Build Your Own Receiver-Transmitter

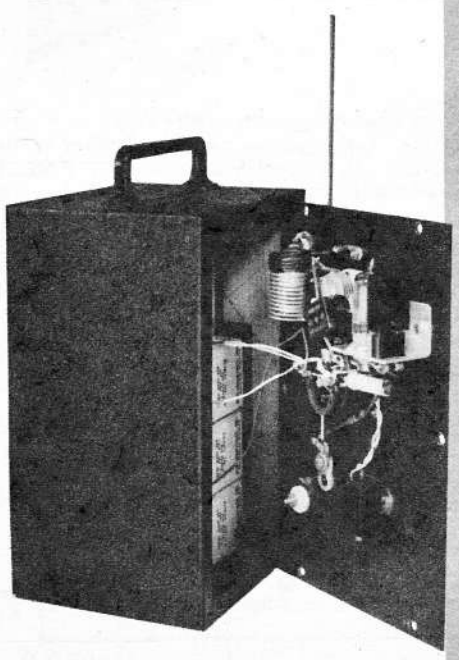
Operate your models by radio control with these two units designed for the Novice Class amateur radio fan

■ We have covered the history of modelplane R/C development. Let's look now at the legal side of R/C operation. In other words, what must you do to work your equipment under Federal Communications Commission rules? Radio Control comes under the category of Amateur Radio and you must have both an Amateur Radio Station license and an Amateur Operator's license. The former is simple; it's the latter that causes all the trouble.

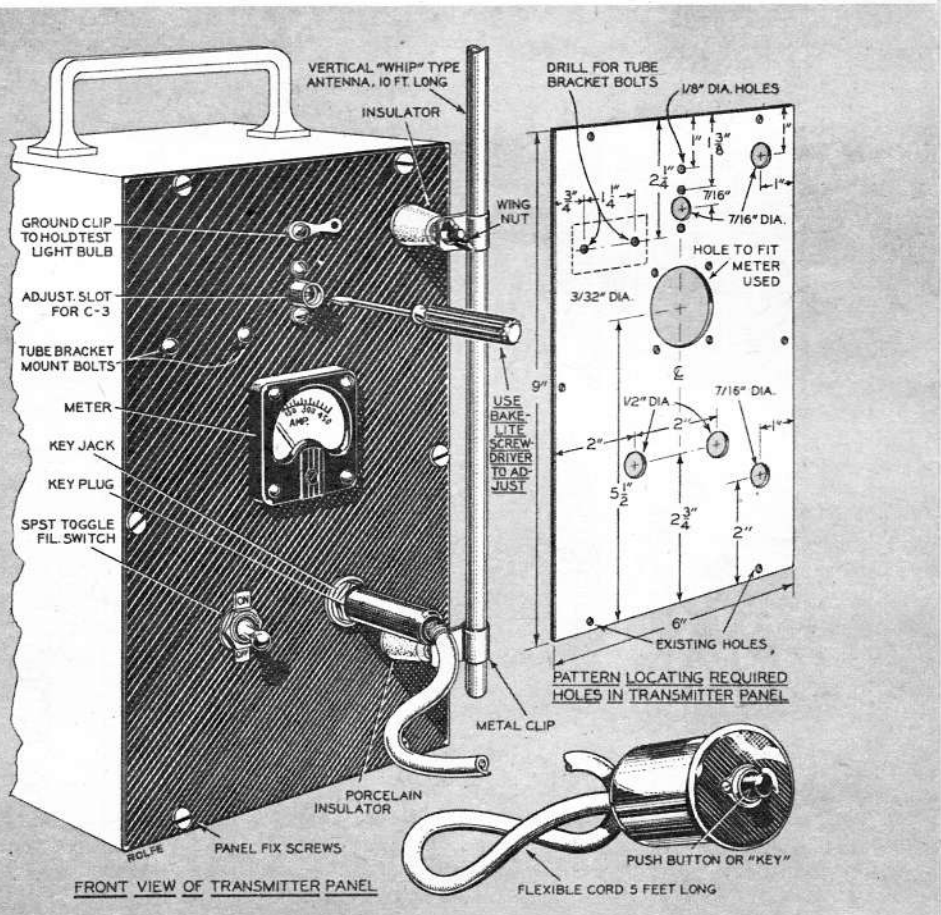
Silly as it may seem to modelplane flyers, who have no interest in communication via radio but just want to operate their plane a mile or less away, it is necessary to pass a code test plus a written exam in communication theory and law before they can legally fly their planes under Radio Control. This restriction has held back the development of R/C in this country to a tremendous extent. Proof of this is seen if we look at the impetus given Radio Control in England where flyers were given two genuine license-free bands several years ago. Prior to this, R/C work in England had been practiced only by a very few licensed pioneers; now that *anyone* can get in on the fun, with homemade equipment and no license problems whatever, R/C has made huge strides.

