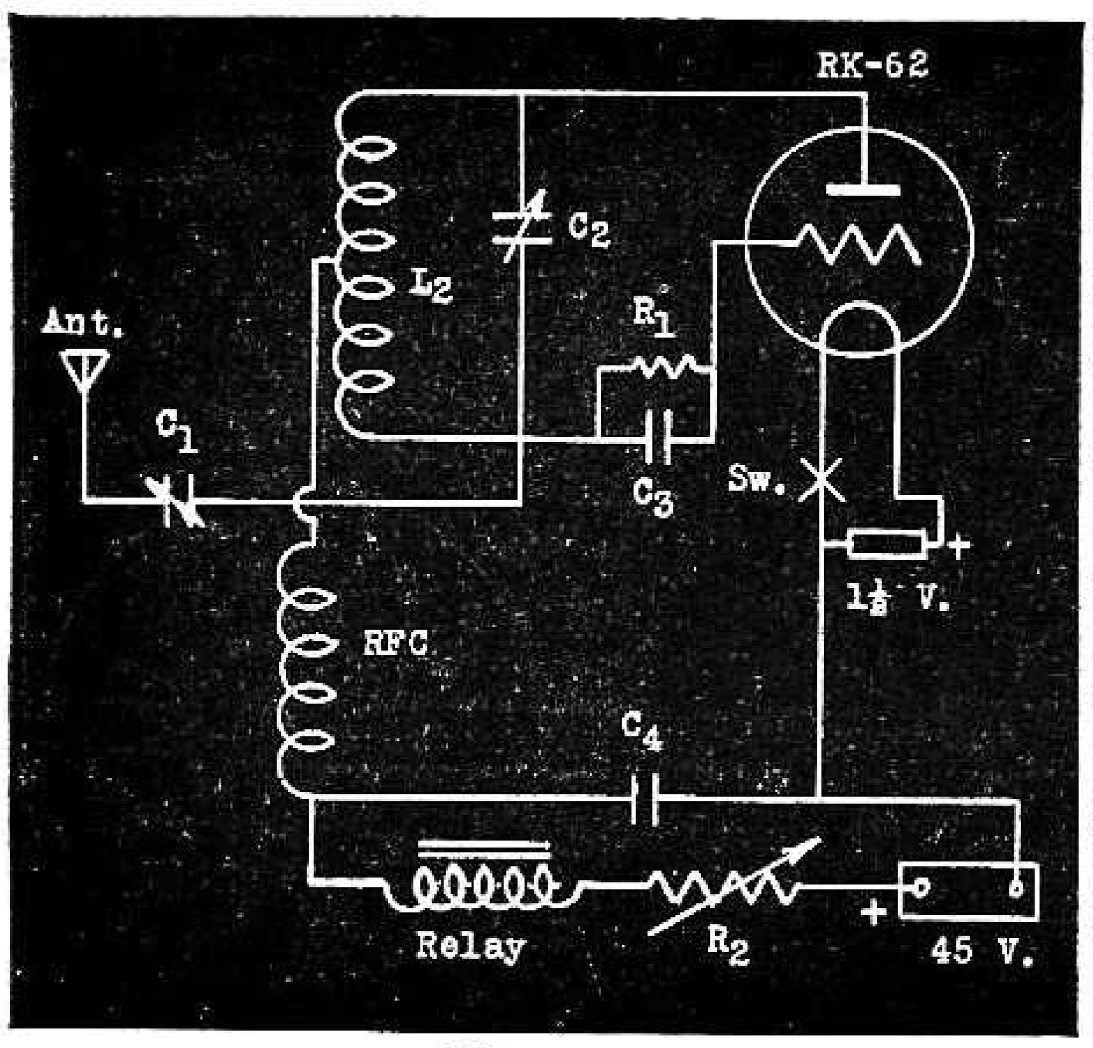

Fig. 1

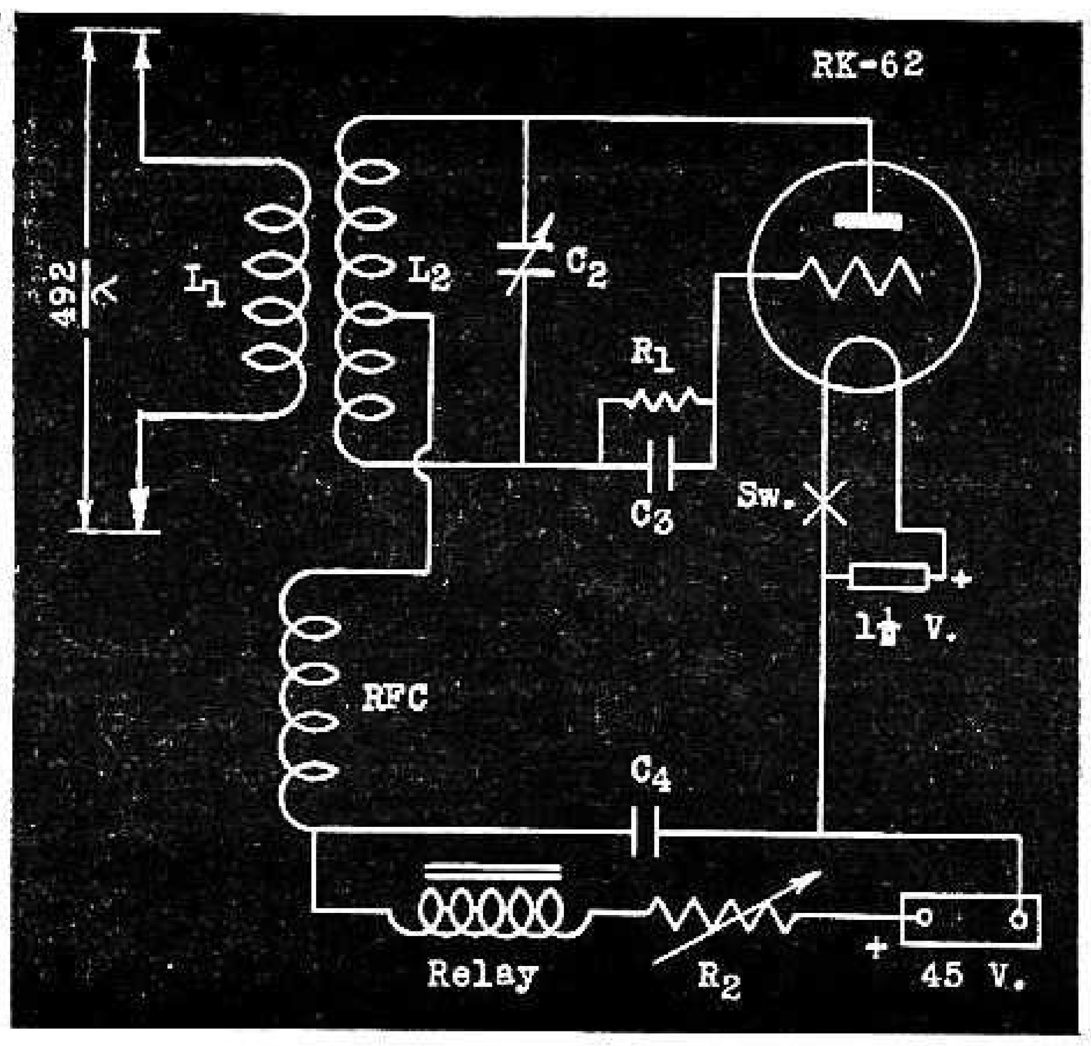

Fig. 2

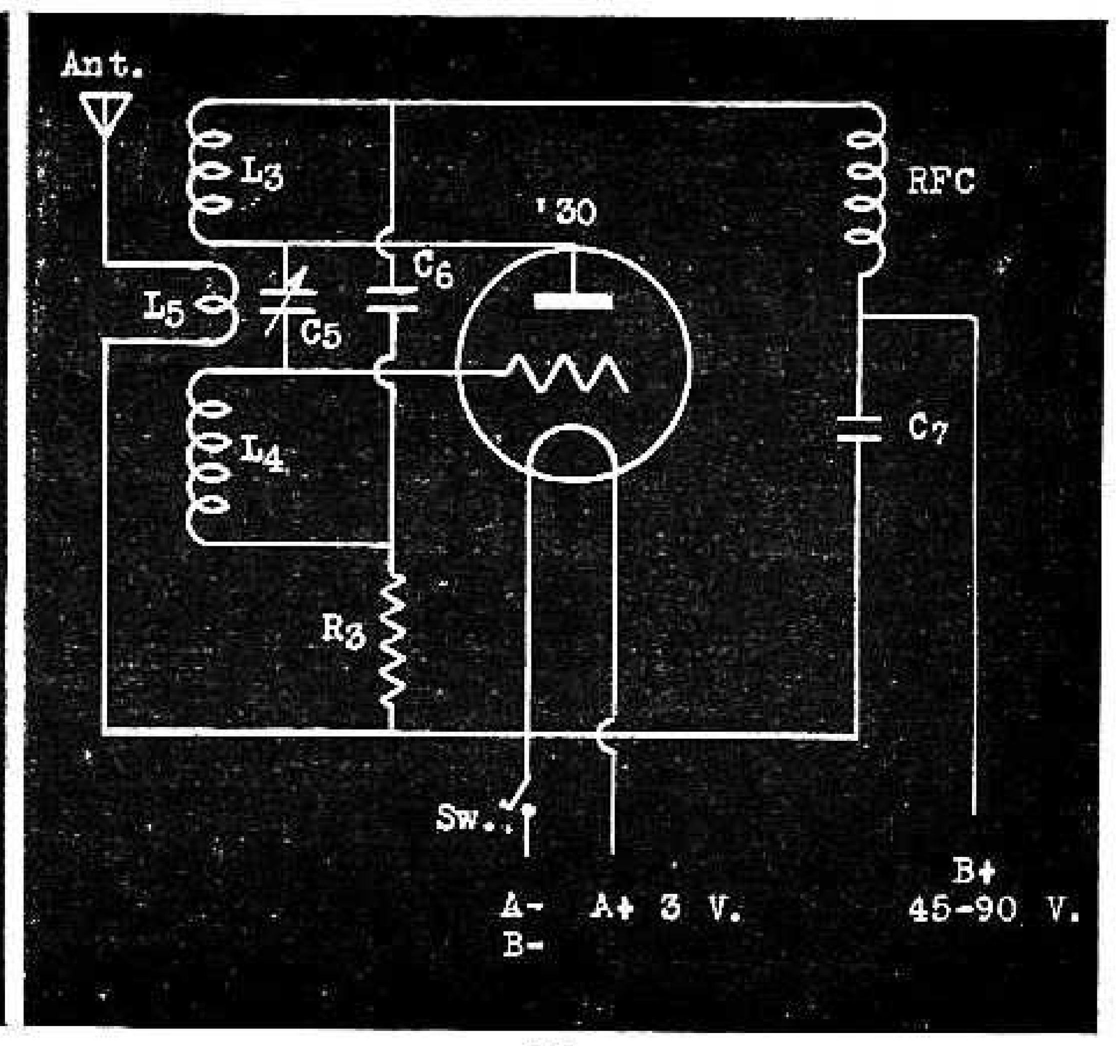

Fig. 3

"AIR CONDITION" YOUR RADIO CONTROL

How to build your radio control installation to give reliable service and facilitate repair

by **JAMES R.** *and* **THOMAS G. CUSTIN**

MUCH has been published in the last three years on the subject of radio control devices. Several kinds of mechanisms have been described and explicit instructions for building a radio control are now easy to find. Unfortunately, however, writers on the subject seem to assume that the controls they describe will operate perfectly as soon as they are put into the airplane, and very little has been said about the troubles which may arise to bedevil the experimenter. Nor has anyone undertaken to indicate the pitfalls which await the pioneer who sets out to design his own equipment.

Four years' experience has shown us that there is as much to be said about what *not to do* in the field of radio control as there is about what *to do*. We hope, therefore, that the hints and suggestions set forth here will be of some value in enabling experimenters to waste less time in finding out what is wrong and permitting them to spend more time in advancing the art.

In radio control work, as in everything else, the best way to eliminate trouble is to prevent it. That's why we'd like to start with a few practical suggestions on the construction of the radio control unit.