It is true that the A.M.A. has been battling unceasingly to get the same privileges for U. S. modelers that are enjoyed by flyers in England and several other countries, and we are glad to say that some progress is being made. Until there is a true license-free band available here, however, when we can build and operate R/C equipment subject only to reasonable restrictions of frequency and power input, let's examine the possibilities of the various Amateur operator license classes now available.

The simplest license that gives an Amateur operator most of the existing privileges is called the Class B, or General Class license. The examination for this requires a code speed of 13 words per minute (both sending and receiving), plus a written test of simple radio theory and radio rules pertaining to Amateur operation. While there are a dozen or so bands (or groups of frequencies) set aside for exclusive Amateur operation, practically all R/C is conducted in the 6 meter band (50-54 megacycles). This was the band in which the early R/C experimenters started their work, and R/C enthusiasts have stuck to it ever since.



This is the transmitter. All parts are mounted on the front of the case. The tube is a Raytheon 1S4, the crystal a Petersen Type Z5.



The F.C.C. announced two new classes of Amateur licenses that went into effect on July 1, 1951; both are of interest to radio controllers. The simplest is called the Novice Class and for this you must pass a code test of only 5 words per minute, plus a simplified theory and law quiz. The Novice license is our best bet so far for R/C operation. Though good only for one year, and non-renewable, it's an ideal place to start. The Novice license is restricted to operation in only three of the many ham bands, and only in certain portions of those. Also, the power is limited and the transmitter *must* be crystal-controlled. These restrictions do not affect the worth of this license class for Radio Control, however; it is the best thing yet for legal R/C work in this country.

A second new license is called the Technician Class; the code test here is also only 5 words per minute, but the theory examination is just the same as for the B Class. The Technician license is good for five years and is renewable indefinitely; licensees are extended all Amateur privileges *above* 220 mc. While little R/C work has been done up to now in this part of the frequency spectrum (aside from that in the "Citizens Band" at 465 mc., to be covered in a moment) it may be that this new simplified license will spur R/C activity on the higher frequencies—a very desirable outcome.

There are other Amateur license classes, offering special privileges or covering special conditions, but we won't go into details here, for the Classes mentioned are those of most interest to R/C enthusiasts.

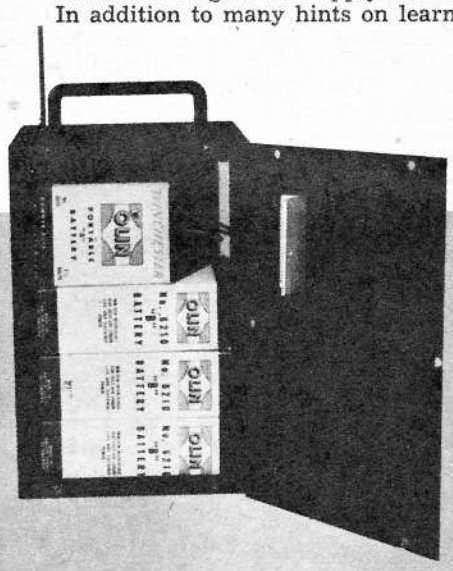
Learning the code is the big stumbling block, of course. You *can* pass the written exam just by memorizing the answers to the questions, but this is a foolish procedure, for you should understand the elements of radio theory in order to keep your R/C apparatus functioning correctly. Actually 5 words per minute is a very slow code speed. Five letters per word is considered average, so you must send or receive only 25 characters each minute—try writing at this speed! The difficulty is simply that you must learn an entirely new means of conveying information.

There are several ways to learn the code, or we should say, to increase your speed once you have learned the code. Regardless of how you do this, however, you must first memorize the letters. After you've done this you can team up with a friend, one keying a buzzer while the other receives. This will give both persons practice in receiving and sending—a real necessity when you recall that the code exam includes *both* receiving and sending ability.

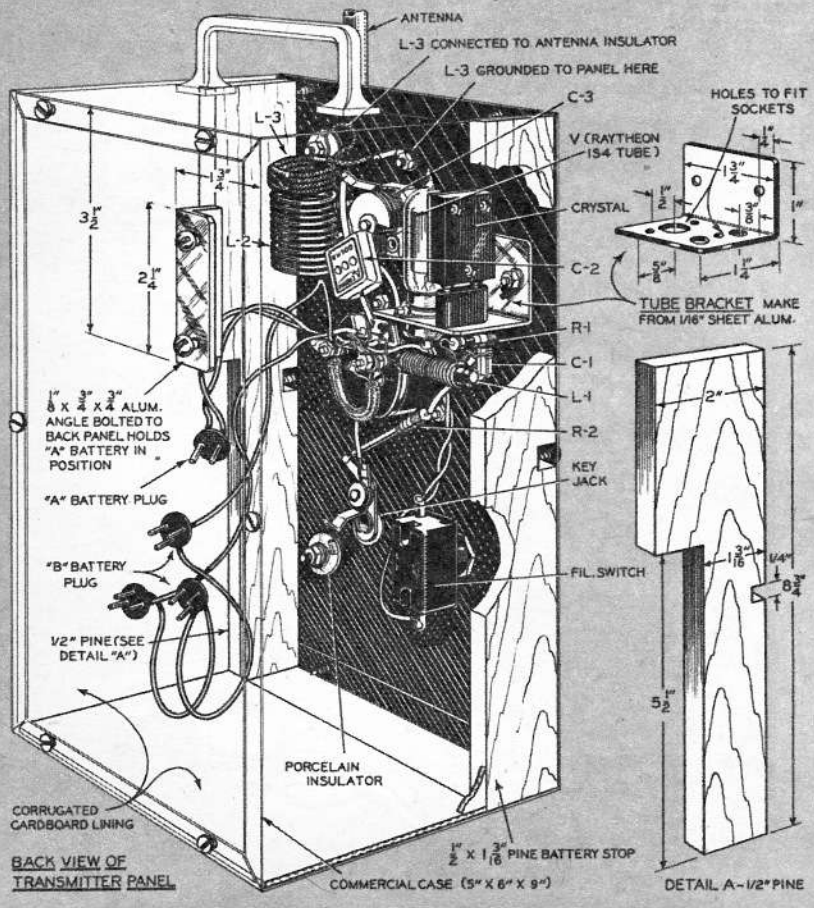
Receiving speed may be gained by listening to radio stations on an all-wave receiver, or by practice with "code machines" such as the Instructograph, which you can set at any speed you desire. Some of these code machines can be rented at a nominal cost, an ideal way for several persons or a club to pick up code speed.

There are, of course, scores of radio schools throughout the country that give radio theory and code courses of any complexity you desire.