Let's begin by considering the problem of weight. Obviously, the control unit to be carried in the plane ought to weigh as little as possible, but how much should be sacrificed for lightness? We feel that cutting corners too much is not a good idea, and that dependability ought to be the first consideration.

For example, removing the tube base and eliminating the socket cuts the weight by only half an ounce, while there is about a quarter of an ounce additional weight added by the baseless mounting. The net gain of a quarter of an ounce hardly compensates for the additional troubles encountered in removing the tube on the field. If the tube has a tendency to come out of the socket under vibration, tiny drops of solder at the bottom of the tube prongs will hold it in and still permit quick removal when necessary.

Another weight saving device which usually proves futile is that of drilling holes in parts in order to cut down the mass of material. This applies to the airplane as well as the control unit. We recall the time that we laboriously cut seven holes in each rib of a large wing. The ribs were made of 1/8" sheet balsa, and the holes were about 3/4" in diameter. We saved all the little disks that we had cut out of the fifty-odd ribs and weighed them to see how much we had gained for our pains. It amounted to less than an eighth of an ounce!

Another element to which weight might well be given a subordinate place is accessibility. Our experience has shown that a device may look perfect on paper, may function flawlessly on the bench—may even work all right for the other guy—but the time will come when it will have to be serviced. And particularly when it has to be serviced on the field is get-at-ability important. If at all possible, the entire control should be built in one unit, removable from the airplane without the necessity of unsoldering wires.

A sturdy framework of 1/4" square hard balsa should hold the entire equipment, including batteries. This unit should be insulated from the airplane frame with sponge rubber in order to damp vibration, and the individual components should be rigidly mounted to the unit. Antenna wires and control wires or cables should clip to terminals at convenient points on the unit chassis. We have found it very handy to have the unit slip into the fuselage just under the wing, so that the center section covers the opening, thus eliminating the need for an excessive number of hatches.

If the necessities of the design make this type of unit construction impracticable, the control components should be grouped as closely together as possible, so as to make them accessible through the least number of hatches. Concentrated grouping of control components also has the advantage of concentrating weights at the center of gravity, a factor which makes for improved dynamic stability of the airplane itself.

When mounting the control components, remember that there are two types of punishment which they will have to take—stresses due to hard landings (and you can figure that *every* landing will be a hard landing), and vibration. Landing stresses are pretty much a problem of airplane construction. While we're on the subject, we might remark that the airplane ought to be designed around the control, and that the usual method of building the airplane and then sticking a control into it leads to unsatisfactory results.

There is no formula for solving the vibration problem, but a few tips on what to expect might not be amiss. We'd like to repeat what we said above: that all of the components ought to be mounted rigidly to the control unit chassis, and that the chassis itself ought to float on shock-proof mountings. These can be made of sponge rubber faced with smooth paper to facilitate sliding the unit into and out of the ship. Letting the parts vibrate individually may lead to trouble. We once mounted a condenser rigidly and a socket on sponge rubber and connected them with a piece of No. 16 bus-bar wire. After a time—believe it or not—the wire was sheared by vibration!

There is another lesson in this experience. Single strand wire has a nasty habit of breaking under vibration. A.C.-D.C. aerial wire, the kind used in midget sets, is flexible stranded wire very suitable for control hookups and ignition wiring. It's a good idea to put a drop of cement at each end of the cloth insulation on the wire, cementing it to the solder joint and

(Continued on page 42)

"Air Condition" Your Radio Control

(*Continued from page 19*)

thus preventing the insulation from sliding back at embarrassing times. Another good scheme is to cement the long wires to the chassis or fuselage frame at two or three inch intervals to prevent them from whipping. A drop of colored dope at each end of a wire provides an easy method of color coding on complicated hookups.

A word of warning. Don't use acid core solder for your wiring jobs! No matter how good the joint, experience has shown that the acid will tend to eat through the copper in time, possibly with disastrous results.

While we're on the subject of soldering, we'd like to say that where batteries are concerned, we're against it. Even the most careful soldering job is bound to heat up the battery, decreasing its life materially if not actually ruining it. It doesn't ease the labors of replacing batteries on the field, either. The trouble is, though, that a satisfactory battery box is a hard thing to find. After experimenting with various pinchpenny substitutes, we finally decided to invest a few nickles in the commercial duraluminum type, and our troubles were over. We might suggest, however, that splitting the ends of these cases vertically gives better results since it allows each of the two batteries to expand or vibrate as it pleases, without regard to the antics of its bedfellow, and insures constant contact.