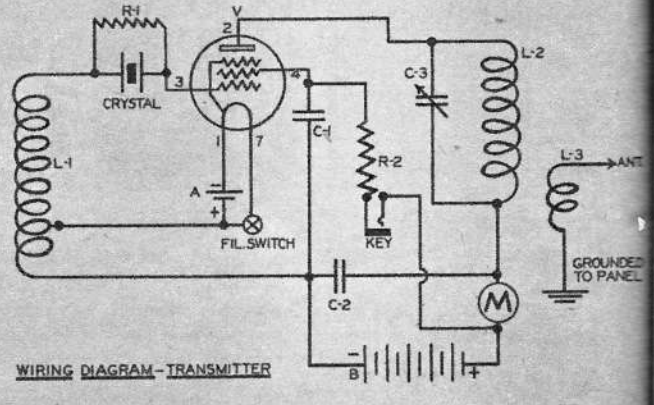
No one who intends to take an Amateur license exam should be without "The Radio Amateur's License Manual," available for 25¢ from American Radio Relay League, West Hartford 7, Connecticut, or from most large radio supply houses. In addition to many hints on learn-



The Transmitter:



Cutaway view of transmitter (left) should be of great assistance. Author has not gone into detailed hole-by-hole and wire-by-wire construction analysis. It must be assumed that the reader has some knowledge of radio building and fundamentals, if he has or is about to obtain a Novice or other "Ham" license. In the case of complete unfamiliarity with the subject the modelplane enthusiast desiring to get active in R/C work is urged to link forces with a nearby licensed radio "ham."



WIRING DIAGRAM—TRANSMITTER

ing the code, this manual lists the requirements for every class of license, the licensing offices of the F.C.C. all over the country, radio laws, and answers to typical theory examination questions.

The foregoing covering license problems applies only to Amateur Band operation. If you wish to build your own transmitter, either from parts you collect together yourself, or from one of the commercially available kits, you *must* have an Amateur license to operate it legally, regardless of the amount of power used, the distance you want to cover, or the intended use. For those who don't want to bother with a license, yet want to stay within the law, there is still an out, however. We have previously mentioned the Citizens Band, and this is your spot.

Note, however, that you must use a commercially built and F.C.C. approved transmitter (there is only one on the market now—the Citizen-Ship unit); you are not allowed to service or adjust the transmitter, even to the extent of replacing a burned-out tube. The tube used in the transmitter, however, has a life of many hundred hours, and you can, of course, install new batteries as required. No license is required for operation of an approved transmitter in the Citizens Band. You just fill out a very simple form, send it to the F.C.C., and a permit is issued without charge. (There is no charge for any class of Amateur license.) If you are technically able to do so, it is quite legal to build your own receiver for Citizens Band use. The R/C portion of the band, incidentally, is a spot frequency at 465 mc.

There is a possibility that the efforts of the A.M.A. will win us a frequency in or near the present 11 meter band, which covers 26,960 to 27,230 kc. Tests are now being conducted on 27,255 kc. in several sections of the country with a group of transmitters licensed to the A.M.A. You will probably see these transmitters in operation at some R/C meets.

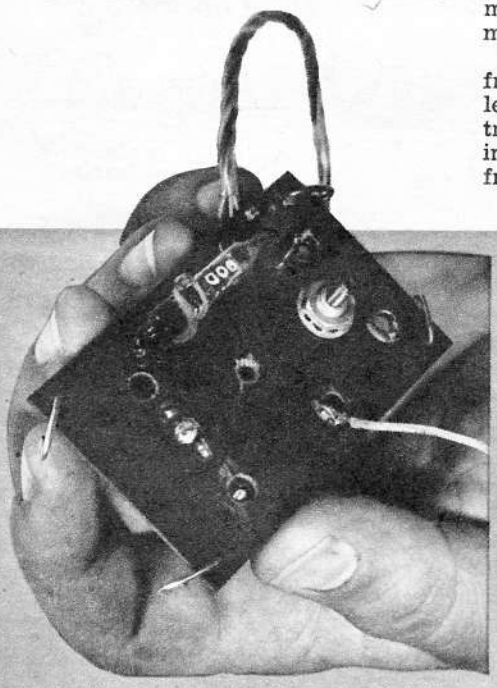
If and when we gain a license-free R/C band, wherein anyone can legally build and operate his own transmitter, it will undoubtedly be in the vicinity of 27 mc., as are the free bands in England and other countries. We present plans for a receiver and transmitter designed to be legally operable in the present 11 meter Ham Band, by holders of the Novice Class license.