We have found that using several small batteries in parallel is less economical and more cumbersome than using larger ones. A penlight cell, the smallest kind, weighs about 5/8 of an ounce, the next size larger weighs 1-1/2 ounces, and the largest size flashlight cell 3 ounces. The life and capacity of the battery increases more than proportionally to its size, so that the larger sizes are the more economical and dependable.

Assuming that they are fresh, the batteries having the longest shelf life will check the lowest when tested with an ammeter; while the cheaper kinds of batteries, which are most suitable for radio control purposes, deliver a higher current but have a much shorter shelf life. It is therefore advisable to check such batteries with an ammeter before purchasing them, in order to be sure of their freshness. When testing a battery hold the ammeter on it for only an instant, so as not to damage it. A high reading for a penlight cell in good condition is four amperes, for an intermediate cell, six, and a good large size cell will deliver between eight and ten amperes when fresh. These figures are for short shelf life batteries.

There are a large number of light weight B batteries, made by various manufacturers, but in these days of priorities not all of them are readily obtainable. Fortunately, however, Burgess makes an excellent battery for the purpose, the XX-45. It is always available, since it is designed for use in the popular small portable receivers, and its price is very reasonable. It comes as a 67-1/2 volt battery, but tearing off the cover reveals that it is built in three neat sections, connected by jumpers. Two of these sections will deliver 45 volts and weigh 6-1/4 ounces. Since they are rectangular they can easily be mounted in a balsa box or framework, and leads can be soldered to the jumper terminals. The life of a B battery can be very much prolonged by keeping it in the refrigerator when not in use.

There are two types of receivers suitable for radio control work, one using a type 30 tube, the other using the RK-62. The chief advantage of the 30 receiver is the low cost of the tube. The RK-62 receiver is easier to build and more reliable. It requires far less adjustment and usually works at once, while a certain amount of tinkering is almost invariably necessary before the 30 receiver will function properly.

The original circuit for the RK-62 receiver, as shown in Fig. 1, will operate satisfactorily with the least amount of preliminary piddling. To obtain best performance from the tube it is a good idea to follow the manufacturer's specifications. It is not advisable to operate the filament at more than 1-1/2 volts, and it is not necessary to do so. A single penlight cell is quite satisfactory for filament supply. It ought to be checked occasionally to make sure that it is not deteriorating. Although somewhat heavier in weight, the midget type air tuned condenser is much more satisfactory than the mica tuned type, since it is easier to adjust and less subject to vibration and temperature change.

The value of the grid leak, R_1, may vary with the individual receiver. Larger values of R_1 will yield a greater dip in plate current, but as the resistance increases, a point will be reached where the time lag in tube response becomes too great. It is advisable to start with a value of about one megohm and add resistance in series until reliable operation is obtained. The volume control, R_2, used as a plate resistor, can be replaced by a small fixed resistor chosen to give the maximum rated plate current of 1.7 mills. The variable type resistor, while slightly heavier, has the advantage of permitting the plate current to be maintained at the optimum point as the B battery deteriorates.

The receiver circuit shown in Fig. 2 is similar to that in Fig. 1, except that it employs a doublet resonant antenna with inductive coupling. One half of the doublet antenna can be mounted in each wing. The total length of the antenna is given by the simplified formula

$$L = \frac{492}{F}$$

where L is the length in feet and F the frequency in megacycles. If this is less than the wing span, "feelers" of 1/32" (No. 13) piano wire, protruding from the wing tips, can be used to extend the antenna. For best results the antenna wire should be kept as straight as possible.