The transmitter is very little more complex than those used in present-day R/C work on 50 mc.; such added complexity as we have is necessitated by the fact that the F.C.C. requires crystal controlled operation by Novice licenses. The transmitter is set to one frequency (unless you have several crystals) and it is necessary therefore to vary the receiver tuning as required.

A standard battery-type receiving tube, the 1S4, is employed, and the power, while very modest, has been found adequate for normal R/C operation. All batteries and other parts fit in a commercial 5"x6"x9" case, while the antenna is of the vertical "whip" type, about 10 feet maximum length.

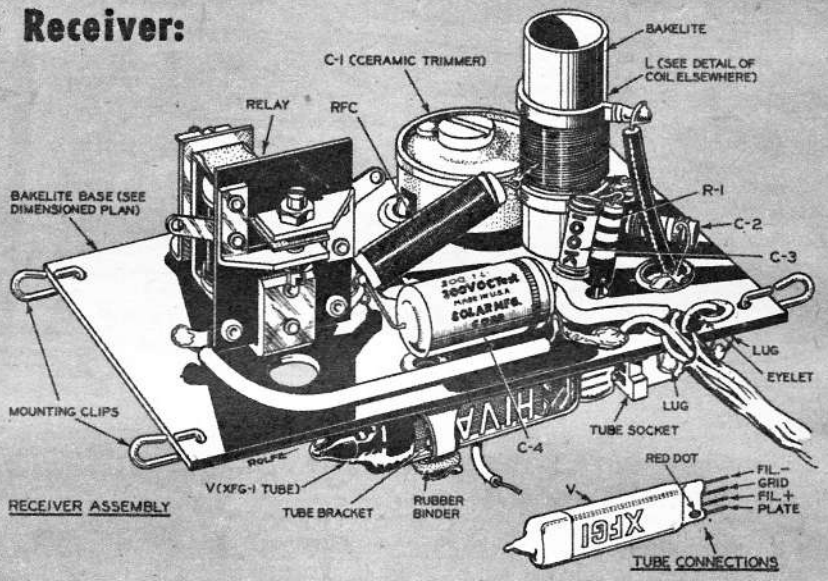
All transmitter parts are mounted on the front of the case. The tube and crystal sockets are fastened to a small aluminum bracket, while other components are bolted directly to the panel. We used an ICA #3801 Steel Utility Case, and location and size of principal panel holes are shown herewith.

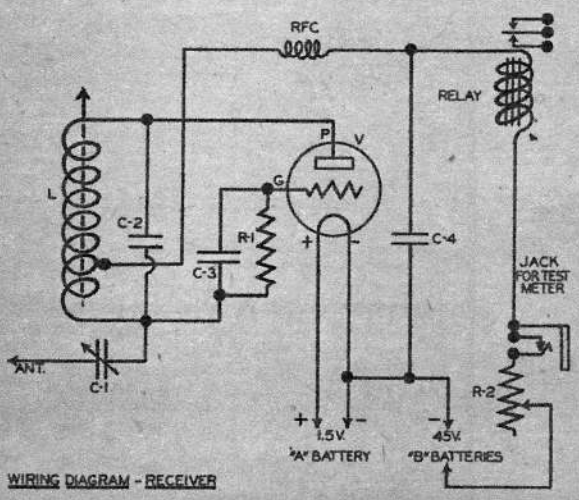
A meter is (*Continued on page 78*)

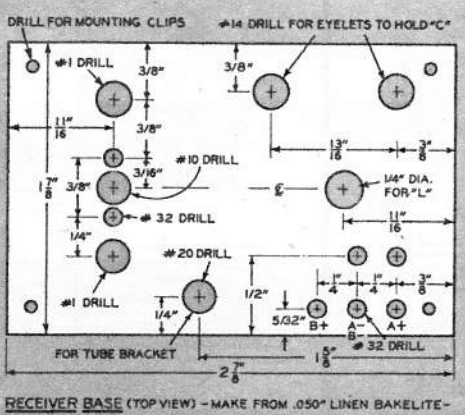


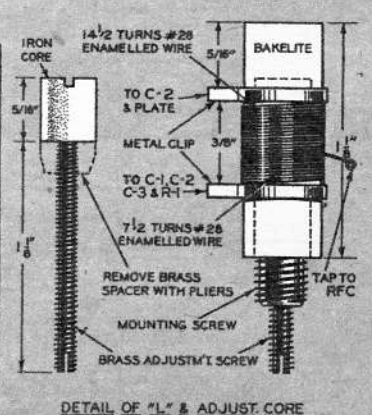
Underside of receiver. Unit features English XFG-1 tube distributed in America by Berkeley. American Telasco imports the E.C.C. type 5A sensitive relay.

The Receiver:









Rcvr-Xmtr

(*Continued from page 73*)

a great convenience, but there is not much space available, and a small one is necessary. We employed a surplus 1½" square job with a scale marked 0-450 amps! It is really a 10 ma. meter movement and we connected sufficient resistance wire across it to give a full scale reading of 45 ma. Actually, a meter of about 0-25 ma. range is just right.

The meter is connected to read only the plate current of the 1S4. Since the circuit is keyed in the screen grid lead, screen current can be checked at the key jack.

Mount and wire the parts carefully. Coil L1 is supported only by its leads, as are L2 and L3. The latter connects to the upper antenna insulator and to a lug on the front panel; scrape the paint clean under this lug. The lower insulator serves only to support the antenna. so the lower 7 in. of the latter is not used.

When all connections have been made and checked, hook up the batteries and turn the switch on. If you have a milliammeter of 0-10 or so range, connect it to the key plug. Turn C3 through its full range (it has no dial, as it should be set at the correct spot and left there). The plate meter should read about 22 ma. near the full capacity position (this indicates the tube is not oscillating). As you reduce capacity to around the halfway position, the meter will *suddenly drop* to about 5 ma., showing that the crystal is oscillating, and all normal operation is near this half-capacity setting.

You can check for output by connecting a #40 pilot lamp (6-8V, .15 A, brown bead) from the antenna post to the panel. Re-set C3 until this bulb glows brightest. If you get a good bright yellow glow, your transmitter is ready for business.

The antenna should be about 9½ ft. long from the top antenna post, or 10 ft. overall. It must be a light one or the transmitter will tip over in a strong wind. With the antenna extended, retune C3 for minimum plate current, which shouldn't be higher than 13 ma. If it is, or if you get no recognizable dip in plate current, move L3 a bit away from L2 and check the current again. With everything working correctly, plate current should be from 12 to 13 ma., and screen grid current 3.1 to 3.4 ma.

You may find another point, near minimum capacity of C3, where your test bulb will light; avoid this spot as it is not the correct frequency. If the parts are made and mounted as specified, the correct operating point will come near the midpoint of C3. If you have a friend owning a frequency meter, have him check your output, just to be sure.

Due to the type of antenna used, it is best to adjust C3 while the transmitter is sitting on the ground or on a car top or hood. Always use it in this same position thereafter; if it is placed on a wooden table the tuning will require rechecking and L3 will probably have to be re-set. In fact, we find that the plate current at resonance can only be brought up to 13 ma.—even with L3 as close as possible to L2—when the transmitter is on the ground.

You will need a flexible cord of 5 ft. or so with a plug at one end and some sort of push button at the other for keying purposes. When using the transmitter, do not hold this cord too near the antenna; don't stand right alongside of it yourself, as this varies the transmitter plate current somewhat. We usually set C3 just a little toward the *low capacity* side from the point of minimum plate current; this assures that the transmitter will not stop oscillating if we inadvertently touch the antenna, or hold the key cord near it.

This transmitter is relatively low powered compared to the average transmitter used for R/C today. The plate input is only 1.7 watts, and the power put into the antenna is about half this. However, tests have shown the transmitter power is adequate for R/C purposes; many R/C flyers make little attempt to attain peak transmitter efficiency or to be certain their transmitter is properly coupled to the antenna, and that the latter is of correct length. Under such conditions it is wise to use considerable transmitter power input so that even though a lot is wasted, enough will be radiated to assure adequate receiver action. It has been proven that, given a well adjusted transmitter and receiver, a tiny fraction of a watt into the transmitter will give perfect receiver operation as far as you can see the plane.