The tuned circuit shown in Fig. 2 requires some cut and try work, but it is much more sensitive to weak signals. Each side of the primary coil, L_1, goes directly to the antenna. This coil is composed of approximately seven turns, but the exact number of turns can only be found by experiment. Disconnect the antenna and insert a low range milliammeter into the plate circuit. Then tune across the band with the variable condenser. A section of the band will be found in which the plate current dips to a minimum, indicating that the tube is not oscillating. When the antenna is reconnected (test with the antenna to be used in the plane) the tube will begin to oscillate in a part of the band in which it had not oscillated without the antenna. This latter oscillation range is the range of greatest sensitivity of the receiver. The number of turns on L_1 should now be changed until this sensitive point on the band corresponds to the resonant frequency of the antenna. The exact number of turns can be found by the cut and try process.

A simple self-excited transmitter is sufficiently flexible to permit its being turned to the sensitive point of the receiver with little difficulty, and its operating characteristics are quite satisfactory for radio control work. We have found that a crystal controlled five meter transmitter is very unreliable, since it often fails to go into oscillation.

The small oscillator shown in Fig. 3 is a handy aid to checking receiver performance. Without an antenna this oscillator should operate the receiver reliably at a distance of about 200 feet.

If the receiver unit is properly constructed and adjusted it should be quite trouble free. Occasionally, however, interference of one kind or another may cause difficulties. Ignition, as a rule, causes no trouble. If it does, the ignition condenser is probably at fault and a larger one—about 1 mfd.—should be substituted. If the ignition condenser is not of the metal case type, be sure that the end marked "outside foil" goes to the engine crankcase. Keep the condenser as close as possible to the breaker points, and keep all leads short.

Occasionally, where electric motors are used to actuate controls, commutator arc may be the cause of receiver interference. Since the RK-62 is at maximum sensitivity just after a signal is received, a slight disturbance such as the arc at the commutator may cause the receiver to remain out of oscillation after the carrier goes off, so that the motor keeps on running. This type of interference is particularly troublesome since it is extremely hard to diagnose. The cure is to shorten and twist the motor leads. If this fails, or if the motor leads cannot be shortened, a sure cure is to put an RF choke in each lead and a .01 (200 volt) condenser across the leads—all as close to the brushes as possible. The RF chokes are made of No. 24 D.C.C. wire, closely wound over a 1/4 inch dowel for about two inches. Pull the coil off the dowel and give it a couple of coats of cement, holding the ends until the cement dries, so as to keep the turns from spreading apart.

Atmospheric interference is seldom a problem, especially since radio controlled models are not usually flown in thunderstorms. The only other kind of interference is that due to other transmitters. There is no complete solution to this problem, but the chances for interference can be lessened by arranging the control system so that the carrier will normally be on at all times and the breaks will be keyed, instead of the usual system of keeping the carrier off and keying it on. This requires that the relay be adjusted so that the circuit is open when the carrier is on.

In conclusion, we might mention one other kind of man-made interference—the interference of the law. This can be avoided either by having a radio amateur's license yourself or by getting together with someone who has one. We suggest the latter method as the better, since radio control is really not a one man job, and the "ham" will usually have some worth while ideas or suggestions just when they're needed most. And when are good ideas *not* needed in radio control work?

PARTS LIST

R_1—See text.

R_2—10,000 ohm variable resistor, adjusted to give 1.7 milliamperes plate current.

R_3—100,000 ohms.

C_1—30 mmf. mica dielectric variable condenser.

C_2—10 mmf. air tuned variable condenser (Hammarlund APC-25, cut to three plates).

C_3—.0001 mfd. mica.

C_4—.25 mfd. paper.

C_5—35 mmf. air tuned variable condenser (Hammarlund MC-35-S).

C_6—.0001 mfd. mica.

C_7—.01 mfd. mica.

RFC—Ultra-high-frequency RF choke, such as Ohmite Z-1.

L_1—See text. Approximately 7 turns No. 16 bare copper wire spaced 1 3/8 in. long, wound on 1/4 in. form. Cemented inside of L_2 with clear model airplane cement.

L_2—13 turns No. 16 bare copper wire, wound on 7/16 in. form, 1 1/2 in. long.

L_3 and L_4—5 turns No. 16 bare copper wire wound on 1/2 in. form, cach coil 1/2 in. long, with 5/8 in. space between coils. Extremities of the two coils are mounted directly to the plate and grid terminals on the tube socket.

L_5—2 turns antenna link placed between L_3 and L_4. Ordinary hookup wire.