It is well to mention that the transmitter tube is operated somewhat over its normal rating in this circuit. However, we had it going literally for hours at a time during tests with no bad results; but, do *not* leave it turned on for long periods with the plate current over 13 ma., or with no antenna or other load connected, even with considerably lower plate current. For testing in the

(*Continued on page 86*)

(Continued from page 78)

shop, always use the #40 pilot lamp as a load if you don't have the antenna in place.

For the receiver we selected the simplest possible circuit, built around a so-called "gas tube" designed especially for R/C purposes. Because the American-made RK 61 tube is temporarily scarce due to defense orders, we have used the English XFG-1 with excellent results. The receiver circuit is familiar to every R/C flyer, but the component values have been chosen especially for the XFG-1 and for proper operation on the 11 meter band. We urge builders not to deviate in any way from the circuit values indicated. For one thing, the tuning system we used does not give us as wide a range of frequency shift as does the more common variable condenser tuned circuit; use L and C2 just as specified and you will have a sensitive, yet stable receiver.

Control Research can supply many of the essential parts of both receiver and transmitter. The English tube is available from Berkeley Model Supplies or from most of their local agents, while the sensitive relay we used, the E.C.C. type 5A, is to be had from American Telasco, Ltd.

The layout of the bakelite receiver base is shown here in detail. The hole sizes are those we employed for the various screws, eyelets and lugs in the test receiver. While the holes shown at the left of the base are for the E.C.C. relay, there is room on the base for either the Kurman 13C44, or the Sigma 4-F relays; the E.C.C. job weighs about ½ oz., considerably less than these two.

The best sequence of assembly is as follows: 1. Cut bakelite base to size. 2. Drill all holes. 3. Insert the various eyelets and lugs. 4. Mount C1 by soldering to the two eyelets. 5. Wind L and RFC and fasten L to the base. 6. Solder the tube socket to the four lugs at lower right corner. 7. Mount relay, add C2, C3, C4, and R1 and complete wiring.

Though the tube socket has five holes, only four are required. Cut the tube leads to ⅜" length, and scrape each lead carefully with a razor blade. Don't fail to do this! The leads are coated with a thin invisible lacquer and if you don't scrape it off you will have erratic operation, or complete failure. The tube is held by its leads in the socket, and by a small rubber band around the lug eyeletted to the base. The red dot on the tube signifies the plate lead.

Battery leads are soldered directly to the three lugs at the lower chassis edge, while the control circuit leads connect to the relay lugs. Most R/C flyers use a phonograph jack and plug for the test meter. These are very light and entirely satisfactory, but you will need *two plugs*, one to connect to the meter and the other to be shorted and put in the jack when the meter is not in use.

There is not much to do to get the receiver operating. Hook up the batteries and other units temporarily on your workbench, and attach 2 ft. of wire to the antenna side of C1. R2 should be set to bring the plate current to about 1.2-1.3 ma. C1 is normally used near the low capacity setting; lowest capacity is had with the metalized portion of the movable disc opposite the two mounting holes—rotate the disc about 45 deg. from this position. Turn on your transmitter (with the bulb connected to the antenna post) and turn the core of L with a bakelite or other insulated screwdriver. A position of the core will be reached where the plate current of the receiver dips sharply to about .1 ma. This is the correct operating point, of course.

If the meter needle seems very jumpy with no signal, it indicates that your receiver is too "hot"; simply increase capacity of C1 another 45 deg., shift R2 to bring the plate current back to 1.2 ma., and retune the core of L. You will find the meter needle will be much steadier—the receiver is now more stable but less sensitive.

At this point it is wise to make a full-scale field test. Either mount the receiver in your plane, or place it on a board with the meter and batteries, and shift test work to the nearest open area. *Final tuning of the receiver should be done at a distance of at least one-quarter mile*, and preferably even farther. You cannot tune it accurately close to the transmitter when the antenna is on the latter. Once properly tuned at a distance, however, the receiver will still operate perfectly, right next to the transmitter.

Our field tests were made at a distance of one-half mile. From a normal idling current of 1.2 ma., the receiver plate current dropped to .15 ma.; right next to the transmitter, the current reading was about .05 ma. These figures are with what we consider to be normally sensitive adjustment of C1 and R2. At the half-mile position, when C1 was considerably increased in capacity (the same result could be had by doubling the antenna length and leaving C1 as it has been), the current dropped only to .5 ma.

The relay should be set to open or "drop out" at about .7 ma., and to pull in at .85. All experienced R/C men have their pet relay settings, but these

will be satisfactory as a starter.

For flying batteries we suggest two Olin #0918, or equivalent, 22.5 V. units for B, and 1½ V. flashlight cells as large as your ship can conveniently carry for A. For *real lightweight* jobs, two Olin #0915 B's and one Eveready 912 sub-midget pen cell, a total weight of 1.6 oz., will give fair life. The receiver alone, with tube, relay, and battery leads, but less meter jack and R2, weighs 1.8 oz.

Because the transmitter antenna is a vertical, a vertical antenna should also be used with the receiver. A piece of music wire makes a good antenna, and need be only heavy enough so that it doesn't bend back at 90 deg. when the plane is in flight. A moderate backward bend will cause no trouble. It is characteristic of vertical antennas of this sort to operate least efficiently off the ends—in other words, your range will be shortest when your plane is directly over the transmitter. Check this carefully on your first flights to see just how far up you can go without evidence of loss of control.

Well, there is your radio link for legal R/C operation with a Novice license, or with any other grade of Ham ticket. We have found this equipment to be simple and relatively un-fussy to operate.

Receiver Parts List

V. XFG-1 tube, Berkeley Model Supplies. *L.* 22 turns #22 enamel wire close wound on CTC form. Tap 7½ turns from *grid* end. *C1.* 4.5-25 mmf ceramic trimmer. *C2.* 4.7 mmf ceramic fixed condenser. *C3.* 100 mmf ceramic fixed condenser. *C4.* .1 mf 150V paper. *R1.* 3. 9 meg. ⅓ watt. *R2.* 25000 ohm variable, Control Research. *Relay.* ECC type 5A sensitive relay, 4500-5000 ohms coil, American Telasco Ltd. *RFC.* Form ¾" x 5/32" diameter wound full of #34 en. wire. *Socket.* Cinch #2H5 sub-miniature socket. *Meter plug and jack,* Control Research.

Transmitter Parts List

V. Raytheon 1S4. *Crystal.* Petersen Type Z5, about 26,980-27,200 kc. *M.* Plate milliammeter 0-25 ma range. *R1.* 50000 ohm ⅓ W carbon. *R2.* 15000 ohm ⅓ W carbon. *C1, C2.* .005 mf., 300V mica. *C3.* 25 mmf variable trimmer, Control Research. *L1.* 30 turns #22 DCC wire on ¼" dia. bakelite rod; tap 3 turns from lower end. *L2.* 11 turns #14 bare tinned copper wire 1⅛" long, ¾" inside diameter. *L3.* 3 turns insulated hookup wire at lower end of L2. *Ant.* Collapsible aluminum whip, 10 feet long. *Key Jack.* Single circuit midget type—insulated from panel. *Fil. Switch.* S.P.S.T. toggle, Control Research. *Socket.* 7 prong miniature, Control Research. *A batt.* Olin #4816, 1.5V. *B batt.* Olin #6210, 45V, three used in series. *Case.* ICA #3801, 5" x 6" x 9". *Crystal socket.* Cinch #2KB or equivalent for FT 243 holder. *Antenna insulators.* Johnson 135-44. One 2 prong A batt. plug. Three 3 prong B batt. plug. Plug, wire and push button as desired.

Double Whammy

(*Continued from page* 11)

Mount the engine in position as shown, making sure to incorporate the 3½ deg. offset according to the top